HAWAIʻI STATE WILDLIFE ACTION PLAN

2025

HAWAI‘I’S STATE WILDLIFE ACTION PLAN

As submitted to the Regional Review Team
October 1, 2025

Department of Land and Natural Resources
1151 Punchbowl Street, Room 325
Honolulu, HI 96813

HAWAIʻI'S STATE WILDLIFE ACTION PLAN

Prepared for

State of Hawai‘i
Department of Land and Natural Resources
Division of Forestry and Wildlife
Division of Aquatic Resources.

This document is an update to the 2005 and 2015 Hawai‘i Comprehensive Wildlife Conservation Strategies

Prepared by

Hawai‘i Coral Reef Initiative

With assistance from:
The Division of Forestry and Wildlife, Department of Land and Natural Resources, and The Division of Aquatic Resources, Department of Land and Natural Resources.

Recommended Citation

Hawai‘i Department of Land and Natural Resources. 2025. Hawai‘i's State Wildlife Action Plan. Prepared by Hawai‘i Coral Reef Initiative

Copies of this publication may be downloaded from https://arcg.is/r9DSe0.

Hard copies may be requested from:

Division of Forestry and Wildlife (DOFAW) or the Division of Aquatic Resources (DAR)
Department of Land and Natural Resources
1151 Punchbowl Street
Honolulu, HI 96813
Phone: 808-587-0166 (DOFAW), or 808-587-0100 (DAR)

TABLE OF CONTENTS

Acknowledgements…… 1

Foreword……..... 2

List of Acronyms …… 3

Executive Summary……. 4

Chapter 1: Purpose and Value ……..……..... 9

Chapter 2: Approach and Methods……... 16

Chapter 3: State of Hawai‘i Overview……. 22

Chapter 4: Statewide Conservation Needs…….……... 52

Chapter 5: Marine Conservation Needs…..……... 84

Chapter 6: Island Conservation Needs……. 102
- **Kaua‘i……... 102**
- **Ni‘ihau…….. 119**
- **O‘ahu……..... 123**
- **Moloka‘i……...…… 140**
- **Lāna‘i…….…….. 158**
- **Maui……. 166**
- **Kaho‘olawe…….……. 187**
- **Hawai‘i…….……..….. 193**
- **Northwestern Hawaiian Islands……..... 218**

Chapter 7: Species of Greatest Conservation Need……. 232
- **Terrestrial Mammal……... 233**
- **Forest birds……. 238**
- **Raptors…… 348**
- **Waterbirds…….……. 354**
- **Seabirds……...…… 378**
- **Migratory Birds…….……. 448**
- **Northwestern Hawaiian Islands Passerines……. 466**
- **Terrestrial Invertebrates……...…… 476**
- **Plants……..... 692**
- **Freshwater Fishes…..…….…… 699**
- **Freshwater Invertebrates.……. 719**
- **Anchialine Pond Fauna..……...…. 732**
- **Marine Mammals..…….…..... 739**

Marine Reptiles …….. 769
Marine Fishes.……. 787
Marine Invertebrates.……..…. 828
Endemic and Native Marine Algae.…….…..…..…..... 881

Chapter 8: Monitoring, Implementation, and Adaptive Management…….…. 884

Glossary……..…….. 899

Bibliography…… 903

Appendices……... 950

A: Wildlife (Fauna) Species of Greatest Conservation Need…….. 950

B: Plant (Flora) Species of Greatest Conservation Need…… 980

C: Overview of Management Programs and Existing Regulations…... 997

D: Summary of Public Comments Received…… 1014

E: Maps of Areas for Management of Species and Habitats…….. 1017

- **Areas for Management of Species and Habitats on the Island of Kauaʻi**
- **Areas for Management of Species and Habitats on the Island of Oʻahu**
- **Areas for Management of Species and Habitats on the Island of Molokaʻi**
- **Areas for Management of Species and Habitats on the Island of Maui**
- **Areas for Management of Species and Habitats on the Island of Kahoʻolawe**
- **Areas for Management of Species and Habitats on the Island of Hawaiʻi**
- **Marine Managed Areas – Main Hawaiian Islands**
- **Papahānaumokuākea Marine National Monument – Northwestern Hawaiian Islands**

ACKNOWLEDGEMENTS

The Department of Land and Natural Resources (DLNR), Divisions of Forestry and Wildlife and Aquatic Resources, took the lead in updating Hawai‘i’s State Wildlife Action Plan (SWAP). The extensive and important work done in 2005 to develop the original SWAP greatly facilitated the update process. Also, in 2005, many DLNR staff, partners, organizations, and interested citizens helped develop and complete the plan, and then updated the plan in 2015. The authors of this 2025 update sincerely thank those who willingly shared their knowledge, comments, resources, time, and enthusiasm to ensure that this plan continues to be a wildlife conservation strategy by and for the people of Hawai‘i. Assistance was provided by various people and organizations at different stages of the process. To everyone involved, thank you for your time and talent.

Finally, we would like to acknowledge all the citizens who participated in the review process and provided input, at public meetings or through emails. Thank you for your dedication and commitment to the conservation of wildlife resources in Hawai‘i and your willingness to participate in this process. Because so much of the work done in 2005 and 2015 has been retained and is the foundation of this current plan, we also want to acknowledge those who were instrumental in developing the first edition of the plan, as well as the 2015 update.

FOREWORD

Aloha! I am proud to present the 2025 edition of Hawai‘i’s State Wildlife Action Plan (SWAP), which outlines the strategies and plans of the Department of Land and Natural Resources and its partners to address the conservation needs of over 10,000 native species in Hawai‘i. This update to the SWAP builds on the original 2005 plan and 2015 revision, which have effectively guided conservation efforts over the past 20 years. In line with the original plan, this SWAP provides a comprehensive statewide strategy for safeguarding native wildlife, covering species from the mountains to the sea, and from Cape Kumukahi, where the sun first rises on the Hawaiian Islands, to Holaniku (Kure Atoll), where the sun last sets at the far western edge of the chain.

This update marks the beginning of a new phase of collaboration, coordination, and renewed efforts to protect Hawai‘i’s native wildlife. While progress has been made, the reality remains that these species and their habitats, many of which are unique to the islands, face major challenges from habitat loss, the introduction of non-native invasive species, and the impacts of a changing climate. More than half of native habitats have been lost, and the ongoing arrival of non-native plants, animals, and diseases continues to threaten native animals and the survival of entire species. Hawai‘i’s SWAP highlights the importance of working together to reverse the decline of native wildlife and habitats. By building on past conservation and research efforts and using the best available science, this SWAP establishes statewide goals and strategies to address the threats facing our native wildlife and habitats.

This plan reflects the hard work of many people—I sincerely thank everyone who contributed to its update. I invite everyone to partner with the Department, our sister management agencies, community groups, businesses, landowners, and citizens to help implement the vision outlined in this plan. Together, we can ensure that Hawai‘i’s native species continue to thrive for future generations.

DGS

Dawn N. S. Chang
Chairperson
Department of Land and Natural Resources

LIST OF ACRONYMS

ACRONYM	MEANING
BLNR	Board of Land and Natural Resources
BRFA	Bottomfish Restricted Fishing Area
CI	Confidence Interval
CITES	Convention on International Trade of Endangered Species
CGAPS	Coordinating Group on Alien Pest Species
CWCS	Comprehensive Wildlife Conservation Strategy
DAR	Division of Aquatic Resources
DHHL	Department of Hawaiian Home Lands
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
DOH	Department of Health
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FMA	Fishery Management Area
FRA	Fishery Replenishment Area
GSN	Genetic Safety Net
HI-GAP	Hawai‘i Gap Analysis Project
HISC	Hawai‘i Invasive Species Council
HRS	Hawai‘i Revised Statutes
IUCN	International Union for the Conservation of Nature and Natural Resources
KIRC	Kaho‘olawe Island Reserve Commission
KS	Kamehameha Schools
MGD	Million gallons per day
MHI	Main Hawaiian Islands
MLCD	Marine Life Conservation District
MMA	Marine Managed Area
NAR	Natural Area Reserve
NEPA	National Environmental Policy Act
NGO	Non-governmental organization
NHP	National Historic Park
NMFS	National Marine Fisheries Service

ACRONYM	MEANING
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NWHI	Northwestern Hawaiian Islands
NWR	National Wildlife Refuge
PEPP	Plant Extinction Prevention Program
PMNM	Papahānaumokuākea Marine National Monument
SE	Standard Error
SEPP	Snail Extinction Prevention Program
SD	Standard Deviation
SGCN	Species of Greatest Conservation Need
SOS	Save Our Shearwaters Program
SMA	Special Management Area
SWAP	State Wildlife Action Plan
SWG	State Wildlife Grant
TNC	The Nature Conservancy of Hawai‘i
UH	University of Hawai‘i
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
WP	Watershed Partnership

EXECUTIVE SUMMARY

BACKGROUND

Hawai‘i’s 2025 edition of the State Wildlife Action Plan (SWAP) presents comprehensive strategies for the long-term conservation of over 6,000 of the state’s native terrestrial and aquatic species, the vast majority of which are found nowhere else on earth. The SWAP continues to build on the original 2005 edition, then called the Comprehensive Wildlife Conservation Strategy (CWCS), and its 2015 revision, by leveraging Hawai‘i’s strong history of conservation and statewide collaboration among resource managers, biologists, and concerned individuals. The plan calls for expanding and strengthening the partnerships that have been developed, and for using the momentum that has been fostered by the Hawai‘i Department of Land and Natural Resources (DLNR) to implement and continually improve this plan’s conservation strategies.

STRATEGY APPROACH AND DEVELOPMENT

The reason for updating the SWAP is twofold: first, to continue the coordinated and comprehensive planning and implementation of conservation strategies and actions to manage and restore native wildlife, and second, to continue participation in the State Wildlife Grant (SWG) program administered by the U.S. Fish and Wildlife Service (USFWS). Under this program, Hawai‘i receives approximately $450,000 - $500,000 per year to fund SWAP projects. To participate, all states and all U.S. territories are required to update their SWAP by October 1, 2025, and to include the following eight required elements:

1) Information on the distribution and abundance of species of wildlife identified as “Species of Greatest Conservation Need,” including low and declining populations, as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state’s wildlife;
2) Descriptions of the locations and relative condition of key habitats and community types essential to the conservation of species identified in (1);
3) Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats;
4) Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions;
5) Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions;
6) Descriptions of procedures to review the plan at an interval not to exceed ten years;

7) Plans for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats; and
8) Provisions to ensure public participation in the development, revision, and implementation of projects and programs.

The Hawai‘i DLNR has worked with conservation partners to update the 2025 SWAP and thus, continue to guide conservation efforts across the state for the next ten years. No major changes were made to the 2025 SWAP revision and follows the same format as the CWCS. It uses the best available science, incorporates information from many existing management, conservation, and recovery plans, and applies the knowledge of DLNR staff and conservation partners who worked on implementing the 2005 plan and 2015 revision. The successes and lessons learned were analyzed to update the chapters of this plan. The plan update also is based on collaboration with local, state, and federal agencies, non-governmental organizations, private landowners, and interested citizens. A variety of outreach methods such as public information meetings, communications with subject matter experts, and an interactive StoryMap was used to invite and expand participation in the update process (see Chapter 2 for more information on the methods and approaches used to update the SWAP).

This plan assesses threats to species and their habitats and conservation needs at three levels: statewide, island-wide, and taxa-specific. Chapters 3 and 4 present an overview of Hawaii's unique species and their habitats, identify the major threats to the long-term conservation of these species and habitats, and present seven conservation objectives to address these threats. For each objective, the SWAP identifies the highest priority conservation strategies needed to manage those species in greatest need of conservation. Because conservation needs in Hawai‘i far exceed the resources available, implementation of conservation strategies and actions that benefit the largest number of the most vulnerable species and ecosystems are preferred. Because so many of Hawaii's species require special management, implementation of SWAP strategies will also benefit a large number of more common species. Chapters 5 and 6 present more specific information for the marine environment (Chapter 5) and the individual islands and the Northwestern Hawaiian Islands (NWHI) (Chapter 6). Fact sheets on individual taxa or on groupings of taxa were developed to present information relating to elements one through five and are compiled in Chapter 7. Finally, recognizing that implementation of actions using cost effective approaches is critical to the overall success of the SWAP, Chapter 8 introduces a new framework being developed to provide managers with more precise tools and applications to guide implementation of cost effective conservation actions and discusses existing and needed monitoring programs for species and habitats, , including the ten-year revision.

HAWAI‘I'S STATE WILDLIFE ACTION PLAN

Hawai‘i's Species of Greatest Conservation Need (SGCN) were identified during a review of all native terrestrial animals, all endemic aquatic animals, additional indigenous

aquatic animals identified as in need of conservation attention, all native plants, and all endemic algae. The 1,409 SGCN include terrestrial mammal (1), birds (78), terrestrial invertebrates (~ 5,000), terrestrial plants (683), freshwater fishes (5), freshwater invertebrates (12), freshwater algae (24), freshwater plants (2), anchialine pond-associated fauna (20), marine mammals (26), marine reptiles (6), marine fishes (138), marine invertebrates (190), terrestrial algae (7), and marine algae (81).

The 2015 revision included updates to all 122 fact sheets, with much greater coverage of native invertebrates (55 new fact sheets and five updates) addressing the status, threats, and conservation needs of native invertebrates; an update of fact sheets addressing status, threats, conservation needs, research and monitoring for 33 forest birds, 11 marine species, seven seabirds, six waterbirds, three birds from the NWHI, the ʻio (*Buteo solitarius*) and Hawaiian hoary bat (*Lasiurus cinereus semotus*). The 2025 revision also includes updates to all 122 fact sheets, with an addition of 107 newly added fact sheets (totaling 229): birds (68), terrestrial inverts (92), marine species (66), rare plants (2) and one land mammal (Hawaiian hoary bat).

The major threats and challenges facing Hawaiʻi's native wildlife are common to most species groups and habitats and include:

- Loss and degradation of habitat resulting from human development and land use practices, alteration of hydrology, wildfire, invasive species, recreational overuse, and natural disaster;
- Invasive species (e.g., habitat modifiers, including weeds, ungulates, algae and corals, predators, pests, competitors, disease carriers, and diseases);
- The ecological consequences of climate change;
- Limited information and insufficient information management;
- Uneven compliance with existing conservation laws, rules, and regulations;
- Overharvesting and excessive extractive use;
- Management constraints; and
- Inadequate funding.

The majority of these threats and challenges are the same as identified in 2005, with the exception that the ecological consequences of climate change have been added. New or increasing threats identified in the 2015 plan include emergence of new diseases such as rapid ʻōhiʻa death or ʻōhiʻa wilt on Hawaiʻi, new or increasing instances of coral disease in reefs throughout the State, spread of mosquitos and avian malaria into high elevation forests on Kauaʻi, climate-change triggered coral bleaching events, excessive extraction of marine invertebrates, and predation on native land invertebrates by a host of introduced pests. In the 2025 update, new diseases have been identified, such as toxoplasmosis in marine mammals, and new or increasing instances of other diseases, invasive species, and environmental changes have been added. The statuses of many species were updated as well as their current threats, conservation actions, mitigation actions, and research priorities.
To address these threats, the SWAP identifies multiple strategies to implement the following seven priority conservation objectives for the state:

A. Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive;
B. Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication;
C. Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs;
D. Strengthen existing and create new partnerships and cooperative efforts;
E. Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i;
F. Support policy changes aimed at improving and protecting native species and habitats; and
G. Enhance funding opportunities to implement needed conservation actions.

Implementation of the 2025 SWAP will continue to require an ongoing effort of local, state, and federal agencies, non-governmental organizations, communities, private landowners, and individual citizens working together. Although the magnitude and scope of the work needed to protect and recover Hawai‘i’s unique native species are large and challenging, expanding our cooperative partnerships and working together to implement the strategies and projects identified are critical if future generations are to see and experience the unique native wildlife of Hawai‘i.

CHAPTER 1: PURPOSE AND VALUE

Mission Statement: *The mission of* Hawai‘i’s State Wildlife Action Plan *is to guide conservation efforts across the state to ensure protection of Hawai‘i’s wide range of native wildlife and the diverse habitats that support them.*

PURPOSE OF HAWAII’S STATE WILDLIFE ACTION PLAN

The purpose of *Hawai‘i’s State Wildlife Action Plan* (SWAP) is to identify the conservation strategies and actions needed to conserve biodiversity, provide actionable guidance for managers responsible for the implementation of those strategies and actions, and communicate plans to partners and constituents. This SWAP update will provide the opportunity for resource managers, partners, and the public to review progress, examine changing needs, and participate in a collaborative planning process to help manage all of Hawai‘i’s unique native wildlife. The original plan, Hawai‘i’s 2005 *Comprehensive Wildlife Conservation Strategy* (CWCS), was comprehensive in scope and went beyond the legislative mandate to fully recognize the interconnectedness of Hawai‘i’s diverse flora and fauna to create an integrated, strategic blueprint for the protection and recovery of Hawai‘i’s biodiversity. Twenty years later, much has been done, and new information and strategies can be incorporated into the plan. Although much progress has been made, the magnitude and scope of the work needed to protect and recover Hawai‘i’s unique species remain challenging. This SWAP will guide the next steps for improving the biological, cultural, and economic well-being of the islands and their people.

LEGISLATIVE MANDATE AND GUIDANCE

Historically, wildlife funding at the national level has been targeted towards species that were hunted or fished for sport and towards species federally listed as threatened or endangered. Declining populations of non-game, non-endangered species throughout the nation and the lack of stable funding to address the needs of these species led to the creation of the Wildlife Conservation and Restoration Program (WCRP) for fiscal year 2001 and the State Wildlife Grants (SWG) program (2002 to present) by the United States Congress. The authorizing legislation for the SWG program is the Department of the Interior and Related Agencies Appropriation Act, 2002 (PL 107-63). For Fiscal Year 2024, Congress provided $59,020,497 to the States and territories under the SWG program (USFWS 2024). These programs provide funds to state agencies to begin the work needed to protect and secure viable populations of the full range of wildlife and their habitats in each state. The Hawai‘i Department of Land and Natural Resources (DLNR) holds the constitutional and statutory authority to protect wildlife resources and administers the use of these funds. Hawai‘i’s share of that funding has varied between $525,000 – 590,000 per year over the past several years, and in 2024 was $590,205 (USFWS 2024).

As a condition for participation in these federal aid programs, Congress required states to develop CWCSs to be eligible for SWG funding. Hawai‘i’s CWCS was developed and

approved in 2005 to meet this requirement and updated in 2015. Congress requires that each state update its plan at least every ten years, and this current 2025 update will meet this requirement. Each state plan must include the following eight elements:

1) Information on the distribution and abundance of species of wildlife identified as "species of greatest conservation need," including low and declining populations, as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state's wildlife;
2) Descriptions of the locations and relative condition of key habitats and community types essential to the conservation of species identified in (1);
3) Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats;
4) Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions;
5) Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions;
6) Descriptions of procedures to review the plan at an interval not to exceed ten years;
7) Plans for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats;
8) Provisions to ensure public participation in the development, revision, and implementation of projects and programs.

The Hawai‘i DLNR is taking the lead to update the SWAP. As was the case in 2005 and 2015, the current update incorporates the best available information from the many existing plans and programs developed for wildlife conservation, and coordinates with other local, state, and federal agencies, non-governmental organizations, private landowners, and interested citizens to implement the best approaches to ensure the long-term conservation of Hawai‘i's native wildlife.

VALUE OF HAWAI‘I'S SWAP

The value of Hawai‘i's SWAP toward achieving its mission of conserving native species and habitats lies in its ability to integrate the needs of the full range of native species and habitats into a coordinated effort that enhances the effectiveness of broad cooperation among agencies and landowners. Much of the groundwork for this collaboration was described in the 2005 plan; this collaboration is currently demonstrated by numerous partnerships, management plans, and species recovery plans. One major value of the SWAP is that it synthesizes all this information into a strategy for the entire state.

Developing one document that covers the needs of a diverse range of species is a historical endeavor for the State. Additionally, by working with and soliciting information from a broad range of governmental agencies, non-governmental organizations, and citizens, and by working together to implement the strategy, DNLR and its partners, through the development of the SWAP, has helped to create consensus, excitement, support, and momentum to protect our native species. The first 20 years of strategic statewide conservation planning has started the process of leaving a legacy of biodiversity to our grandchildren. This update is intended to continue that progress.

By identifying important species and habitats, key threats, and objectives and strategies for their conservation, and by creating a framework to measure the effectiveness of these strategies, Hawai‘i’s SWAP lays the foundation for conservation of native wildlife and their habitats for the next 10 years. By taking a proactive approach, Hawai‘i’s SWAP also takes a fiscally responsible approach. The SWAP focuses on landscape-scale actions to aid as many species as possible and to aid not only threatened or endangered species, but more common species, providing a cost-effective alternative to recovering species populations only after they have been listed as threatened or endangered and have declined to critically low numbers. Additionally, by emphasizing measures that benefit multiple species groups and habitats in which they reside, the SWAP represents an improvement over single-species management, aiding many species for the same costs. The challenge, however, will come with the sustained implementation of the SWAP. The 2025 update to the SWAP builds on the opportunity of this plan to integrate planning for species conservation at landscape scales by developing a systematic framework to prioritize the management sites and actions that maximize benefits to the largest numbers of the most vulnerable species and habitats, per unit cost. The new approach is being developed as a pilot project for Maui Nui and is described in Chapter 8.

HAWAI‘I’S UNIQUE WILDLIFE RESOURCES AND THEIR VALUES

The SWAP is especially relevant in Hawai‘i where native species are a tremendously significant biological, cultural, and economic natural resource. The Hawaiian Islands are the most isolated archipelago in the world, situated in the middle of the Pacific Ocean more than 3,200 kilometers (2,000 miles) from the nearest continent. Because of this extreme isolation, relatively few life forms survived the rigors of the ocean crossing and reached the islands. Fewer still were able to successfully establish populations in the archipelago over its 70 million year history. Those that did, however, found a diversity of climatic and geological features that provided an enormous range of habitat types. With extremely limited gene flow from their distant, original populations, settlers rapidly adapted to their novel environments. For many such settlers, unique adaptations occurred in different populations that were isolated from one another on different islands or even in different parts of the same island. Hawai‘i provides many outstanding examples of adaptive radiation, the process by which many new species evolved from a single common ancestor in a relatively short time span.

Expressing its unique biology, the Hawaiian Islands surpasses many others in the number and variety of species that evolved from a small set of original settling ancestors. The Hawaiian archipelago is now recognized as the world's premier showcase of adaptive radiation. The diversity of unique species that have evolved in the islands is nothing less than astounding, with plants and animals that are so distinctive that the archipelago has been described as its own biogeographic province that possesses the world's highest degree of endemism (native and found no where else in the world) – 90 percent for terrestrial species and 15 to 20 percent for marine species.

The value and importance of Hawai'i's astonishing diversity of unique resources is expressed and perpetuated through the livelihood and culture of the Hawaiian people who call the archipelago home. The Kumulipo (Hawaiian origin chant), that contains the origin story of the world, begins with a coral polyp and the simplest lifeforms, continuing in organismal complexity in successive wā (eras) that include humans and our familial lineage with all living things. This origin mele (chant) details the accustomation of Hawai'i's unique species with human life. Through centuries of kilo (extensive observation) and mo'olelo (story telling), the Hawaiian people became intelligible in almost every species specific to each region and climate within the islands and were able to preserve such knowledge for generations to come. The intrinsic relationship that the Hawaiian people nurtured with their environment is the foundation for years of prosperous life and environmental achievement. The connection and understanding between human and nature is an ingrained skill in these native people, as it is for many other indigenous peoples alike, which inevitably protects and promotes the natural environments and species that provide humans with life.

The arrival of Westerners in 1778 and increasingly there after, contributed to the destruction of native habitats and introduced many novel threats, such as unknown diseases, invasive species, and industrialization, to which the archipelago's species had never been exposed. For more than 70 million years, the evolution of new species vastly exceeded losses to extinction. Yet after the arrival of Westerners to the islands, numerous species began precipitous declines to extinction. These losses include at least half of the native bird life, hundreds of unique plant species, and undoubtedly thousands of lesser-known taxa such as terrestrial insects and spiders that were lost before they were ever described. Today, with less than 0.2 percent of the land area of the United States, the Hawaiian Islands hold 28 percent of the nation's imperiled species. These include 490 taxa of plants and animals listed by the U.S. Fish and Wildlife Service as endangered or threatened, and 50 taxa that are candidates for listing (USFWS endangered species database, as of June 30, 2024).

- While so many species and their habitats are threatened, the importance and continuation of Hawai'i's unique resources is deeply rooted and understood within present day communities, their cultural practices, and long-carried traditions, such as mahi'ai (farming), lawai'a (fishing), lā'au lapa'au (medicine), hula (Hawaiian dance), as well as many others. Today, local indigenous knowledge is one guiding factor in natural resource management, while ancient Hawaiian systems and practices like kapu (system grounded in restrictions or

prohibitions), ahupuaʻa (land division management similar to a watershed system), and aloha ʻāina (care and love for the land) help to ensure prosperity and wealth for the future of the ʻāina (land) and its kānaka (people).

Hawaiʻi's native species and habitats are intricately linked to the state's ecological health, biocultural heritage, and economic prosperity. These ecosystems form the foundation of cultural practices, natural resource management, and local economies. In the 2004 *Wildlife Values in the West* survey, 71% of residents strongly agreed that it is crucial to take steps to prevent the extinction of endangered species (Dayer et al., 2006). Critical services provided by native habitats include coral reefs that protect coastlines from erosion, storms, and tsunamis, and wetlands that filter the water supply and mitigate flooding. Additionally, Hawaiʻi's native wildlife and ecosystems provide essential services to residents, including water filtration, soil stabilization, carbon storage, and recreational opportunities. A University of Hawaiʻi study estimated that the value of ecosystem services—such as water quality, habitat for native species, hunting, ecotourism, and climate regulation—ranges from $7.4 to $14 billion per year in the Koʻolau Mountains of Oʻahu alone (Kaiser & Roumasset, 2002). Economically, wildlife viewing and other ecotourism activities contribute hundreds of millions of dollars annually to Hawaiʻi's $10 billion tourism industry.

Efforts to prevent the introduction and spread of invasive species benefit both native ecosystems and the residents of Hawaiʻi. Invasive species, such as the highly flammable fountain grass (*Pennisetum setaceum*), increase the risk of catastrophic wildfires that threaten homes and native habitats. Introduced ungulates (hooved animals) degrade native forests, leading to soil erosion, sedimentation in streams, and negative impacts on nearshore reefs and fisheries. Invasive plants like Miconia (*Miconia calvescens*) provide inadequate erosion control compared to native trees, thereby threatening vital watersheds that supply billions of gallons of water. The coqui frog (*Eleutherodactylus coqui*) diminishes quality of life for residents by its loud calls and by preying on native invertebrates. Additionally, the introduction of diseases such as West Nile Virus, Dengue, and Avian Influenza raises public health and safety concerns. One of the most harmful invasive species, the little fire ant (*Wasmannia auropunctata*), poses a grave threat to Hawaiʻi's native biodiversity, disrupts tropical ecosystems, and negatively impacts human health. This invasive ant also threatens the state's tourism, agriculture, and horticultural industries by reducing agricultural productivity and damaging sales, making it one of the world's most damaging invasive species (Krushelnycky et al., 2005)

ORGANIZATION AND FORMAT OF HAWAIʻI'S SWAP

Hawaiʻi's SWAP retains the organization and format of the original 2005 CWCS, and addresses the required eight elements at multiple scales, from the statewide perspective to island-specific and taxon-specific levels. Chapter 2, **Approach and Methods**, describes the processes used to update the SWAP and addresses elements 7 and 8. Chapters 3 and 4, **State of Hawaiʻi Overview** and **Statewide Conservation Needs**, provide a statewide

overview outlining the current condition of the state's natural resources, management activities, key threats to native species and habitats, and statewide conservation goals, objectives, and strategies. Chapter 5, **Marine Conservation Needs**, and Chapter 6, **Island Conservation Needs**, go beyond the statewide perspective to location-specific threats and strategies, including those for the Northwestern Hawaiian Islands. Chapter 7, **Species of Greatest Conservation Need**, provides details on all the listed wildlife taxa in fact sheets that each contain information for one taxon, closely related groups of species, or species facing similar threats. These chapters (3-7) address required elements 1 through 5. Chapter 8, **Monitoring, Implementation, and Adaptive Management,** discusses existing and needed monitoring programs for species and habitats, and DLNR plans for future review of the SWAP, addressing elements 6 and 7. Finally, supporting sections consisting of **Appendices,** a **Glossary,** and a **Bibliography** are included to provide additional detail.

References:

Dayer AA, Manfredo MJ, Teel TL, and Bright AD. 2006. State Report for Hawai`i from the Research Project entitled "Wildlife Values in the West." Project Rep. No. 68. Project Report for Hawai`i Department of Land and Natural Resources. Colorado State University, Human Dimensions in Natural Resources Unit, Fort Collins, Colorado.

Kaiser B, Krause N, and Roumasset J. 1999. Environmental valuation and the Hawaiian economy. Honolulu: University of Hawai'i Economic Research Organization.

Kaiser, B., & Roumasset, J. 2002. Valuing indirect ecosystem services: the case of tropical watersheds. Environment and Development Economics, 7(4), 701-714.

Krushelnycky, P. D., et al. 2005. The Ecology, Policy, and Management of Ants in Hawai'i. Proceedings of the Hawaiian Entomological Society, 37, 1-25.

Lee, D. J., Motoki, M., Vanderwoude, C., Nakamoto, S. T., & Leung, P. (2015). Taking the sting out of Little Fire Ant in Hawaii. Ecological Economics, 111, 100–110. https://doi.org/10.1016/j.ecolecon.2015.01.010

Mitchell, C, Ogura C, Meadows DW, Kane A, Strommer L, Fretz S, Leonard D, and McClung A. 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. October. Department of Land and Natural Resources, Honolulu, Hawai'i. 722 pp.

Teel TL, Dayer AA. 2005. Preliminary state-specific results from the research project entitled "Wildlife values in the west 2004." Fort Collins: Human Dimensions in Natural Resources Unit, Colorado State University.

U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2003. 2001 National survey of fishing, hunting, and wildlife-associated recreation. Available at: http://www.census.gov/prod/2003pubs/01fhw/fhw01-hi.pdf (May 24, 2005).

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Available at: https://www.census.gov/prod/2012pubs/fhw11-nat.pdf (accessed June 27, 2015).

U.S. Fish and Wildlife Service. 2015. Listed Species Believed to or Known to Occur in Hawaii. Endangered species lists by state report. Available at http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=HI&status=listed (accessed June 30, 2015).

U.S. Fish and Wildlife Service. 2024. Environmental Conservation Online System (ECOS). Listed species with spatial current range believed to or known to occur in Hawaii. Available at: https://ecos.fws.gov/ecp/report/species-listings-by-state?stateAbbrev=HI&stateName=Hawaii&statusCategory=Listed

U.S. Fish and Wildlife Service. 2024. State Wildlife Grant Apportionments. Available at https://tracs.fws.gov/stateWildlifeGrantApportionments.html

CHAPTER 2: APPROACH AND METHODS

APPROACH

The State of Hawai‘i developed the first edition of its state wildlife action plan in 2005; at that time, it was called *Hawai‘i’s Comprehensive Wildlife Conservation Strategy* (CWCS). Every ten years that plan must be updated to facilitate the effective implementation of its conservation strategies and actions, and to continue receiving funds through the State Wildlife Grants (SWG) program, administered by the U.S. Fish and Wildlife Service (USFWS). Periodic updating of the plan, now called the State Wildlife Action Plan (SWAP), is a requirement for receipt of federal funding under the SWG program, and USFWS has developed guidance on requirements, process, deadlines, and content, including eight required elements. The Association of Fish and Wildlife Agencies also has developed a set of best management practices to provide guidance and examples that assist its member states in the process of developing a SWAP, and to strive for uniformity in product. These documents have guided the major revision of the Hawai‘i SWAP in 2015, and the current revision for 2025. The deadline for completion of the revision and submittal to USFWS was October 1, 2025.

As was the case in 2005, the dire status of native ecosystems in Hawai‘i and the importance of protecting all native terrestrial animals, all endemic aquatic wildlife, other aquatic species threatened with decline, and a broad range of native flora is recognized and retained as the foundation of the plan. Identifying and protecting the best remaining native habitats and intact native ecosystems is recognized as a high priority and a major focus of conservation efforts. The status of key native habitats is described in general, and the location and habitat needs of individual native species is described by species or similar taxa. On the ecological level, the SWAP takes a habitat management approach and landscape view that takes into account the complex relationships among species and their habitats and the need for change and adaptability. The approach in 2025 was to build on and synthesize information from the 2005 plan and 2015 revision, nurture and expand on conservation partnerships and cooperative efforts implemented thus far, and incorporate new information learned over the past ten years. Successful partnerships and their efforts in Hawai‘i are highlighted with the goal of enhancing and expanding existing partnerships and creating new partnerships that increase support for, and the effectiveness of, Hawai‘i’s SWAP.

The Hawai‘i Department of Land and Natural Resources (DLNR) leads the development and renewal of Hawai‘i’s SWAP, with joint cooperation by the Division of Forestry and Wildlife (DOFAW) and the Division of Aquatic Resources (DAR), the divisions primarily charged with protecting the state’s terrestrial and aquatic resources. For the previous update, DLNR staff began assembling and updating the document in 2014, but with staff shortages and turnover, decided to seek additional assistance to complete the project. In 2015, DLNR asked H. T. Harvey & Associates to assist with revising content and drafting the update. The SWAP team involved in the 2015 update includes DOFAW and DAR staff members who are directly involved in planning and implementing SWAP projects, plus H. T. Harvey & Associates ecologists who have helped to write and edit the document. The SWAP team involved in the 2025 update includes DOFAW and DAR staff members who are directly involved in planning and implementing SWAP projects.

Because so much of the 2005 and 2015 plans remains relevant, the structure and content of those documents were retained as much as possible. The content of this 2025 plan was reviewed and evaluated by the SWAP team, species experts within DLNR, management staff members who implement the plan, and staff members who use the plan for grant applications. This group worked together to identify the content and sections to be updated. Particular attention was paid to gaps in information on the Species of Greatest Conservation Need (SGCN), new threats and challenges to native wildlife, new or changing conservation strategies or management approaches or priorities, information on vulnerability assessments and the impacts of climate change, island-specific information, and the identification of important lands for conservation. Inquiries on these topics were then addressed to agency and conservation partners, species experts, and management experts via written requests and interviews.

The SWAP team prepared revisions to the plan and submitted a draft for public review to DOFAW and DAR for evaluation and approval before distribution to the public. In addition, the SWAP team developed a StoryMap that showcases the updates and key elements of the 2025 revision, enhancing public accessibility to the plan. The draft update, accompanied by the StoryMap, was made available for a one-month public review period through two virtual public information meetings. These meetings, open to the public statewide, were scheduled at various times to accommodate different availabilities. Public comments from the meetings, and any written submissions were incorporated into the final version of the plan, as deemed appropriate.

METHODS

Multiple methods were used to update Hawai‘i’s SWAP. The goal was to engage department staff, federal and state agency partners, conservation partners, technical experts, and the public to garner information to improve and update the plan, meet the required content (eight elements), and continue support for wildlife conservation efforts. The following sections describe the planning process and methods utilized to address required elements 7 and 8, coordination with federal and state agencies and public participation.

Public Participation

The DLNR revision team held two virtual public meetings — one during regular business hours and one in the evening — to maximize participation. Both meetings took place on April 29, 2025. During the April 29 sessions, the revision team presented the major revisions, and provided clear instructions for submitting comments. A Microsoft OneDrive folder containing individual SWAP chapters was made publicly accessible for download. A Survey123 form was also developed to collect feedback in addition to email submissions with tracked changes. The public comment period closed on May 31, 2025.

Resource Management Agency and Technical Expert Participation

Conservation and management of natural resources in Hawai‘i traditionally have involved strong collaborative efforts. Hawai‘i’s 2005 CWCS was developed on a foundation of input from and collaboration with conservation partnerships, paired with the incorporation of management activities and strategies already established by existing species recovery plans, location-specific management plans, and other available related plans and documents. That approach was

continued in the development of the 2015 and 2025 updates. The SWAP team invited resource agencies, managers, and technical experts to participate in the update, provide input on information gaps, and make recommendations on SGCN.

Participants in the revision included a wide range of agencies and organizations that have been integral in implementing the 2005, 2015 and 2025 plans and in conducting research on, and management of, wildlife resources. Major contributors included Bishop Museum, The Nature Conservancy of Hawai‘i (TNC), the Hawai‘i Invasive Species Council (HISC), Hawai‘i Rare Plant Restoration Group (HRPRG), Hawai‘i Watershed Partnerships, the University of Hawai‘i, the Hawai‘i Institute of Marine Biology, the National Tropical Botanical Garden (NTBG), USFWS, the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the U.S. National Park Service (NPS), and the Pacific Islands Climate Change Cooperative.

UPDATE ON CONSERVATION STRATEGY

From the methods described above, DAR and DOFAW staff and individuals and organizations with expertise on species groups or islands were contacted for input on the SWAP update. These groups along with secondary resources were used to develop updates for the following components of Hawai‘i’s SWAP.

Identifying Species of Greatest Conservation Need and Their Habitats

The Hawaiian Islands are biologically diverse, with fauna and flora characterized by high levels of endemism. Many migratory species spend key parts of their life cycles (e.g., breeding or wintering) in Hawai‘i. The 2005 CWCS and the 2015 SWAP recognized the global rarity of these species or the importance of Hawai‘i to these species and developed a broad list of Hawai‘i’s SGCN. The 2005 list included species meeting the following criteria: 1) all terrestrial indigenous animals as identified by the Hawai‘i list of indigenous species (Hawai‘i Administrative Rules Title 13 Chapter 124); 2) all aquatic endemic animals; 3) any animal taxa on the federal threatened, endangered, candidate, or species of concern list; 4) any animal protected by the U.S. Marine Mammal Protection Act; 5) any native animal on the International Union for the Conservation of Nature and Natural Resources' (IUCN) Threatened Red List or the Convention on International Trade in Endangered Species (CITES) appendices; and 6) additional animals suggested by technical experts in natural resource management agencies and informal advisory groups as deserving of attention for other reasons. Migratory species with irregular or insignificant presence in the state were not included on the list; neither were introduced species, which by their nature do not represent the natural biodiversity of Hawai‘i. Native plant species were included in SGCN list if they met the following criteria: 1) plant species federally listed as threatened, endangered, or as a candidate for listing; 2) plant species identified as targets for the Plant Extinction Prevention Program (PEPP) (plant taxa with fewer than 50 individuals extant in the wild); 3) plant species identified as important elements of native habitats; 4) endemic aquatic plants; and 5) endemic terrestrial and aquatic algae. A plant species was considered an important element of native habitat if it was a dominant or codominant member of an identified natural community according to the *Manual of the Flowering Plants of Hawai‘i* or if there was evidence

that the plant was known to be a host for native wildlife, a food source for native wildlife, or habitat for native wildlife.

Given the large number of species, for organizational and management purposes, species were grouped into the following categories: terrestrial mammals, birds (forest birds, raptors, waterbirds, seabirds, migratory shorebirds and waterfowl, and Northwestern Hawaiian Islands passerines), terrestrial invertebrates, freshwater fishes, freshwater invertebrates, anchialine pond fauna, marine mammals, marine reptiles, marine fishes, marine invertebrates, and native flora in dire need of conservation attention.

Together, the Fauna Species of Greatest Conservation Need and the Flora Species of Greatest Conservation Need compose Hawai‘i’s SGCN. The focus of the SWAP is on habitats essential to these species, threats to these important habitats, management strategies needed to preserve and expand these habitats, and mitigation and control of threats to species that are endangered or at risk of extinction. The best remaining native habitats and communities often provide the core habitat where native wildlife persist. The SWAP describes the key native habitats, their associated wildlife and threats at a statewide and island level. The Plan also describes the habitat needs of SGCN by individual species or taxa, including key habitats in need of restoration to support viable populations of SGCN. The conservation of habitat is approached at an ecosystem and landscape level to benefit multiple species.

To develop the 2025 update, the 2005 and 2015 SGCN lists were reviewed by DLNR agency staff, partner agencies, and species experts, was posted on DLNR StoryMap for public consideration and comment and was discussed at public meetings. DOFAW and DAR species experts and management staff, partner resource management agencies, other species experts, and the public provided recommendations to update the list. Species recommended for inclusion were evaluated by the SWAP team technical staff using the above criteria and were included as appropriate. Updated species accounts are identified by a footer with the date “October 1, 2025,” whereas accounts that were not revised retain the 2005 or 2015 dates.

Identifying Threats, Conservation Objectives, Research Needs, Monitoring Needs, and Priorities

A similar process was used to update the plan’s information on threats, conservation objectives, and management approaches, and to solicit new information on species vulnerability and the impacts of climate change. Hawai‘i’s SWAP team reviewed existing plans, policies, and scientific literature from local, state, and federal agencies, private landowners, non-governmental organizations, and academic researchers. The SWAP team solicited input from resource managers and biologists through conversations, emails, meetings, and interviews. Based on this input, information on threats, conservation objectives and management approaches, research needs, monitoring needs, species vulnerability assessments, and climate impacts were updated at the island level and statewide level. Issues such as funding and management challenges, public use impacts, public outreach, and coordination with other programs such as the public hunting and outdoor recreation programs were considered. At the statewide level, the seven major conservation objectives for Hawai‘i’s SGCN and their important habitats were reviewed and updated based on expert input. These objectives reflect the conservation priorities for the state without regard to the limitations of the SWG program, recognizing the need to comprehensively

identify the state's conservation priorities to enhance the possibility of implementation. Under each objective, strategies of highest priority were labeled, but no further prioritization occurred as all strategies are important priorities and implementation of these strategies depends on several factors beyond relative ecological importance, such as funding, landowner interest, community support, or technological capacity. Because conservation needs in Hawai‘i far exceed the resources available, development of strategies that increase benefits per cost for native wildlife and habitats are critical to success. Important threats and conservation strategies were highlighted for each island, for the Northwestern Hawaiian Islands, for the marine environment, and for specific taxa.

Maps/Geographic Information System Information

The SWAP team worked closely with DOFAW and DAR project managers and species experts to review and update the SWAP's information on species distributions, and areas to be managed for conservation enhancement. Spatial information was obtained from DOFAW and DAR GIS databases, as well as from published information in DOFAW and DAR records and the published reports and databases of USFWS, USGS, NPS, and NOAA.

The maps in the Chapter 7 species accounts were updated if the species account was new or revised.

Plan Review

The public review draft Hawai‘i SWAP was announced and shared through multiple venues, including the DLNR website, press releases, public meetings, and emails to interested parties. The schedule of public meetings also was publicized using these methods. The complete revised draft of new materials, such as fact sheets on terrestrial invertebrates, and the update of the SWAP Chapters, were included in the public review process.

Upon the conclusion of the public meetings and public review process, the comments were compiled, reviewed, and evaluated. Comments received during the public review process were incorporated as appropriate. The draft SWAP was then finalized and presented to DOFAW and DAR for final review. The SWAP was presented as an information item to the Board of Land and Natural Resources at a regular meeting to brief them on the plan update and process. The finalized plan was subsequently submittal to the USFWS by the October 1, 2025 deadline.

Plan Style

The writing style, document structure, and relevant content of the 2005 and 2015 plans was retained as much as possible in drafting the 2025 update. The preparers followed the approach of trying to make the document readable for a general audience. The definitions of abbreviations and the scientific names of species are provided on their first mention in each chapter. Reference materials and sources are listed at the end of each chapter and in the Bibliography, rather than in extensive citations throughout the text. As was the case with the 2005 plan, references are cited sparingly in text (much information was obtained from generally available resources like agency websites, and from personal communications with staff and species experts). The Bibliography sections in each chapter, and the master Bibliography at the end of the plan, were revised to add new sources of information used for the update but were not edited to remove older references.

References:

Association of Fish and Wildlife Agencies, Teaming With Wildlife Committee, State Wildlife Action Plan (SWAP) Best Practices Working Group. 2012. Best Practices for State Wildlife Action Plans—Voluntary Guidance to States for Revision and Implementation. Washington, D.C.

Mitchell, C, Ogura C, Meadows DW, Kane A, Strommer L, Fretz S, Leonard D, and McClung A. 2005. Hawaii's Comprehensive Wildlife Conservation Strategy. October. Department of Land and Natural Resources, Honolulu, Hawai'i. 722 pp.

U.S. Fish and Wildlife Service and Association of Fish and Wildlife Agencies. 2007. Guidance for Wildlife Action Plan (Comprehensive Wildlife Conservation Strategy) Review and Revisions. Guidance Letter. Washington, D.C.

CHAPTER 3: STATE OF HAWAIʻI OVERVIEW

Due to its extreme isolation and climatic conditions, Hawaiʻi is characterized by high levels of endemism in both its native animals and plants, with over 10,000 species found nowhere else on earth. Unique and varied habitats are also found across the islands. As a result, Hawaiʻi presents both an opportunity and challenge for conservation. While the threats to Hawaiʻi's native species persist, there has been greater awareness of the need to take action to conserve biodiversity, more assertive political will to take steps to address the problems, and wider community involvement in projects. These sentiments were evident in 2005, when the first edition of this plan was produced, and have grown even stronger today. The collective conservation efforts over the years have resulted in positive steps towards the recovery for Hawaiʻi's endangered species and towards the protection for those species that remain common so that they do not become endangered. Success stories include bringing the nēnē (*Branta sandvicensis* [Hawaiian goose]) back from the edge of extinction and establishing populations in new areas throughout the state; successfully propagating endangered forest birds like the ʻalalā (*Corvus hawaiiensis* [Hawaiian crow]) and puaiohi (*Myadestes palmeri* [small Kauaʻi thrush]) to reintroduce them back into the wild; increasing populations of honu (*Chelonia mydas agassizi* [green sea turtle]); increasing populations of koholā (*Megaptera novaeangliae* [humpback whale]); protecting important habitats such as those of Hanawī and Kahikinui on Maui; establishing new areas for wildlife conservation like Kawainui Marsh Wildlife Sanctuary on Oʻahu and Mānā Plains Forest Reserve (wetland) on Kauaʻi; constructing predator-proof fences to protect seabird breeding colonies and habitat at the Kaʻena Point Natural Area Reserve (NAR) in Oʻahu, the Kīlauea Point National Wildlife Refuge (NWR) in Kauaʻi, and the Kahakuloa Section of the West Maui NAR; and implementing community-based restoration efforts in marine managed areas throughout the state, as well as at Waimānalo streams to encourage the return of the endangered aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]). Much foundational conservation work has been accomplished. Currently, 2.2 million acres are enrolled in watershed partnerships (HAWP 2023),and 30,100 acres are protected in wildlife sanctuaries and refuges (DBEDT 2023) for the conservation of natural resources. Conservation partners have implemented programs across the state to significantly increase the acreage of priority watersheds and associated native ecosystems protected from approximately 10% in 2011 to 21% in 2024.

However, despite these success stories, Hawaiʻi continues to face major conservation challenges in protecting its over 10,000 native wildlife species. Since the 2015 SWAP was released, 56 species have been added to the state and federal threatened and endangered species lists (USFWS n.d.) and conservation efforts have achieved stable or increasing populations for only a tiny fraction of species at risk in Hawaiʻi. New ecosystem and individual species threats and stressors have arrived and must be addressed to maintain the wildlife resources of the State. This chapter provides both a social and a biological overview of the current status of natural resources in the state. In combination with Chapter 4, this chapter addresses the essential elements 1-4 of the SWAP update, at the statewide level.

SOCIAL OVERVIEW

HUMAN LANDSCAPE

Since 2014, Hawai‘i’s estimated population has increased 2.5% to approximately 1,455,271 people in 2020 (U.S. Census Bureau 2021), with the majority (1,016,508 residents, or just under 70 percent) living on O‘ahu. Approximately 9.49 million people visited Hawai‘i by air in 2023 (DBEDT 2024) compared to 8.17 million visitors in 2013. On average, there are approximately 234,000 visitors in the state per day. O‘ahu and Maui were the most frequently visited islands in 2023.

Hawai‘i has four local governments: the City and County of Honolulu (island of O‘ahu and the Northwestern Hawaiian Islands [NWHI]), the County of Kaua‘i (islands of Kaua‘i and Ni‘ihau), the County of Maui (islands of Maui, Moloka‘i, Lāna‘i and Kaho‘olawe), and the County of Hawai‘i (island of Hawai‘i). Hawai‘i also has a fifth county, Kalawao County, which does not have a separate government unit. Kalawao County covers the former Hansen’s disease settlement at Kalaupapa (Moloka‘i) and is managed by the National Park Service (NPS) under a cooperative agreement with the State Department of Health.

Tourism is the primary economic activity in the state, with more than $22.5 billion in expenditures in 2022 alone (DBEDT 2023). Real estate, rental, and leasing, accomodation and food services, and state and local government are other important industries in the state (DBEDT, 2023).

LAND AND WATER USE

According to *The State of Hawai‘i Data Book* put out by the Department of Business, Economic Development, and Toursim, approximately half of Hawai‘i’s 1.66 million hectares (4.1 million acres) are managed by the state or federal government. The largest landowner, the State of Hawai‘i, manages just under 556,700 hectares (1,375,635 acres) for watershed protection, preservation of natural resources, agricultural use, recreation, transportation, and public safety. The State Department of Hawaiian Home Lands manages an additional 80,490 hectares (198,896 acres) in trust for the present and future use by Native Hawaiians. The Office of Hawaiian Affairs manages 10,682 hectares (26,397 acres) under its legacy program for conservation of cultural and natural resources. The federal government (NPS, the U.S. Fish and Wildlife Service [USFWS], and the Department of Defense) owns or manages, through leases or cooperative agreements, more than 215,067 hectares (531,444 acres) for a variety of purposes, including conservation of natural and cultural features, protection of wildlife habitat, military support and training, and public safety. There are no lands managed by the Bureau of Land Management in Hawai‘i.

The remaining land is in private ownership. Much of this land is controlled by a few owners; four private landowners own approximately 16 percent of the land in the state (Kamehameha Schools, Parker Ranch, Robinson Family, and Pūlama Lāna‘i [DBEDT 2023]). Some of these lands are managed in cooperation with adjacent landowners for conservation purposes as part of

a watershed partnership. Modeled after the first watershed partnership that began in East Maui in 1991, there are now ten watershed partnerships on five islands, involving 74 public and private partners and covering over 890,308 hectares (2.2 million acres) of forested watershed (Hawai‘i Assoc. of Watershed Partnerships, 2024). These voluntary partnerships are the primary vehicle for conservation on private lands in Hawai‘i (as opposed to conservation easements, acquisition, or other methods).

Over the last couple of decades, major land use trends include the transition from agriculture (e.g., sugar cane, pineapple cultivation) to resort-residential development and large-lot residential subdivisions on agricultural lots. Example areas include Mānele Bay (Lāna‘i), west Maui, central O‘ahu, the north shore of Kaua‘i, and the Hāmākua Coast (island of Hawai‘i).

Unlike many other states, Hawai‘i has statewide land use classifications, with all land being zoned in one of four categories: Conservation, Agricultural, Urban, and Rural. About 48 percent of the state (798,765 hectares or 1,973,792 acres) is in the State Conservation District, a designation where development and commercial activity is generally limited with varying levels of restrictions based on the applicable subzone. While the State Department of Land and Natural Resources (DLNR) manages land in the Conservation District, the counties have primary responsibility for regulation of land uses in the other three districts. Those districts are subject to county land-use and development controls, including county community plans, zoning, and building code regulations which affect farm, residential, commercial, and industrial development and use. In addition, in Special Management Areas located along the shoreline, each county has an additional layer of regulation that provides special control of development, even for land already subject to Conservation District restrictions.

Hawai‘i withdraws about 1.4 billion gallons per day of water, with just over 600 million gallons coming from groundwater sources, and the rest from surface water diversions and withdrawals. Water consumption is about 320 million gallons per day.

Freshwater resources are managed by a number of different state and federal agencies. DLNR’s Division of Aquatic Resources (DAR) and USFWS are responsible for managing freshwater animals. The Hawai‘i Department of Health and the U. S. Environmental Protection Agency are responsible for managing water quality and pollution under the Clean Water Act and other legislation. Coastal zone management, including development permits in Special Management Areas, is the joint responsibility of the State Department of Business, Economic Development & Tourism Coastal Zone Management Program, the U. S. National Oceanic and Atmospheric Administration (NOAA), and each county that issues permits for development in its coastal Special Management Areas.

A significant portion of the state has been designated for long-term resource protection and receives varying degrees of management: 281,647 hectares (695,966 acres) are in State Forest Reserves (DLNRa n.d.), 147,710 hectares (369,000 acres) are within national parks (NPS), 44,177 hectares (109,165 acres) are in State NARs (DLNRb n.d.), 38,400 hectares (94,900 acres) are in State Wildlife Sanctuaries (DLNR), and 265,897 hectares (657,048 acres) of emergent and submerged land are in NWRs (USFWS).

Hawai‘i also has taken impressive steps for the protection of its marine resources. The state and federal governments have created the single largest fully protected conservation area in the United States and one of the largest marine conservation areas in the world, with the establishment of the Papahānaumokuākea Marine National Monument. It encompasses 1,508,870 square kilometers (587,578 square miles or 376,049,920 acres) of land and marine waters around the NWHI in the north Pacific Ocean—an area larger than all the country's national parks combined (DLNRc n.d.). In addition to that, the Hawaiian Islands Humpback Whale National Marine Sanctuary (NOAA and DLNR) protects 3,537 square kilometers (1,366 square miles or 874,240 acres) of coastal and marine waters around the main Hawaiian Islands (MHI) (NOAA n.d.).

CULTURAL SIGNIFICANCE OF NATIVE WILDLIFE

Native species in Hawai‘i play a significant role in Native Hawaiian culture. Historically, feathers from forest birds were used to make elaborate ‘ahu ‘ula (feather cloaks or capes), lei and mahiole (helmets) for the ali‘i (royalty). Whale ivory, shells, and shark's teeth were used for necklaces and other adornments. Fish and sea turtle bones were used as kitchen implements, tools, and fishhooks, while sea turtle shells and scutes were used as containers. Koa (*Acacia koa*) trees were used for wa‘a (ocean-voyaging canoes). Numerous other examples of the use of native plants and animals in both daily life and ritual exist. In present day Hawai‘i, the link between Native Hawaiian culture and native species has not been lost and continues to be practiced in belief systems, as well as in traditional practices such as gathering of native plants for hula, Lā‘au lapa‘au (traditional medicine), ho‘okupu (offerings), kuahu (altars), carving, weaving, and ceremonies.

The belief system of the Kānaka Maoli (Native Hawaiians) links people with all living and non-living things. Because all components of ecosystems were descended from Wākea (sky father) and Papahānaumoku (earth mother) and their offspring, kini akua (multitude of gods), both living and non-living elements possess spiritual qualities and mana (spiritual power). As such, Kānaka Maoli are guardians of these ecosystems and their well-being is directly related to the well-being of these ecosystems. For example, areas such as wao akua (upland forests) are sacred places, the realm of the gods. Native Hawaiian land use and resource management were often based on a unit called the ahupua‘a, which typically corresponded with what we today call watershed areas. This understanding of the link from uplands to the ocean was ahead of its time. Kapu (taboo) systems that limited certain classes or sexes from eating certain animals or fishing in certain places or at certain times may have aided in the conservation of some species (e.g., only men were allowed to eat honu (green sea turtle) and only royalty could eat certain fishes).

Native wildlife also play an important role in Native Hawaiian culture as many species such as the pueo (*Asio flammeus sandwichensis*), ‘io (*Buteo solitarius*), ‘elepaio (*Chasiempis sandwichensis*), ‘alalā (*Corvus hawaiiensis*), honu (sea turtles), and manō (sharks) are believed to be ‘aumakua (ancestors or guardians) of certain Hawaiian families. Hawaiian names have been given to many of the native wildlife and they have been incorporated into oli (chants) and mo‘olelo (stories, tales). Today, Native Hawaiian teachings play an increasing role in natural resource management, especially in areas of cultural significance like Kaho‘olawe or Wao Kele o Puna (island of Hawai‘i). The SWAP recognizes that the State and its agencies are obligated to

protect, restore, and expand the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible, in accordance with *Public Access Shoreline Hawaii versus Hawaii County Planning Commission* and subsequent case law.

MANAGEMENT OF GAME WILDLIFE SPECIES IN THE STATE OF HAWAIʻI

One of the mandates of the DLNR is to preserve, protect, and promote public hunting. This program involves the management of 15 species of game birds and six species of game mammals. The game species hunted in Hawaiʻi are not native, and game mammal species in particular may have negative impacts on sensitive native species and ecosystems. The game mammals in Hawaiʻi, all of which are ungulates, are pigs (*Sus scrofa*), goats (*Capra hircus*), sheep (*Ovis aries*), mouflon sheep (*Ovis musimon*), Columbian black-tailed deer (*Odocoileus hemionus columbianus*), axis deer (*Axis axis*), and, to a lesser extent, feral cattle (*Bos taurus*). Game animals—game mammals in particular—are a valued source of food and subsistence in many communities in Hawaiʻi. They also are a valued source of outdoor recreation for residents and visitors, and hunting is often part of an individual, family, and cultural identity. Hunting game animals also can be a source of employment and livelihood for some and has an important role in many people's lives.

DLNR manages game resources under the federal Wildlife Restoration Program (also known as the Pittman-Robertson, or PR, Program). This program is administered by the Division of Forestry and Wildlife (DOFAW) and supports and facilitates hunting on public and private lands by providing a structured program that promotes and encourages participation. The program aims to provide opportunities for public hunting that are compatible with statutory mandates for the conservation of biodiversity and the goals of this SWAP, including directing hunting toward less ecologically sensitive areas and facilitating hunter access to sites where recreational hunting can help to control game mammal populations. Hawaiʻi's current Game Management Program plan is available on the DOFAW website. The plan includes projects for monitoring hunter activities, monitoring game population status, leasing land to provide additional areas for public hunting, improving game habitat, controlling alien predators to increase game populations in suitable habitats, developing facilities and infrastructure, and gathering and analyzing data. These and other activities are all aimed at maximizing hunter recreational opportunities and staff efficiency, within budgetary constraints, and are carried out in conjunction with other DOFAW mandates and in compliance with relevant state and federal laws and regulations.

Most states have native wildlife species that are designated as game animals and hunted and that may be included in their wildlife action plan. Some game species, because of habitat loss, predation, or overutilization, may be in need of conservation actions and could be identified as species of greatest conservation need and become a major focus of a state's plan. That is not the situation in Hawaiʻi, where game animals are not native wildlife. Balancing the dual and often conflicting mandates to conserve native wildlife and their habitats while providing for public hunting involves managing indigenous wildlife and endangered species in the areas that are essential for their long term viability, controlling or eliminating ungulate populations in places necessary to sustain and conserve native wildlife, and managing game programs in appropriate

areas that are not essential for sustaining native wildlife and ecosystems. The focus of this plan is the conservation of native plants, wildlife, endangered species, and their ecosystems.

PUBLIC SUPPORT FOR CONSERVATION

Public Perspectives on Wildlife

Based on a 2018 a survey for the "America's Wildlife Values Report," it is clear that Hawai'i respondents value our environment and unique species. Seventy six percent of Hawai'i respondents agree that we should strive for a society that emphasizes environmental protection over economic growth, and only 15 percent agree that private property rights are more important than protecting declining or endangered fish and wildlife. Those surveyed also believe in including communities as partners, with 68 percent agreeing that local communities should have more control over the management of fish and wildlife. They are supportive of the work of the Department of Land and Natural Resources, with 70 percent of respondents reporting they share similar values with their state fish and wildlife agency and 58 percent expressing trust in their state and wildlife agency either "most" or "all" of the time to do what is right for fish and wildlife management in Hawai'i.

Reflecting this strong public support, SB 849 (2025) designates the ʻio (Hawaiian hawk) as a protected indigenous species, strengthening its legal protections under Hawai'i's conservation laws. The bill prohibits the intentional taking, harming, or killing of the ʻio and establishes penalties including a minimum $250 fine or up to one year of imprisonment for a first misdemeanor offense, and a class C felony with at least a $1,000 fine for subsequent violations. The bill also increases fines and penalties for harming any indigenous species—whether wildlife, aquatic life, or land plants—demonstrating the Legislature's commitment to upholding the conservation values supported by the majority of Hawai'i's residents.

In 2011, an estimated 22 percent of the population participated in some type of wildlife-associated recreation (e.g., fishing, hunting, wildlife watching). Expenditures for wildlife-watching activities in Hawai'i, by both residents and visitors, is estimated at $669 million dollars and at $993 million for all types of wildlife-related recreation (U.S. Department of the Interior 2011). A large proportion of the $13 billion dollar tourism sector is indirectly related to the viewing of marine wildlife, with one study estimating that snorkeling and diving alone generate $364 million dollars each year in added value for the State.

The DLNR Forestry & Wildlife website was revised in 2021 to provide additional reference and education information about wildlife and other topics. For the section of the website dedicated to wildlife, page views increased by roughly 480% from 2019 to 2023.

In the past ten years, new programs have evolved in which the public can pitch in and show its support for wildlife and natural resource conservation. In 2021 DLNR Forestry & Wildlife added an online donation portal to the portion of its website dedicated to the Native Ecosystems Protection & Management program. In 2016 DLNR Forestry & Wildlife, as the administrative host of the interagency Hawai'i Invasive Species Council, launched the 643pest.org platform to engage the public in reporting invasive species in Hawai'i. The reporting website links to a database that facilitates the processing of reports to various agencies with response authority.

The platform is marketed as the online component to the existing 643-PEST telephone hotline managed by the Hawai‘i Department of Agriculture. The DLNR conservation enforcement branch created the Makai Watch program to engage local communities to help protect local natural resources. The Makai Watch recruits community members as volunteers to help manage marine resources by promoting education, monitoring, and compliance with rules. The Makai Watch approach is based on the idea that people who use, deal with, or live close to natural and cultural resources are in the best position to facilitate a greater understanding of the nature of the area. Community members are the ‘eyes and ears’ that look out for their resources, and their direct involvement reduces inappropriate uses of those resources. In 2024, 18 communities on Kauai, O‘ahu, Maui, and Hawai‘i participated in the program. This program recognizes that the people who use a resource ultimately are responsible for its long-term health.
DAR has worked with local coastal communities to establish community-based subsistence fishing areas (CBSFA, also referred to as community-based marine managed areas) throughout the state. There are currently three CBSFA--Hā‘ena, Kaua‘i, Kīpahulu, Maui, and Miloli‘i, Hawai‘i Island--established by statute and administrative rules.

Funding for Conservation

Hawai‘i ranks near the bottom (48th) in the nation for state spending on fisheries and wildlife, though the state forest reserve system ranks 11th in size and the state boasts the largest marine protected area in the United States. In Fiscal Year 2024, the State Department of Land and Natural Resources was allocated $262.8 million of the state’s $18 billion dollar executive budget (Dept. of Budget and Finance 2022). With slightly more than one percent (1.46%) of the state’s budget, the Department must manage the state’s marine and freshwater resources (e.g., commercial fisheries, aquaculture, aquatic resources protection, recreational fisheries), protect and recover threatened and endangered species, manage state-owned lands (both those for lease and those set aside as forest reserves, natural areas, plant and wildlife sanctuaries, and parks), manage statewide ocean recreation and coastal areas programs (i.e., boating), oversee permitting associated with the Conservation District, implement the state’s historic preservation mandates, maintain the statewide recording system for title to real property, and enforce the Department’s rules and regulations.

A conservative estimate of the amount of state funds actually dedicated solely to conservation of native wildlife and their habitats is approximately $50 million for Fiscal Year 2024.. Though no comprehensive cost estimates exist for the protection and recovery of wildlife in Hawai‘i, the inadequacy of current funding levels is obvious based on costs included in recovery plans for endangered species. For example, the 2006 Revised Recovery Plan for Hawaiian Forest Birds estimates the cost of recovering 21 species of forest birds at nearly $2.5 billion dollars over 30 years—an annual cost ($83 million) that is more than twice the wildlife conservation budget for the entire DLNR. Costs associated with the recovery for endangered whales, sea turtles, seabirds, waterbirds, terrestrial insects, snails, and plants would add tens of millions more per year. The State switched its funding base for the natural area reserve and watershed protection program from a dedicated special fund to annual general fund appropriations in 2015. It is yet to be seen whether the long-term support needed to fund natural resource conservation can be maintained and increased to meet the needs identified in this plan when these needs compete with other general fund programs such as public health, public safety, and education.

Funding levels from federal sources are also inadequate and inequitably apportioned. In 2014, with 28 percent of the nation's imperiled species, Hawai‘i received 16 percent of the national appropriation under the Endangered Species Act, Traditional Section 6 Program and just three percent of the Non-traditional Grant Programs. Hawai‘i received only one percent of the national appropriation under the State Wildlife Grants Program, which totaled $590,205 in 2024. In recent years, through related competitive grant programs within the Section 6 program, additional funding for conservation on private lands and for land acquisition has become available. Though Hawai‘i has been successful in securing a portion of these grants (3% in 2014) because of extensive and progressive partnerships with landowners, lack of sufficient overall funding to implement recovery programs, especially on state lands, leaves both critically endangered species and lesser known native species (e.g., terrestrial invertebrates) with little support. An analysis of federal funding levels in 2008 found that, on average, endangered bird species on the mainland received 15 times more funding than endangered Hawaiian birds. Hawaiian birds received only 4.1 percent of recovery funding from all sources even though they represent nearly a third of listed endangered birds (Leonard 2008).

Clearly, unprecedented efforts are needed to increase the funding base for the protection of Hawai‘i's wildlife and their habitats, and comprehensive and integrated strategies are needed to ensure that limited funding for wildlife conservation is used wisely and for maximal benefit.

BIOGEOGRAPHICAL OVERVIEW

The Hawaiian archipelago is composed of eight main islands and approximately 124 smaller islands, reefs, and shoals spanning over 2,400 kilometers (1,500 miles) that vary in size from fractions of hectares to thousands of square kilometers. The archipelago was formed over the last 70 million years through volcanic eruptions from a relatively stationary hotspot beneath the slowly moving seafloor. The island of Hawai‘i is the youngest island, with island age increasing to the northwest as the Pacific plate carries the older islands away from the hotspot. Millions of years of erosion, subsidence, and reef building resulted in the formation of the atolls which form the NWHI and the submersion under the sea surface of the seamounts which used to be islands.

Located over 3,200 kilometers (2,000 miles) from the nearest continent, Hawai‘i is the most remote island chain in the world. Despite its relatively small area (less than 1.7 million hectares or 4.1 million acres), an elevation range from sea level to 4,205 meters (13,796 feet) results in Hawai‘i containing all the major known ecological zones. With a wide temperature range due to the elevational gradient and with average annual rainfall ranging from less than 40 centimeters to over 1,200 centimeters (15 inches to over 480 inches) per year, Hawai‘i displays most of the earth's variation in climatic conditions. Finally, Hawai‘i possesses many natural wonders: the most active volcano in the world, the wettest place on earth, the tallest sea cliffs, and extensive coral reefs.

HABITATS

The Hawaiian Archipelago possesses the full range of habitats, from wet forests to extremely dry coastal grasslands. Due to evolution and extreme isolation, these native habitats were characterized by high levels of plant endemism. With the arrival of humans and consequent

introduction of invasive plants and animals and development, many of these habitats have declined. For example, 90 percent of Hawai‘i’s dryland habitat, 61 percent of the mesic habitat, and 42 percent of the wetland habitat are estimated to be lost, with less than 40 percent of the land surface covered in native vegetation today. Similarly, much of the habitat for freshwater species has declined, with 58 percent of the perennial streams in the state having been altered in some way. The following section provides specific information on terrestrial, freshwater, and marine habitats, including associated wildlife and major threats.

Terrestrial Habitats

Distribution of terrestrial habitat in Hawai‘i is heavily influenced by elevation, climate, and substrate. Five elevation zones are recognized: alpine (typically found over 3,000 meters [10,000 feet]); subalpine (typically found between 2,000 and 3,000 meters [6,500 to 10,000 feet]); montane (typically found between 1,000 and 2,000 meters [3,000 to 6,500 feet]); lowland (typically found between 0 and 1,000 meters [0 to 3,000 feet]); and coastal (typically found along the coast at low elevations). Further, three general moisture categories are recognized: dry (typically receive less than 125 centimeters (50 inches) of rainfall each year); mesic (typically receive between 125 to 250 centimeters (50 to 100 inches) of rainfall each year); and wet (generally receive over 250 centimeters (100 inches) of rain per year).

Using the elevation zones and moisture categories, the state can be classified roughly into nine terrestrial habitat types: alpine communities, subalpine communities; montane wet communities; montane mesic communities; montane dry communities; lowland wet communities; lowland mesic communities; lowland dry communities; and coastal communities. These nine habitat types can be refined further based on the dominant plants and structural characteristics of the vegetation. Although Hawaiian communities or habitats have been classified in a number of different ways, the *Manual of the Flowering Plants of Hawai‘i* (Wagner, 1999) recognizes 33 native forest communities, 36 native shrubland communities, eight native grassland communities, and four native herbland communities. Subterranean systems form a tenth habitat type defined by geology rather than elevation zones and moisture. A short description of each of these habitats, associated wildlife, and primary threats is presented below.

Alpine communities

Alpine communities are found only on the islands of Hawai‘i (Maunakea and Maunaloa) and Maui (Haleakalā). Conditions are dry, vegetation is sparse, and the soil is predominantly cinder or barren gravel. Native species include terrestrial invertebrates, including the Maunakea and Maunaloa wēkiu bugs (*Nysius wekiuicola* and *N. aa*), wolf spiders (*Lycosidae*), and a few plants, most notably the ‘āhinahina or silversword (*Argyroxiphium sandwicense*). This specialized habitat is at risk in Hawai‘i as a result of increasing levels of human disturbance as well as the cumulative impacts of a warming climate. There has been relatively little invasion by alien plants, but introduced alien insects, including the Argentine ant (*Linepithema humile*), are a growing problem.

Subalpine communities

Subalpine communities are found only on the islands of Hawai‘i and Maui. Mainly located above the inversion layer, these communities are predominantly dry habitats, but subalpine mesic and wet habitats are found on East Maui and a subalpine mesic habitat is

found on Maunaloa, Hawai‘i. Dominant plants include māmane (*Sophora chrysophylla*), naio (*Myoporum sandwicense*), and ‘ōhi‘a (*Metrosideros polymorpha*) trees, ‘a‘ali‘i (*Dodonaea viscosa*), ‘ōhelo (*Vaccinium* spp.), and pūkiawe (*Styphelia tameiameiae*) shrubs, and *Deschampsia nubigena* grass. Notable native species present include the palila (*Loxioides bailleui*), other endemic forest birds, seabirds, such as the ‘ua‘u (*Pterodroma sandwichensis*) and ‘akē‘akē (*Oceanodroma castro*), nēnē (Hawaiian goose), and terrestrial invertebrates such as the koa bug (*Coleotichus blackburniae*), Haleakalā black-faced bee (*Hylaeus takumiae*), and ‘āweoweo longhorn beetle (*Plagithmysus looki*). Introduced ungulates, including mouflon sheep (*Ovis musimon*), pigs (*Sus scrofa*), goats (*Capra hircus*), sheep (*Ovis aries*), and cattle (*Bos taurus*), are the primary threat to these communities, browsing the native vegetation and spreading invasive plant species.

Montane wet communities

- Montane wet communities occur on the islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i. A diverse variety of montane wet communities exist, including bogs, densely vegetated shrublands and forests, cliff faces, and steep valley walls. These communities typically exhibit a richer understory development than montane dry or mesic systems. Important native plants include the ferns hāpu‘u (*Cibotium* spp.) and ‘ama‘u (*Sadleria* spp.), sedges (*Carex* spp.), *Oreobolus furcatus* (found in many bogs), and the ‘ōhi‘a tree. Notable native wildlife species include critically endangered forest birds such as the puaiohi (*Myadestes palmeri*) and kiwikiu (*Pseudonestor xyanthrophrys*) Hawai‘i’s only land mammal, the ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]); pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]); ‘io (*Buteo solitarius* [Hawaiian hawk]); and a spectacularly diverse invertebrate fauna, including hundreds of critically-imperiled kāhuli (terrestrial snails) and insect species such as pinapinao (*Megalagrion* spp. [damselflies]), picture-winged pomace flies (*Drosophila* spp.), long-legged flies (*Campsicnemus* spp.), nalo meli maoli (yellow-faced bees, *Hylaeus* spp.), and ground beetles (*Blackburnia* spp. and *Mecyclothorax* spp.). Montane bog communities are particularly vulnerable to rooting pigs. Feral pigs contribute to the spread of habitat-modifying invasive plants such as strawberry guava (*Psidium cattleianum*) and Himalayan ginger (*Hedychium gardnerianum*) and mosquito breeding habitat in montane wet forest. While these forests were once considered a disease refuge for forest birds, climate change has the accelerated upslope invasion of mosquito-borne diseases, which threaten the persistence of many endangered birds. Logging and then conversion to pastureland has also resulted in the loss of montane wet forest.

Montane mesic communities

Montane mesic communities occur on the islands of Kaua‘i, Maui and Hawai‘i. ‘Ōhi‘a, koa, olopua (*Nestegis sandwicensis*), and a‘e (*Sapindus saponaria*) are dominant trees, and the understory is composed of diverse trees, shrubs, sedges, and ferns. Notable native vertebrate species include forest birds, such as ‘akiapōlā‘au (*Hemignathus wilsoni*), pueo, and ‘io and ‘ōpe‘ape‘a. These communities contain the highest diversity of terrestrial arthropods, including picture wing pomace flies, death-watch beetles (*Mirosternus* spp. and *Xyletobius* spp.), longhorn beetles (*Plagithmysus* spp.), flat wasps (*Sierola* spp.), case-making moths (Hyposmocoma spp.), and leaf bugs (*Orthotylus* spp.) Conversion to

pastureland, the spread of introduced grasses, browsing by feral goats, sheep, and pigs, fires, clearing for commercial tree planting, and the spread of mosquito-borne disease have contributed to the loss and degradation of this habitat.

Montane dry communities

Montane dry communities are found on the leeward slopes of East Maui and of Hualālai, Mauna Loa, and Mauna Kea on Hawai‘i. Substrates are typically cinder or ash or weathered lava flows. Dominant plants include ‘ōhi‘a, māmane, naio, ‘a‘ali‘i, lovegrass (*Eragrostis atropioides*), and pili grass (*Panicum tenuifolium*). Notable native vertebrates include pueo, the ‘ōpe‘ape‘a (Hawaiian hoary bat), and forest birds. Terrestrial invertebrates include a unique community of nalo meli maoli (yellow-faced bees) such as *Hylaeus paradoxicus* and *H. dimidiatus*, and a high diversity of longhorn beetles. The primary threats to these communities are invasive plants, particularly fountain grass (*Pennisetum setaceum*), and grazing by feral ungulates, including goats, sheep, and mouflon.

Lowland wet communities

Lowland wet communities are generally found on the windward side of every island except Ni‘ihau and Kaho‘olawe. Dominant plants include ‘ōhi‘a and koa trees and mamaki (*Pipturus albidus*) and uluhe (*Dicranopteris linearis*) shrubs, and hāpu‘u ferns are an important component of the native understory. Notable native wildlife includes the loulu and ‘ohe‘ohe picture-wing flies (*Drosophila mulli* and *D. ciliaticrus*), waterbirds, migratory shorebirds and waterfowl, pueo, ‘io, and the ‘ōpe‘ape‘a. Threats include the establishment and spread of invasive plants, especially Himalayan ginger and strawberry guava, invasive ants, and degradation of the understory by feral pigs. Many native forest birds that would otherwise occur in these forests have been extirpated by mosquito-borne disease. A new threat is Rapid ‘Ōhi‘a Death or ROD caused by two newly discovered fungi-- *Ceratocystis lukuohia* and *Ceratocystis huliohia*. The species name *C. lukuohia* contains the ‘Ōlelo Hawai‘i word ‘luku’ meaning “massacre, slaughter, destruction,” (Ulukau n.d.) as this aggressive fungal disease can kill up to 50 percent of ‘ōhi‘a in a stand. *C. lukuohia* is currently establishedon Hawai‘i island and Kaua‘i, but there is fear it will be spread to other islands, putting their ecosystems at risk. The less agressive *C. huliohia* was detected and removed from one location on Maui and occurs at a dozen locations on O‘ahu.

Lowland mesic communities

Lowland mesic communities are found on every island except Kaho‘olawe. Most lowland mesic communities have been converted to agricultural or ranching use or lost due to logging, and the remaining native communities are threatened by a number of invasive plant species, including guava (*Psidium guajava*), strawberry guava, molasses grass (*Melinis minutiflora*), firetree (*Morella faya*), Christmas berry (*Schinus terebinthifolius*), silk oak (*Grevillea robusta*), *Eucalyptus* spp., guinea grass (*Megathyrsus maximus*), and beardgrasses (*Andropogon virginicus* and *Schizachyrium condensatum*). Wildfires, invasive ants, feral ungulates and introduced game animals, particularly goats, pigs, and axis deer, also contribute to the degradation of these communities. In the remaining lowland mesic communities, dominant plants include kāwelu (*Eragrostis variabilis*),

pūkiawe, ʻaʻaliʻi, and ʻūlei (*Osteomeles anthyllidifolia*) shrubs, and koa, ʻōhiʻa, and lama (*Diospyros sandwicensis*) trees. Notable native wildlife species include waterbirds, migratory shorebirds and waterfowl, ʻōpeʻapeʻa, nalo meli maoli, and picture-wing flies. Rapid ʻŌhiʻa Death is a threat in this habitat.

Lowland dry communities

Lowland dry communities occur on the leeward sides of all eight of the MHI, as well as the windward side of Hawaiʻi in the Puna and Kaʻū districts. Dominant vegetation includes ʻōhiʻa, lama, olopua, and wiliwili (*Erythrina sandwicensis*) trees, ʻaʻaliʻi shrubs, and pili grass. Notable native wildlife includes nalo meli maoli, waterbirds, migratory shorebirds and waterfowl, and forest bird species which have apparently developed immunity to avian malaria and pox. Most lowland dry communities have been converted to urban and residential use or degraded by fire, grazing, invasive ants, and invasive plants, especially fountain grass, beardgrass, guinea grass, and natal redtop (*Rhynchelytrum repens*). These invasive plants now dominate some lowland dry areas and constitute a major fire threat.

Coastal communities

Coastal systems are communities subject to marine influences and include dry, mesic and wet communities. In addition, this habitat includes anchialine ponds, which are areas where fresh and saltwater mix through underground connections. These communities are found on coral atolls and island remnants in the NWHI, along coastlines of the major islands in the MHI, and on the many offshore islands in the MHI. Naupaka kahakai (*Scaevola sericea*) is an important native shrub throughout the coastal system. Notable native wildlife includes nalo meli maoli, seabirds, migratory shorebirds, and marine animals that use the coastal area for basking and nesting, such as the Hawaiian monk seal (*Monachus schauinslandi*) and honu (green sea turtle). Primary threats include conversion to residential development, introduction of invasive plants (e.g., mangrove [*Bruguiera gymnorrhiza* and *Rhizophora mangle*], pickleweed [*Batis maritime*], Indian pulchea [*Pulchea indica*], and ironwood [*Casuarina equisetifolia*]), invasive insects (including little fire ants [*Wasmannia auropunctata]*, off-road vehicle activity, and arson. Compounding the issues, a changing global climate is resulting in rising sea levels, which accelerates widespread coastal erosion by increasing storm frequency and wave intensity. Such changes will also further salt water intrusion, which irreversibly alters salinity levels in delicate anchialine ecosystems.

Subterranean systems

Subterranean cave and lava tube ecosystems in Hawaiʻi contain remarkable natural and cultural resources. Some of Hawaiʻi's most unique native invertebrates such as the Kauaʻi cave wolf spider (*Adelocosa anops*), the Kauaʻi cave amphipod (*Splaeorchestia koloana*) and ʻōhiʻa root plant hoppers (*Cixiidae*) are associated with lava tube and cave ecosystems. These habitats can be found from higher elevations down to the coast throughout the MHI. Cave ecosystems are divided into five distinct zones (entrance, twilight, transition, dark, and stagnant air zones) with each characterized by different vegetation and animals. Cave ecosystems are impacted by above-ground land

management practices. Primary threats include loss of native vegetation above caves. Vegetation removal depletes underground vegetative growth of roots, a primary nutrient input into cave systems, and a resource which many invertebrate species depend on. Ground-disturbance associated with the construction of above-ground infrastructure can collapse and/or fill caves with debris, eliminating interstitial habitat, and change hydrological processes. Such activities also result in the spread of new or existing pest species into cave ecosystems. Degradation of habitat by human visitation and trampling is also a risk to cave fauna and habitat integrity. All of the aforementioned activities also threaten cultural resources which have been preserved in many cave systems.

Aquatic Habitats

Aquatic habitats ecologically link together most of the terrestrial habitats. Over geologic time, the flow of water and wind have carved the topography of the mountains and valleys creating microhabitats in which many plants and animals have evolved and adapted. The flow of water that rains down on the high mountaintops transports nutrients, organic matter (energy), and water down through the various forested and shrubland habitats into estuaries and wetlands at low elevations and then finally into the sea. This organic energy from dead plants and animals fertilizes the growth of other plants and animals in lower elevation habitats, while the streams and groundwater flow play an important role in providing water for plants and animals throughout the ecosystem. Many of Hawai‘i’s native freshwater aquatic animals migrate between the ocean, estuaries, and upper reaches of streams as part of their life cycle.

Streams

Small streams usually join together to form larger and larger streams and rivers until finally the largest stream in a system enters the ocean. A map of the smaller streams that are interconnected with the single bigger stream usually looks like the branches on a tree. This interconnected network of streams and the adjacent land areas share much of the same nutrients, energy, and water and often becomes the home area of populations of living things. This network and the habitat it encloses is called a watershed, similar to the traditional Hawaiian land division of the *ahupua‘a*. Activities or threats that affect one part of this interconnected system will affect some other part or the whole of the system. Thus, to effectively protect watersheds, often the entire *ahupua‘a* must receive adequate protection.

Hawaiian streams, or sections of streams, are either perennial or intermittent. Perennial streams flow year-round; however, some flow continuously, discharging into the ocean, while others are interrupted, discharging into the ocean only seasonally. Perennial streams are important to most of Hawai‘i’s freshwater fauna, because these species depend on the ocean for part of their larval life stage and would not survive without this connection to the sea. Perennial streams are habitat to all of Hawai‘i’s freshwater fauna including five native stream fishes or ‘o‘opu, invertebrates including mollusks and shrimps, algae, and mosses. Intermittent streams, or sections of streams, flow only seasonally, typically with high rainfalls, when these streams may reach the ocean. These streams may have water in their upper sections year-round, while their lower sections are dry. Although some recent studies suggest that viable populations of stream animals can

survive in intermittent streams, intermittent stream fauna primarily consists of oligochaete worms, several crustaceans, and algae.

The biology and ecology of stream systems also are defined by the "order" of a stream. First order streams are the smallest initial streams at the highest altitudes in an *ahupua'a*. They are often in the steepest gradient areas and have the coolest waters with least amounts of nutrients and energy. Many freshwater species cannot inhabit the upper parts of these streams in Hawai'i because of these limiting factors. Some native fishes, however, are highly evolved at climbing waterfalls. Second order streams are stream sections downstream from the junction of two first order streams and so on down to third or fourth order stream sections. Hawai'i does not have many streams higher than fourth order because of the steep terrain and short distance to the sea. Lower order streams in flatter areas have more nutrients and energy in them and are bigger and easier to inhabit for stream fishes and invertebrates. These areas also have the highest number of threats from sedimentation caused by grazing animals at higher elevations, nearby development, water diversions and dams, channelizing or concreting of the stream bottom and sides, and introduced gamefish. Streams in disturbed areas also do not typically have native vegetation along their banks, reducing shade, nutrient inputs from decaying plant matter, and shelter provided by tree roots. In some streams, non-native vegetation adjacent to streams provides excessive shading and nutrient input, leading to declines in native aquatic organisms. These threats are often most acute in the middle sections of streams as the areas nearest the ocean receive greater protection through zoning and coastal zone management requirements.

Estuaries

As streams near the ocean, the streambed often becomes dominated by finer grain sediments as salty seawater intrudes with the tides. The area where seawater from the ocean mixes with freshwater is an estuary. Estuaries in Hawai'i typically have a unique group of species that can tolerate the variable conditions and the large amount of sediments and sand in the water and on the bottom. Too much sediment, however, can be harmful even here. In addition, many marine animals also can inhabit these areas where the salinity is not too low, so the overall diversity of species is higher. Many of the same threats occurring in the middle sections of streams such as sedimentation, development, and invasive species occur in estuaries as well, though coastal zone regulations provide some degree of protection. Since estuaries are often calmer areas of water, boat harbors and other sources of human disturbance are often concentrated in these areas.

Sandy Bottom

The amount of sediment moving into the open ocean largely determines the presence of various types of marine habitats in Hawai'i. Too much sediment limits the presence of corals, so coral reefs can only occur away from estuaries. Instead of coral reefs, these areas close to estuaries are dominated by various sandy bottomed habitats that are rich in animals that live in the sand, like many worms or shelled animals, and in fishes like rays and flatfishes that feed in soft sediment.

Coral Reefs

Coral reefs develop in most of the rest of the shallow water fringe around the high islands. This results in the formation of "fringing reefs" that have coral growth near the surface of the water, very close to shore, with limited shallow water lagoons inshore of the reef. Reefs in areas with relatively recent lava flows, such as on the island of Hawai‘i, have poorly developed fringing reefs. Kāne‘ohe Bay on O‘ahu and a small area of Kaua‘i also have "barrier reefs," where the development of coral occurs further offshore. There is a more extensive shallow water lagoon inshore of the barrier reef that has a higher degree of development of what are called patch reefs, or small sections of coral interspersed in sandy habitat in waters of one to ten or 20 meters (three to 65 feet) deep. Many of the low islands in the NWHI are "atoll reefs." These reefs are the tops of drowned and submerged volcanic peaks that result in a ring of coral that can be many miles in circumference. They may or may not surround a small sandy island or islands somewhere inside a very extensive lagoon that also usually contains numerous patch reefs. Mokupāpapa or Hōlanikū (Kure Atoll) and Holoikauaua or Manawai (Pearl and Hermes Reef) are classic examples of atoll reefs. Coral reefs are threatened by human impacts, invasive species, disease and global climate change.

Bathypelagic, Mesopelagic, and Pelagic

Because the MHI are the tops of steep volcanic peaks, waters off these islands become very deep very quickly so that even within the 5 kilometer (3 mile) boundary of state waters, the water is thousands of meters or feet deep. In this bathypelagic or deep zone, the waters are cold and dark, with many unusual fishes and invertebrates about which little is known. In the mesopelagic or middle realm (waters of only around 100 to 300 meters (330 to 1,000 feet) depth), there is some small amount of light and the species that occur here are often different from both the shallower and deeper species. Many species in this zone are important food sources for marine mammals in Hawai‘i. The pelagic or nearshore waters on the surface above these deep water areas are home to some of the most desirable gamefishes including ono, mahimahi, ‘ahi (tunas), and marlins, which increases the importance of this habitat. Offshore aquaculture is a potential new threat to these areas.

Additional Marine Habitats

Tidepools and rocky beaches provide important habitat for many of Hawai‘i's invertebrate species and larvae of many fishes. Desirable species including ‘opihi (limpets) and some shelled invertebrates occur here. Some species are adapted to the strong wave action in these areas. Seagrass beds provide foraging areas for sea turtles as well as habitat for endemic invertebrates. Beaches are essential nesting grounds for sea turtles as well as areas where monk seals haul out, give birth, and protect and feed young. Threats to these habitats include direct and indirect human impacts due to proximity to the coast.

All of the marine ecosystems can be affected by pollution or other activities originating onshore so the conservation management of the terrestrial habitats has relevance to the health of the marine systems. Additional information on marine habitats is found in Chapter 5.

NATIVE TAXA

Because of the extreme isolation and distance, relatively few life forms successfully colonized the Hawaiian Archipelago over its 70-million year history. Those species that did, however, found habitats that varied enormously over very short distances. As a result, the archipelago displays some of the world's premier examples of evolution, with the creation of countless new lineages of plants and animals through natural selection and adaptive radiation. Rates of endemism (i.e., percent of species found nowhere else on earth) are typically 99 to 100 percent for terrestrial insects, spiders, and land snails, 90 percent for plants, more than 80 percent for breeding birds, and 15 to 20 percent for aquatic fauna.

Although thousands of Hawaiian species have yet to be described, the estimated number of indigenous species is thought to include more than 14,000 terrestrial, 100 freshwater, and 6,500 marine taxa. Among these are an estimated 10,000 species found nowhere else on the planet, and extreme examples of rapid evolution are found among Hawai‘i's birds (especially passerines), insects, spiders, land snails, plants, and fishes. The Hawaiian honeycreepers (family: Fringillidae) are often cited as a dramatic example of this process, with at least 40 species having evolved from a single common ancestor. This group of birds diversified to fill niches often occupied by separate families on continental environments and at first glance, bear little resemblance to one another.

Even more prodigious are the innumerable groups of Hawaiian invertebrate species, most which have also displayed dynamic natural radiations from single founders. For example, among the cosmopolitan family of drosophilid (Diptera: *Drosophilidae*) flies, there are nearly 600 described Hawaiian species, as well as hundreds of undescribed species, all of which evolved from perhaps two colonists. Land snails boast equally impressive radiations and many other explosive radiations are found among terrestrial arthropod groups: more than 400 species of *Hyposmocoma* (Lepidoptera: Cosmopterigidae) moths, 400 species of *Sierola* (Hymenoptera: Bethylidae) wasps, and 161 species and 19 subspecies of *Proterhinus* (Coleoptera: Belidae) beetles are but a few examples.

This rapid evolution produced many species with unusual characteristics or life-histories, including two dozen flightless birds (now extinct), mintless mints, flightless flies, stinkless stink bugs, blind big-eyed spiders, carnivorous caterpillars, diadromous fish that scale 300-meter (1,000-foot) waterfalls, and nectarivorous birds with bills superbly adapted to the corollas of particular flowering plant species.

Beginning with the settlement of Polynesians in Hawai‘i around 1,600 years ago and accelerating with the arrival of Westerners following Captain Cook's European exploration of the islands in the 1780s, humans have taken a dramatic toll on the biota of the Hawaiian Islands. With humans came the destruction of native habitats for agriculture, aquaculture, and development, and the introduction of perhaps thousands of alien species. The effects of these novel pressures on the native biota of the islands resulted in rapid declines and extinctions among hundreds if not thousands of native species. Some species were exterminated by Polynesians for food, especially species such as flightless birds which would have been relatively easy to capture. Some species

were lost because of degradation or destruction of their unique habitats. Others persisted in more remote areas only to be weakened or overcome by non-native predators such as cats (*Felis catus*), rats (*Rattus* spp.), and mongooses (*Herpestes auropunctatus*). Native forest birds were virtually eliminated from lowland areas by the southern house mosquito (*Culex quinquefasciatus*) following its introduction in 1826, and the subsequent introduction of the protozoan parasite (*Plasmodium relictum*) which causes avian malaria in the early 20th century. The southern house mosquito and other invasive mosquitoes spread avian malaria and avian poxvirus, diseases for which the native birds had no natural resistance.

As a result of the widespread and rapid changes brought by humans, an estimated half of the native bird species have been lost to extinction. Numbers among other taxa are far higher, including 60 percent of the native land snails, and thousands more terrestrial insects and spiders that were forever lost long prior to being described. The known extinctions alone in Hawai‘i represent 75 percent of the recorded extinctions of plants and animals in the United States. Today, Hawai‘i has the highest number of threatened and endangered species in the United States, accounting for 28 percent of the federally listed taxa. The decline in native species is also mirrored by the loss of native habitat, with less than 40 percent of the land surface covered with native-dominated vegetation today.

Of this great diversity, the following species or taxa are covered in the SWAP as Species of Greatest Conservation Need (SGCN): one terrestrial mammal, 78 birds, 136 terrestrial invertebrates, over 600 plants, six species of endemic terrestrial algae, 12 freshwater invertebrates, five freshwater fishes, 24 species of endemic freshwater algae, two freshwater plants, 21 anchialine-pond associated fauna, 26 marine mammals, six marine reptiles, 138 marine fishes, 190 marine invertebrates, 78 species of endemic marine algae, and three native marine algae. A brief discussion of each species group is presented below, with more specific information presented in Chapter 7 (Species of Greatest Conservation Need).

Terrestrial Mammal

The ‘ōpe‘ape‘a (Hawaiian hoary bat) is the only land mammal native to the Hawaiian archipelago and is an endemic subspecies of a bat found throughout North and South America. Historically, it is known from all of the MHI but Ni‘ihau. It is federally listed as endangered due to apparent population declines and limited information on its distribution, abundance, and habitat needs. Bats are affected by habitat loss, roost disturbance, collision with wind turbines, and pesticides. A group of stakeholders composed of government agencies, non-profit organizations, and private landowners, is working together to prioritize and fund needed bat research.

Birds

The avifauna in Hawai‘i are of national and global importance, as Hawai‘i is home to the highest number of endemic forest birds in the United States and provides habitat for globally significant nesting populations of seabirds. Only about twenty avian arrivals occurred in Hawai‘i. These represent just a few of the bird families known worldwide (19 out of 144). Most species are year-round residents, including forest birds, waterbirds, and three endemic seabirds, but many species of seabirds and migratory birds have breeding or wintering grounds in the state.

Forest birds

The ancestors of the forest passerines encountered different resource opportunities and limitations on different islands (e.g., foods and forest types). Because the distances between islands are formidable barriers to most small birds, inter-island isolation also contributed to speciation and led to several island endemic species. As a result, within each of the five families of passerines found in Hawai‘i, there are related but distinct subspecies or species represented on different islands. Unfortunately, only one of five historic species of the family Corvidae is extant, and all members of the family *Melephigidae* are extinct.

There are only about 30 extant species of native Hawaiian forest birds—less than half the number known from historic and fossil records--and one third of those remaining are extremely rare or possibly extinct. More than half are endangered. A number of factors have contributed to this decline. Conversion of land from native forests to agricultural and other human use began with the arrival of Polynesians and accelerated with European contact. Remaining forests have been degraded by ungulates and invasive plant species. The introduction of the avian malaria and avian pox have proven catastrophic to Hawai‘i’s native bird species, especially the passerines. Many individuals die within days to weeks of receiving an infected mosquito bite, and survivors can remain long-term disease reservoirs. Rats, feral cats, and mongooses’ prey on bird nests, nestlings, and even on incubating adults. In addition, alien bird and arthropod species may compete with native forest birds for food or nest resources. Natural events such as hurricanes and severe storms can adversely affect forest birds with small populations.

As a result of these changes, especially the introduction of mosquitoes, most remaining forest birds survive in montane mesic and wet native forests dominated by ‘ōhi‘a and koa or in subalpine forests dominated by māmane and co-dominated by māmane and naio, where cooler temperatures limit mosquitoes. These include forests on Hawai‘i and Maui, as well as remnant forest patches at high elevations on Moloka‘i, Lāna‘i, O‘ahu and Kaua‘i. Thus, some species may be persisting in marginal habitats, further complicating their recovery. Furthermore, climate change is warming these forests and facilitating the rapid upslope invasion of mosquitoes and disease. Critical conservation actions include implementation of landscape-scale mosquito control techniques, such as the incompatible insect technique (IIT) and/or aerial application of *Bacillus thuringiensis israelensis* (Bti), protection of remaining native forest habitats from further degradation by ungulates and non-native plant species, control and eradication of introduced predators (primarily rodents and cats); captive propagation (‘alalā, kiwikiu *[Pseudonestor xanthophrys*], palila, ‘akikiki [*Oreomystis bairdi*], ‘anianiau [*Magumma parva*] and ‘akeke‘e [*Loxops caeruleirostris*]), planning and implementing translocation to high elevation habitat on Hawai‘i Island, the prevention of the introduction of additional predators (e.g., snakes), disease (e.g., West Nile virus), or any other habitat-modifying plants or , and implementation of landscape-scale mosquito control using the incompatible insect technique (IIT) and/or aerial application of *Bacillus thuringiensis israelensis* (Bti). Both of these mosquito control techniques are safe, have been approved and registered for use with the U.S. Environmental Protection Agency, and have been used around the world for decades to prevent the spread of human diseases and agricultural pests. IIT involves

releasing male mosquitoes that carry a different, incompatible strain of *Wolbachia* bacteria than what is present in the wild population, and when these males mate with wild females the resulting eggs do not hatch. This decreases the mosquito population over time. The *Wolbachia* bacterium cannot be transferred from the mosquitoes to birds or humans. BTI is a naturally occurring bacterium found in soil, and acts by specifically targeting mosquito larvae without harming other species.animal.

The Hawaiian Forest Bird Recovery Team, a cooperative effort involving multiple government agencies and non-profit organizations, guides forest bird conservation work, including the development of the Revised Recovery Plan for Hawaiian Forest Birds 2006) and five-year implementation plans for identified critical species, captive propagation, annual forest bird surveys, mosquito control, as well as other identified research and management projects.

Raptors

The ʻio (Hawaiian hawk) and the pueo (Hawaiian short-eared owl) are the only extant native raptors in Hawaiʻi. The ʻio (Hawaiian hawk) is listed as endangered by the State and is restricted to the island of Hawaiʻi. USFWS has removed the ʻio from the endangered species list in 2020 because the population is secure and no longer requires federal protection. The pueo occurs on all the MHI and is listed by the State as endangered on Oʻahu only. Both birds are found from sea level to high elevations across most habitats. Primary threats include predation by introduced rodents and cats (particularly for the ground-nesting pueo), habitat loss, rodenticide poisoning, and gunshot wounds (particularly for ʻio). Information on the distribution and abundance of these species as well as potential limiting factors (e.g., environmental contaminants and harassment by humans) is needed for both species. USFWS is particularly interested in information on the ʻio's biology, range, and population trends, including the species' use of koa plantations and exurban areas, and the positive and negative effects of current and foreseeable land management practices.

Waterbirds

Six species of extant, endemic waterbirds occur in Hawaiʻi: the Laysan duck (*Anas laysanensis*), nēnē (Hawaiian goose), koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ʻalae ʻula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), and aeʻo (Hawaiian stilt). An additional indigenous species, ʻaukuʻu (*Nycticorax nycticorax* [black-crowned night-heron]), is common throughout the MHI. All of the endemic species are listed as endangered by the USFWS and by the State. A Revised Recovery Plan for the Laysan duck was published in 2009, a Draft Recovery Plan for the nēnē (Hawaiian goose) was published in 2004, and a Revised Recovery Plan covering the other four listed waterbird species was published in 2011. The ʻalae keʻokeʻo (Hawaiian coot) and aeʻo (Hawaiian stilt) have been observed on every MHI except Kahoʻolawe, the distribution of the other three endemic waterbird species is more restricted within the MHI, and the Laysan duck which in 2005 was limited to Kauō or Kamole (Laysan island) and Pihemanu or Kuaihelani (Midway Atoll) in the NWHI has been newly introduced to Mokupāpapa or Hōlanikū (Kure Atoll).

Three of the waterbird species (ʻalae ʻula [Hawaiian moorhen], ʻalae keʻokeʻo [Hawaiian coot], and aeʻo [Hawaiian stilt]) inhabit wetland habitats including tidal flats and estuaries, playas and ephemeral basins, freshwater marshes, coastal ponds, taro patches, and human-constructed wetlands, such as irrigation ditches and sewage treatment ponds. The koloa maoli (Hawaiian duck) occurs in the above freshwater environments as well as montane streams and swamplands. Nēnē (Hawaiian goose) have been reintroduced to Kauaʻi, Maui, Hawaiʻi, and Molokaʻi, where they can be found from sea level to 2,400 meters (7,900 feet) in elevation, predominantly in dry forest, shrubland, and grassland. A translocation project between 2011 - 2016 moved over 600 nēnē from near the Kauaʻi International Airport to Hawaiʻi and Maui Islands. The Laysan duck utilizes all available habitats with vegetation cover and fresh water, includingw upland vegetation, ephemeral wetlands, mudflats, and coastal areas. Historically found in the MHI as well as the NWHI, the Laysan duck was found only on Kauō or Kamole (Laysan Island) until 2004, when 20 birds were translocated to Pihemanu or Kuaihelani (Midway Atoll). In 2014, 28 birds were translocated and in 2023 24 birds translocated from Kuaihelani to Mokupāpapa or Hōlanikū (Kure Atoll) in the NWHI.

The loss and degradation of wetland habitats negatively affects these species. Predation (primarily by feral cats, but also by mongooses and feral dogs (*Canis familiaris*), hybridization between non-native mallards and the koloa maoli (Hawaiian duck), and disease also negatively affects these birds. Protecting and maintaining existing habitat, identifying and securing needed additional habitat, controlling or eradicating introduced predators, improving understanding of the use of non-breeding habitats (e.g., maintenance sites), reintroduction, and monitoring of populations are priority conservation actions.

Seabirds

Forty different seabird species have been observed in the Hawaiian Islands, and at least 20 are known to breed in Hawaiʻi. Two seabirds are endemic to Hawaiʻi: ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]) and the ʻaʻo (*Puffinus auricularis newelli* [Newell's shearwater]). Many of these seabirds are of global or national importance: over 95 percent of the world's mōlī (*Phoebastria immutabilis* [Laysan albatross]) and kaʻupu (*Phoebastria nigripes* [black-footed albatross]) populations nest in the Hawaiian Archipelago. Other seabirds of conservation concern include the ʻakēʻakē (*Oceanodroma castro* [band-rumped storm petrel]), listed as endangered by the State and USFWS, the short-tailed albatross (*Phoebastria albatrus*), listed as endangered by USFWS, and the Christmas shearwater (*Puffinus nativitatis*), the Tristram's storm petrel (*Oceanodroma tristrami*), and the blue-gray noddy (*Procelsterna cerulean*), identified as of "high concern" in the U.S. Seabird Conservation Plan for the Pacific Region.

Historically, high densities of seabirds nested on all Hawaiian Islands, but now most are restricted to the NWHI or to predator-free offshore islands within the MHI. A few birds, such as the ʻuaʻu (Hawaiian petrel) and ʻaʻo (Newell's shearwater), nest in high elevations or in inaccessible locations (e.g., sheer cliffs) in the MHI. Primary threats to seabirds while in Hawaiʻi include predation by feral cats, rodents, and mongooses, loss or

degradation of habitat due to habitat-modifying invasive plants or animals, and human-caused disturbances, including artificial lighting and collision with utility lines and structures. Threats at sea include fisheries bycatch and pollution (including oil spills). Needed conservation actions are protection of existing habitat, eradication of introduced predators (cats, rodents, and mongooses) from additional offshore islands and known breeding colonies, and additional surveys to locate additional breeding colonies and monitor population status and trends, particularly at sea.

Migratory shorebirds and waterfowl

Several species of migratory shorebirds and waterfowl winter in Hawai‘i. Of these, the kōlea (*Pluvialis fulva* [Pacific golden plover]), the ‘akekeke (*Arenaria interpres* [ruddy turnstone]), the ‘ūlili (*Heteroscelus incanus* [wandering tattler]), and the kioea (*Numenius tahitiensis* [bristle-thighed curlew]) are regular migrants that have been identified as important (by the U.S. Shorebird Conservation Plan) because the populations in Hawai‘i are hemispherically significant or relatively large. The habitats used by these migratory shorebirds and waterfowl generally overlap with those used by resident species, thus, protected wetland and coastal habitats often support both endemic waterbirds and migratory shorebirds and waterfowl. Primary threats to migratory shorebirds and waterfowl include loss or degradation of habitat and predation by feral cats and dogs. Protecting and maintaining existing habitat, identifying and securing needed additional habitat, controlling or eradicating introduced predators, improving understanding of the role of Hawai‘i’s wintering habitats on global populations, and assessing population size and distributions are priority conservation actions.

Northwestern Hawaiian Islands passerines

Three species of passerines are found in the NWHI: the Laysan finch (*Telespiza cantans*), Nihoa finch (*Telespiza ultima*), and Nihoa millerbird (*Acrocephalus familiaris*). Found within the Papahānaumokuākea Marine National Monument and Hawaiian Islands NWR in the NWHI, these three species are among the rarest birds in the world. Prior to 2011, the Nihoa finch and millerbird were restricted to Nihoa, and the Laysan finch was found only on Kauō (Laysan) and two small islands in Holoikauaua or Manawai (Pearl and Hermes Atoll). But in 2011, the Nihoa millerbird was successfully translocated to Kauō to establish a self-sustaining population there. Major threats include the introduction of habitat-modifying alien plants, the introduction of habitat-modifying or predaceous non-native animals, and environmental factors, including natural disaster, drought, and long-term climate change (e.g., sea level rise). Priority conservation actions include maintaining the integrity of the islands’ habitat by preventing and responding to non-native plant and animal introductions.

Terrestrial Invertebrates

More so than any other group, Hawai‘i’s native terrestrial invertebrates are characterized by high levels of endemism – over 99 percent of terrestrial invertebrates are found nowhere else on earth. Native invertebrate species are found in almost every habitat known throughout the Hawaiian Archipelago, including aeolian alpine summits, lava tube and lava cave systems, and strand and littoral habitats. Snails, insects, spiders and other invertebrates perform important roles as decomposers and nutrient-cyclers, pollinators, and also serve as food resources for native

vertebrate species. Given the absence of mammalian herbivores in Hawai‘i, native invertebrates are integral primary consumers, transferring the bulk of energy and nutrients from plants to the broader ecosystem. However, habitat loss and habitat alteration, the introduction of non-native species, direct human uses, and a changing climate, have resulted in dramatic declines in Hawaiian invertebrates. The likelihood that a given species will persist varies depending on the severity of the threats it faces, its inherent adaptability and resilience, and more recently, the management actions that can be implemented by resource managers to support its survival.

Arthropods

Thirty arthropods have been listed as endangered or threatened by the USFWS: the Kaua‘i cave wolf spider (*Adelocosa anops*), the Kaua‘i cave amphipod (*Spelaeorchestia koloana*), the Blackburn’s sphinx moth (*Manduca blackburni*), fourteen species of picture-wing flies (*Drosophila* spp.), seven species of yellow-faced bees (*Hylaeus* spp.) and six species of damselflies (*Megalagrion* spp.). Recovery Plans have been prepared for Blackburn’s sphinx moth and the Kaua‘i cave wolf spider, and critical habitat has been designated for the sphinx moth, somepicture-wing flies, damselflies and the Kaua‘i arthropods. Many more native arthropods are known to be incredibly rare. Listing packages which are required to propose the protection of additional species under the Endangered Species Act of 1973 must include extensive data relating to species distribution, life history, habitat, population status and threats. Such information remains unavailable for the vast majority of native arthropods, and therefore precludes additional species from receiving federal and state protection, despite widespread risk of extinction.

While historically overlooked, the conservation of native arthropods is essential in order to perpetuate the vital ecological services they provide: Hawaiian plant species could not exist without the pollination services and nutrient cycling which native arthropods perform, and Hawaiian birds and bats have evolved to depend on native arthropods for food resources. For example, rare Hawaiian plant species such as *Psychotria grandiflora* and *Brighamia insignis* are currently facing the prospect of extinction due to the loss of their highly-specialized native pollinators. A multitude of peer-reviewed studies have documented widespread declines in insect populations are occurring around the world, and while the impacts of such losses are still being evaluated, it is clear that significant interruptions to food webs will result. Given the diversity and abundance of native arthropods in Hawaii, such losses to assemblages of native arthropods are a grave concern. In addition to sustaining other native wildlife, native arthropods support healthy native Hawaiian forests. Healthy and diverse native plant communities contribute to healthy forest structure, preserve hydrological processes, and protect watersheds by ensuring erosion control, flood control, recharging water supplies, and sustaining near-shore marine communities. The loss of native arthropod fauna will ultimately result in the loss of native Hawaiian forest species and many essential ecosystem functions. Conservation and management efforts which protect native arthropods inherently protect the native plants and animals which depend upon them in perpetuity.

Like much of the native biota, native arthropods are highly susceptible to habitat loss and alteration. Invasive plant and animal species can irreversibly degrade habitat by altering

species composition and reducing native host plant availability. Direct predation of native arthropods by invasive generalist predators, such as ants, wasps and rats (in the case of terrestrial arthropods) or invasive mosquito fish and macroinvertebrates (in the case of aquatic arthropods) are also a well-documented threat. The impact of invasive predators increases annually as incipient invasive species are introduced and/or established invasive species expand their ranges. The presence of invasive competitors, parasitoids and pathogens are also correlated with local extirpations of native arthropods, however their impacts are difficult to evaluate and monitor. For example, in just the last 10 years researchers have identified multiple factors contributing to declines in populations of endangered yellow-faced bee, *Hylaeus anthracinus*, including but not limited to: competition for floral resources and nesting substrate between other introduced solitary bees and wasps, the presence of both native and non-native parasitoids, predation by non-native arthropods, and infection by microorganisms and diseases that are known to be pathogenic to, and have likely spilled over from, European honey bees. Similarly, a previously unstudied species of *Hydra* was identified to be causing mortality of endangered orange-black damselfly, *Megalagrion xanthomelas*, and would not have been identified if research had not been pursued to study a suspected damselfly pathogen. Surveillance for new and emerging threats is critical to the continued conservation of remaining populations of rare arthropods.

Land snails

Forty four snails have been listed as endangered or threatened by the USFWS: Oʻahu tree snails of the genus *Achatinella*, two species of Lānaʻi tree snails (*Partulina* spp.), the Newcomb's tree snail (*Newcombia cumingi*) and the Newcomb's snail (*Erinna newcombi*),

Recovery Plans have been prepared for Newcomb's snail and the Oʻahu tree snails, and critical habitat has been designated for the Newcomb's snail.

In addition to the threats listed above, all native invertebrates are also facing increased risk of extinction due to our changing global climate. Significantly warmer or colder temperatures adversely impact the fecundity and survivorship of invertebrates, while increasingly wetter and/or drier conditions can impact the availability of native vegetation, floral resources and biofilm. Changing availability of resources affects species foraging capability, as well as makes native habitat more susceptible to invasion by non-native species. Increased frequency and intensity of storm events can have catastrophic impacts on native habitat, and rare invertebrates which are already geographically restricted and present in low abundance. Mitigating the effects of all of these threats is impossible unless more resources are allocated to arthropod-specific research and management programs.

Conservation actions needed for terrestrial invertebrates include improving the availability of information (e.g., species biology, population assessments, habitat needs and interactions), protection and restoration of native habitats, increased quarantine and inspection at ports of entry

to intercept incipient pest species as well as assessment of pest-control and biocontrol measures to prevent further injurious alien introductions, establishment of long-term monitoring programs, and better education and outreach programs. Most importantly, researchers and managers need increased funding to rigorously evaluate the conservation status of target native invertebrate species, and additional funding to implement management actions which will achieve recovery objectives for rare and declining species.

Plants and algae

Over 1,000 distinct flowering plant species evolved from approximately 295 successful flowering plant colonist species. In addition, Hawai‘i supports over 150 recognized taxa of native ferns and fern allies. Total species richness is concentrated on older islands, primarily in mesic and wet habitats and at relatively low elevation (700 to 800 meters; 2,100 to 2,400 feet), as a function of evolutionary and ecological processes acting within the constraints of geologic history. Richness of endangered plant species is highest in mesic and dry habitats of the Wai‘anae mountains of O‘ahu, with somewhat high concentrations in the mesic habitats of western Kaua‘i and the wet habitats of the Ko‘olau mountains on O‘ahu. Plant species that are naturally rare (those projected to have had a restricted range prior to human impact) are concentrated in the mesic habitats of the Wai‘anae mountains (O‘ahu), the Alaka‘i swamp region (Kaua‘i), and other wet summit regions (e.g., Ko‘olau mountains, O‘ahu). Plant species that have suffered the greatest percentage of habitat loss are concentrated in very low elevation mesic habitats on Kaua‘i mesic to dry habitats in the Wai‘anae mountains (O‘ahu), very low elevation mesic habitats in the Ko‘olau mountains (O‘ahu), and low elevation dry to mesic habitats on Moloka‘i, Maui and Lāna‘i. Critical habitat has been designated on every island in the MHI and on Nihoa, Mokumanamana (Necker), and Kauō in the NWHI for over 300 listed plants.

Feral ungulates, such as cattle, pigs, goats, deer (*Odocoileus hemionus* and *Axis axis*), and mouflon sheep, pose a major threat to native plants by consuming and trampling native understory plants, creating conditions favoring non-native plant infestation and establishment, preventing the establishment of ground-rooting native plants, and disrupting soil nutrient cycling. Introduced invertebrates like yellowjacket wasps (*Vespula* spp.) and little fire ants (*Wasmannia auropunctata*) are a direct threat to native pollinators. Plant diseases such as the newly identified ‘ōhi‘a wilt can wipe out local populations of native plants. Invasive habitat-modifying plants outcompete native plants within the habitat. Conservation actions needed include protection of existing native habitats from feral animals, invasive plant control and eradication, monitoring of populations for early detection and rapid response, and additional research on methods to address the role of invertebrates and disease. Extremely rare plants require additional *ex situ* (off site) conservation actions (e.g., seed banking, *in vitro* propagation, and cryopreservation).

Hawai‘i also has an endemic marine plant, the seagrass *Halophila hawaiiana*, which is host to an endemic snail. Threats to seagrass include limited habitat, as it occurs in discrete patches on sandy substrate off a few islands, limited sexual reproduction as male and female flowers occur on separate plants and male plants are seldom found, and nearshore disturbance (e.g., dredging or sedimentation).

Little is known about Hawai‘i’s endemic algae and its role in the ecosystem, beyond the importance of marine algae as a food source for marine fishes, invertebrates, and green sea

turtles. Over 100 species of endemic terrestrial, freshwater, and marine endemic algae have been identified.

Freshwater Species

Streams in Hawai‘i have a relatively small number of native species. There are five native fishes or ‘o‘opu, that occur in freshwater streams and evolved from two families of marine fishes. These ‘o‘opu are mostly small herbivores or omnivores. There are twelve freshwater invertebrates of conservation need, including two omnivorous shrimps, at least eight species of herbivorous snails, one endemic worm species, and one endemic sponge species. Some of these invertebrates spend a brief part of their larval stage in the ocean before returning to the freshwater streams as juveniles. Threats include insufficient instream flow standards, stream diversions, dams, and channelization, and sedimentation and pollution of streams. Needed actions include reversing or mitigating these destructive impacts and organizing management for stream animals along continuous stream corridors from the mountain to the ocean.

Anchialine-pond Fauna

Anchialine ponds are home to numerous animals. Eight species of anchialine shrimps are hypogeal, which means they live in subterranean aquatic habitats in the water that occurs in cracks and slits between rocks. One species of anchialine pool shrimp (*Vetericaris chaceorum*) has been listed as endangered, and three others (*Metabetaeus lohena*, *Palaemonella burnsi*, and *Procaris hawaiana*) are candidates for listing under the Endangered Species Act. These shrimps can be found in anchialine ponds where the subterranean water system reaches the surface through natural or man-made connections and where the salinity of seawater intrudes to at least some degree. It is not clear whether anchialine ponds are necessary for the survival of any of the eight shrimp species, as one shrimp has also been found in the open ocean, and many species have been found in artificially created ponds, some many miles from the nearest naturally formed pond. However, the importance of the little-understood hypogeal system is clear, and the anchialine ponds may greatly increase the amount of energy in the hypogeal systems because of the access to photosynthetic organisms in the pools. Anchialine ponds are also home to eleven species of amphipods, two of which have also been found in the open ocean. Little is known about their biology or ecology. One snail species is also often commonly found in anchialine ponds and other estuarine habitats. Some *Megalagrion* damselflies are also found in anchialine ponds but require vegetation that is often removed from the ponds. Many other marine species can be occasionally found in anchialine ponds. Threats to the ponds themselves include excessive use, filling in or alteration of ponds for alternate use or development, and the introduction of invasive predatory fishes and invertebrates. Needed conservation actions include better management of human access, protection of pond habitats, and development of effective methods to prevent and control invasive species.

Marine Species

Marine ecosystems in Hawai‘i support over 1,200 species of fishes, with around 500 species adapted to live on coral reefs, and the rest adapted to the open ocean waters, deep habitats, estuaries, or areas characterized by sandy bottoms. These fishes occupy a range of niches from herbivores to carnivores that specialize on microscopic plankton, seashells, crabs, shrimp, or other fishes. At the top of the food chain are the apex predators such as the many sharks of Hawai‘i. Over 5,000 marine invertebrates are known from Hawai‘i, including over 100 species

of hard, soft and precious corals, as well as hundreds of types of seashells, crabs, and shrimps and small numbers of worms, jellyfish, sponges, starfish, and tunicates. Many commercially or recreationally fished species are protected by Fishery Management Plans developed under the U.S. Magnuson-Stevens Fishery Conservation and Management Act. Stony corals, black corals, seahorses, and some sharks are protected by the Convention on International Trade in Endangered Species (CITES) Appendix II.

A small number of marine reptiles occur in Hawai‘i. Two sea turtles are common residents here, and three others are more occasional visitors. All sea turtles are listed as threatened or endangered by the USFWS. The honu (green sea turtle) is an herbivore and the hawksbill sea turtle (*Eretmochelys imbricata*) specializes on eating sponges. Both lay eggs on Hawai‘i’s beaches. There are two species of sea snake reported from Hawaiian waters, although these are rarely seen.

About 26 species of marine mammals are resident or occasional visitors to Hawai‘i. All are protected by the Marine Mammal Protection Act. These include the popular spinner (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*), resident year-round, and the migratory humpback whales (*Megaptera novaeangliae*) which spend a few months each year in Hawaiian waters to birth and breed. Humpback whales, false killer whales (*Pseudorca crassidens*), and the Hawaiian monk seal (*Monachus schauinslandi*) are the more commonly occurring marine mammals in Hawai‘i that are listed as endangered under federal and state law. Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawai‘i’s coasts.

References:

Atkinson CT, Woods KL, Dusek RJ, Sileo LS, Iko WM. Wildlife disease and conservation in Hawaii: Pathogenicity of avian malaria (Plasmodium relictum) in experimentally infected Iiwi (*Vestiaria coccinea*). Parasitology. 1995;111(S1):S59-S69. doi:10.1017/S003118200007582X

Atkinson, C.T. and Samuel, M.D. (2010), Avian malaria Plasmodium relictum in native Hawaiian forest birds: epizootiology and demographic impacts on ʻapapane *Himatione sanguinea.* Journal of Avian Biology, 41: 357-366. https://doi.org/10.1111/j.1600-048X.2009.04915.x

Atkinson, C.T., Utzurrum, R.B., Lapointe, D.A., Camp, R.J., Crampton, L.H., Foster, J.T. and Giambelluca, T.W. (2014), Changing climate and the altitudinal range of avian malaria in the Hawaiian Islands – an ongoing conservation crisis on the island of Kaua'i. Glob Change Biol, 20: 2426-2436. https://doi.org/10.1111/gcb.12535

Benning, T.L., LaPointe, D., Atkinson, C.T., & Vitousek, P.M., Interactions of climate change with biological invasions and land use in the Hawaiian Islands: Modeling the fate of endemic birds using a geographic information system, Proc. Natl. Acad. Sci. U.S.A. 99 (22) 14246-14249, https://doi.org/10.1073/pnas.162372399 (2002).

Cesar H, Beukering P, Pintz S, Dierking J. 2002. Economic Valuation of the Coral Reefs of Hawai‘i. Hawai‘i Coral Reef Initiative Research Program. Available at: http://www.hawaii.edu/ssri/hcri/rp/cesar/noaa_final_report_01-02/cesar_final_report-01-02.htm.

Davis SD, Heywood VH, Hamilton AC, editors. 1995. Centres of Plant Diversity. Information Press, Oxford, United Kingdom. 550 pp.

Dayer AA, Manfredo MJ, Teel TL, and Bright AD. 2006. State Report for Hawai`i from the Research Project entitled “Wildlife Values in the West.” Project Rep. No. 68. Project Report for Hawai`i Department of Land and

Natural Resources. Colorado State University, Human Dimensions in Natural Resources Unit, Fort Collins, Colorado.

Eldredge, LG, and Evenhuis NL. 2002. Hawai'i's biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. Bishop Museum Occasional Papers 76:1-28.

Engilis A, Naughtond M. 2004. U.S. Pacific Islands regional shorebird conservation plan. U.S. Shorebird Conservation Plan. Portland, (OR): U.S. Department of the Interior; Fish and Wildlife Service.

Hawai'i Association of Watershed Partnerships, n.d. Watershed Partnerships. Available at: https://hawp.org/partnerships/#:~:text=Together%2C%20these%20partnerships%20involve%20over,of%20land%20in%20the%20state. (accessed June 17, 2024)

Hawai'i Conservation Alliance. 2004. "Draft Hawai'i biodiversity strategy."

Hawai'i Department of Agriculture. 2002. Kahului airport pest risk assessment. Maui. Available at: http://www.hawaiiag.org/PQ/KARA%20Report%20Final.pdf (accessed last August 17, 2005).

Hawai'i Department of Budget and Finance. 2022. The 2023 Executive Biennium Budget, Budget in Brief. Available at: https://budget.hawaii.gov/wp-content/uploads/2022/12/FB-23-25-BIB-12-16-22.Lk0_.pdf (accessed June 24, 2024)

Hawai'i Department of Business, Economic Development, & Tourism. 2023. 2022 State of Hawai'i Data Book. Available at: https://dbedt.hawaii.gov/economic/databook/db2022/. Accessed 18 June 2024.

Hawai'i Department of Business, Economic Development &Tourism. 2013. The State of Hawaii Data Book—A Statistical Abstract. Available at: http://files.hawaii.gov/dbedt/economic/databook/db2013/db2013.pdf (accessed June 27, 2015).

Hawai'i Department of Business, Economic Development, & Tourism, Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 13 May 2024.

Hawai'i Department of Business, Economic Development &Tourism. 2015. Visitor Statistics—Annual Visitor Research Report. Available at: http://dbedt.hawaii.gov/visitor/visitor-research/ (accessed June 27, 2015).

Department of Land and Natural Resources (DLNRc), Division of Aquatic Resources. n.d. Papahānaumokuākea Marine National Monument. Available at: https://dlnr.hawaii.gov/dar/marine-managed-areas/papahanaumokuakea-marine-national-monument/#:~:text=A%20vast%2C%20remote%2C%20and%20largely,km)%20of%20the%20Pacific%20Ocean. Accessed 19 June 2024.

Hawai'i Department of Land and Natural Rsources (DLNRa), Division of Forestry and Wildlife, Forestry Program. n.d. Forestry Reserve System. Available at: https://dlnr.hawaii.gov/forestry/frs/ Accessed 19 June 2024.

Hawai'i Department of Land and Natural Resources (DLNRb), Division of Forestry and Wildlife, Native Ecosystem Protection and Management. n.d. Natural Area Reserves System. Available at: https://dlnr.hawaii.gov/ecosystems/nars/. Accessed 19 June 2024.

Hawai'i Department of Land and Natural Resources (DLNR). 2014. Makai Watch Briefing to the Board of Land and Natural Resources. Available at: http://dlnr.hawaii.gov/makaiwatch/2014/11/26/makai-watch-briefing-to-the-board-of-land-and-natural-resources/ (accessed June 27, 2015).

Hawai'i Department of Land and Natural Resources (DLNR). 2004. Statewide report on invasive species. Honolulu, (HI): DLNR.

Hawai'i Department of Land and Natural Resources (DLNR). 2004. Hawai'i's priority invasive species. Honolulu, (HI): DLNR.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Conservation education and outreach program strategic plan - DRAFT. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Legacy Land Conservation Program Projects. Available at: http://dlnr.hawaii.gov/ecosystems/files/2013/09/Legacy-Land_Projects-Map.pdf (accessed June 30, 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Hawai‘i Game Management Program. Available at: http://dlnr.hawaii.gov/recreation/files/2015/06/Pittman-Robertson-Game-Management-Plan.pdf (accessed September 4, 2015).

Hawai‘i Department of Land and Natural Resources, US Fish and Wildlife Service, and The Nature Conservancy of Hawai’i. 1992. Hawai‘i's extinction crisis: a call to action.

Hawai‘i Revised Statutes. Chapters 171, 183, 183D, 187A, 188, 190, 195, 195D. Honolulu, (HI).

Hawaii’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i State Commission on Water Resource Management. (2022). *Hawai‘i Water Resources Protection Plan*. Retrieved from https://files.hawaii.gov/dlnr/cwrm/planning/wrpp2022/WP2022_FullReport.pdf

Hawai‘i State Legislature. 2005. House Bill 100, Conference Draft 1 (State Budget). Honolulu, (HI). Available at: http://www.capitol.hawaii.gov/sessioncurrent/bills/hb100_cd1_.htm (accessed on May 25, 2005).

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Holt JD. 1985. The art of featherwork in old Hawai‘i. Honolulu: University of Hawai‘i Press.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Leonard, DL. 2008. Recovery expenditures for birds listed under the U.S. Endangered Species Act: the disparity between mainland and Hawaiian taxa. Biological Conservation 141:2054-2061.

Loope LL. Status and trends of the nation’s biological resources: Hawai‘i and the Pacific Ocean. U. S. Geological Survey. Available at: http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed 7 December 2004).

Mitchell, C, Ogura C, Meadows DW, Kane A, Strommer L, Fretz S, Leonard D, and McClung A. 2005. Hawaii’s Comprehensive Wildlife Conservation Strategy. October. Department of Land and Natural Resources, Honolulu, Hawai‘i. 722 pp.

Nature Conservancy of Hawai‘i. 2003. Last Stand: the Vanishing Hawaiian Forest.

National Oceanic and Atmospheric Administration. n.d. Hawaiian Islands Humpback Whale National Marine Sanctuary. Earth is Blue Magazine. Available at: https://sanctuaries.noaa.gov/magazine/4/hawiian-islands/. Accessed 19 June 2024.

National Oceanic and Atmospheric Administration. 2015. National Marine Sanctuaries. Website about Hawaiian Islands Humpback Whale National Marine Sanctuary. Available at: http://hawaiihumpbackwhale.noaa.gov/management/mgmt_overview.html (accessed July 1, 2015).

National Oceanic and Atmospheric Administration. 2015. National Ocean Services. Website about Papahānaumokuākea Marine National Monument. Available at: http://www.papahanaumokuakea.gov (accessed July 1, 2015).

Office of Hawaiian Affairs 2015. Wao Kele O Puna. Website about Wao Kele O Puna forest legacy reserve. Available at: http://www.oha.org/aina/waokele-o-puna (accessed July 1, 2015).

Paine JR. 1991. IUCN directory of protected areas in Oceania. Gland: International Union for Conservation of Nature and Natural Resources.

Palmer DD. 2003. Hawaii's ferns and fern allies. Honolulu: University of Hawai'i Press.

Price JP. 2004. Floristic biogeography of the Hawaiian Islands: influences of area, environment and paleogeography. Journal of Biogeography 31(3):487-500.

Price JP, Wagner WL. 2004. Speciation in Hawaiian angiosperm lineages: cause, consequence, and mode. Evolution 58(10):2185-2200.

Pukui MK, Elbert SH. 1986. Hawaiian dictionary revised and enlarged edition. Honolulu: University of Hawai'i Press.

Richmond L, and Levine A. 2012. Institutional analysis of community-based marine resource management initiatives in Hawaii and American Samoa. U.S. Dep. Commerce., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-35, 48 p. + Appendices.

Ricketts TH, et al. 1999. Terrestrial ecoregions of North America: a conservation assessment. Washington, DC: Island Press. 147 pp.

Scott MJ. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. United States Department of Interior, National Biological Survey. Available at: http://biology.usgs.gov/s+t/pdf/Hawai'i.pdf (accessed 3 December 2004).

Southwick Associates. 2013. The Conservation Economy in America: Direct Investments and Economic Contributions. The National Fish and Wildlife Foundation, Washington, D.C. Available at: http://www.avcrp.org/wp-content/uploads/2013/04/NFWF-Conservation-Economy-Rpt-Southwick-3-11-2013.pdf (accessed June 30, 2015).

Stone CP, Pratt LW. 1994. Hawaii's plants and animals: biological sketches of Hawai'i Volcanoes National Park. Honolulu: Hawai'i Natural History Association.

Sumiye J. 2002. Ko'olau Mountains Watershed Partnership management plan. Ko'olau Mountains Watershed Partnership.

Teel TL, and Dayer AA. 2005. Preliminary state-specific results from the research project entitled "Wildlife values in the west 2004." Fort Collins: Human Dimensions in Natural Resources Unit, Colorado State University.

Titcomb M. 1972. Native use of fish in Hawai'i. Honolulu: University of Hawai'i Press.

Titcomb M. 1978. Native use of marine invertebrates in old Hawai'i. Pacific Science 32:325-386.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/ (accessed June 24, 2024)

U.S. Department of Commerce, U.S. Census Bureau. 2021. Hawai‘i Census Bureau Profile. Available at: https://data.census.gov/profile/Hawaii?g=040XX00US15. Accessed 22 May 2024.

U.S. Department of Commerce, U.S. Census Bureau. 2015. State and County Quick Facts. Updated 28 May 2015. Available at: http://quickfacts.census.gov/qfd/states/15/15003.html (accessed June 27, 2015).

U.S. Department of Commerce, U.S. Census Bureau. 2010. National Park Service Visits and Acreage by State 2010. Available at: http://www.census.gov/compendia/statab/2012/tables/12s1254.pdf (accessed June 27, 2015).

U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2003. 2001 National survey of fishing, hunting, and wildlife-associated recreation. Available at: http://www.census.gov/prod/2003pubs/01fhw/fhw01-hi.pdf (May 24, 2005).

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Available at: https://www.census.gov/prod/2012pubs/fhw11-nat.pdf (accessed 27 June 2015).

U.S. Fish and Wildlife Service. 1999. Draft revised recovery plan for Hawaiian waterbirds, Second Revision. Portland, (OR): U.S. Fish and Wildlife Service. 107 pp.

U.S. Fish and Wildlife Service. 2003. Draft revised recovery plan for the ‘Alala (*Corvus hawaiiensis*). Portland, (OR): U.S. Fish and Wildlife Service. Xi+78 pp.

U.S. Fish and Wildlife Service. 2003. Draft revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

U.S. Fish and Wildlife Service. 2004. Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose (*Branta sandvicensis*). Portland, Oregon. 148 pp.

U.S. Fish and Wildlife Service. 2004. Draft Regional Seabird Conservation Plan. Portland, Oregon.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2009. Revised Recovery Plan for the Laysan Duck (*Anas laysanensis*). U.S. Fish and Wildlife Service, Portland, Oregon. 114 pp.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2015. Threatened and Endangered Species Lists. Available at http://ecos.fws.gov/ecp/ (accessed June 30, 2015).

Wagner WL, Herbst DR, Sohmer SH. 1999. Manual of the flowering plants of Hawai‘i, Revised Edition, Volumes 1 and 2. Honolulu: University of Hawai‘i Press and Bishop Museum Press.

Yamamoto M, Tagawa A. 2000. Hawai‘i’s native and exotic freshwater animals. Honolulu, (HI): Mutual Publishing. 200 pp.

Ziegler AC. 2002. Hawaiian Natural History, Ecology, and Evolution. Honolulu: University Press, 157 pp.

CHAPTER 4: STATEWIDE CONSERVATION NEEDS

Based on the overview provided in Chapter 3, Chapter 4 discusses the major threats affecting species statewide, followed by seven objectives and priority strategies to address the major threats outlined. The adoption of these seven objectives and priority strategies by the people and institutions of Hawai‘i represent a commitment to ensure that a legacy of healthy biodiversity is left for future generations. This chapter addresses elements 3 and 4 at the statewide level.

OVERVIEW OF THREATS

CURRENT THREATS AND CHALLENGES

The major threats to Hawai‘i’s native wildlife are widespread and common to most species groups and habitats. Major threats include:

- Loss and degradation of habitat resulting from human development and land use practices, alteration of hydrology, wildfire, recreational overuse, natural disaster, infrastructure, and other factors;
- Invasive species that modify habitats and impact survival and reproductive success of native species, including weeds, invasive terrestrial arthropods, slugs, snails, ungulates, algae and corals, mammalian and other predators, competitors, zoonotic diseases and their vectors, and plant pathogens;
- Ecological consequences of climate change;
- Limited information and insufficient information management;
- Uneven compliance with existing conservation laws, rules, and regulations;
- Overharvesting and excessive extractive use;
- Management constraints; and
- Inadequate funding.

Loss and Degradation of Habitat

Loss, fragmentation, and degradation of habitat have been primary contributors to extinction and rarity of Hawai‘i’s native species. Historically, impacts on native species resulting from logging, agricultural practices, grazing, military use, fire, invasive species, urban and residential development, and an overall lack of public awareness, have contributed to the loss of more than half of Hawai‘i’s native habitats. At low elevations where development pressures are highest, less than ten percent of native vegetation remains. Direct habitat loss can be impactful to native birds, and even more so for native plants and invertebrates, many of which are naturally geographically restricted, have limited dispersal abilities, and/or occur in low abundance. Alterations of streams, non-point source pollution, sedimentation, and stormwater runoff have decreased, fragmented, or degraded freshwater habitats.

Marine systems and coastal areas downstream are affected by changes in stream systems, responding negatively in most cases to significant or prolonged increases in sediment or contaminant loads. Corals and fish are highly susceptible to negative impacts of pollution and excessive sedimentation. Millions of seabirds and shorebirds in our archipelago are at risk from oil and contaminant spills. Corals, fish, turtles, marine mammals and other marine life are at risk as well from oil and contaminant spills into our coastal areas, waterways, and marine systems.

Anchialine pools and ponds are threatened by the filling and trampling of the ponds, and the photosynthetic organisms (algae) that form the base of their food chain are easily disturbed. For many sensitive areas such as subterranean systems, coastal areas, and nearshore reefs, the increasing interest and frequency of visitation and use is resulting in cumulative effects on habitat quality and need to be incorporated effectively into natural resource management strategies.

Populations of many species are limited by the amount of suitable habitat available. This results in multiple problems that increase the probability of future extinction. Because many plants and animals co-evolved and are native to Hawai‘i, extinction of one or several species might contribute to the extinction rate of other species. While the current land use zoning of the Conservation District limits further loss of forested habitat to development, this designation confers only the coarsest protection, and does not protect important forested habitat in the other land use zones. Even in the Conservation District, without active management, these lands remain threatened by invasive plants and animal species or require restoration to support native wildlife. In addition, zoning does not protect all of the remaining quality habitat from being converted to another land use.

Development and Shoreline Alterations

Many important wetland and coastal habitats have been destroyed, and remaining habitats continue to be threatened by residential and commercial development. The limited amount of shoreline and the constant demand for beach-front housing has resulted in the division and conversion of formerly open coastal areas to homes, businesses, hotels and resorts. Landscaping in and around such developments leads to increased chemical inputs (herbicides, pesticides, fertilizers) and the accidental introduction of non-native plant and animal species. The conversion of low elevation habitat to agricultural lands and the accompanying diversion of streams for irrigation, previously eliminated habitat for innumerable native species. The more recent closure of sugar plantations resulted in the loss of irrigation ponds used as habitat by waterbirds, and many former fields are being subdivided for residential use. As housing demand increases, development constitutes a threat away from the coast, in many of the lands previously used for agriculture, as well in areas formerly considered “remote,” such as Ka‘ū on Hawai‘i Island or north shore of Kaua‘i. Shoreline alterations, including the building or expansion of harbors, seawalls, and other structures, damages marine habitats for corals and other species directly or indirectly by changing water flows or sediment deposition. Developments along the coasts also increase the number of light sources around the islands and the potential for problems caused by light attraction of nocturnally active seabirds and sea turtles.

Development of energy facilities such as wind turbines and powerlines creates collision hazards for wildlife such as seabirds, waterbirds, raptors, and bats. In some cases, urban and residential developments of golf courses, water features, and maintained landscaping provide attractive habitat for wildlife species, which can then be drawn into urban areas where other threats such as projectiles, vehicles, and predators are abundant. Many times, wildlife and people can coexist, such as at urban wetlands like Hāmākua Marsh on O‘ahu where native waterbirds persist, but in other cases, wildlife and urban uses clash and conflicts develop. One example is the public safety hazard caused by high numbers of nēnē (*Branta sandvicensis* [Hawaiian goose]) nesting on

resort property adjacent to the Līhuʻe Airport, and the resulting risk of nēnē-aircraft collisions at the airport.

Alteration of Hydrology

Alteration of hydrology includes watershed development, stream diversions, channelization, and excessive freshwater withdrawals, which lower aquifer levels and result in degradation of habitat used by native fishes and invertebrates. Long term, these activities also affect terrestrial wildlife by altering plant communities and availability of drinking water. Insufficient water quality and instream flow standards, diversions, and alterations continue to threaten many streams. Inadequate zoning in riparian zones threatens aquatic ecosystems by allowing agriculture, grazing, and development to occur too close to streams. Climate change models of rainfall for the Hawaiian Islands through the remainder of the century predict, on average, a decrease in rainfall and reduced availability of freshwater resources (Timm et al. 2015), particularly in the dry climatic regions.

Fire

Unlike in many continental ecosystems, Hawaiʻi's native plants and animals are poorly adapted to wildfires. Today, invasive plants have increased the fuel loads in many areas, and most fires continue to be caused by human activities. Wildland fires are more likely to occur on the dry leeward sides of the islands, destroying existing habitat and providing ecological conditions that enable invasive species to rapidly dominate the landscape and habitat areas and displace native plant species. The progressive invasion of high fuel grasses into native forest areas following fires results in grass-fire cycles that penetrate deeper into native ecosystems and watersheds with each fire incident. Furthermore, Hawaiʻi is more prone to wildfire due to climate change, which is causing temperatures to increase and rainfall to decrease.

Introduced Invasive Species

Due to their evolutionary history, high degree of endemism, and significant declines, Hawaiʻi's native plants and animals are particularly susceptible to the threats posed by the continued introduction and spread of introduced invasive species and pathogens. Invasive species are species whose introduction does or is likely to cause environmental or economic harm or cause direct harm to human health. Virtually no native habitat is free from the threat of introduced (also called "non-native," "alien," or "exotic") species, and most native habitats experience at least some level of negative impacts related to non-native species. Non-native species almost always outcompete native species or may directly harm native species through predation, herbivory, parasitism, infestation, or infection. Non-native species may also threaten native species through interbreeding and hybridization, leading to genetic swamping and loss of genetic diversity of the native species. Unique and isolated in the central North Pacific Ocean, Hawaiʻi faces an unprecedented biological and economic threat due to the invasion of non-native competitors, predators, habitat-modifiers, and vectors of infectious disease and pathogens, all of which affect the trajectory of numerous increasingly rare species.

Because Hawaiʻi is a hub for trade, tourism, and military activities, it is highly vulnerable to human-assisted alien introductions. The establishment of non-native species is facilitated by Hawaiʻi's moderate climate, year-round growing season, wide range of habitats, and availability of unoccupied niches. Before human arrival, colonization of new species probably occurred

every 25,000 years. Over the last two centuries alone, the rate of plant introductions to Hawai‘i has averaged more than 40 species per year. It is estimated that over 10,000 plants have been introduced into Hawai‘i and about 1,215 (roughly equal to the number of native vascular plant species in the state) have naturalized. While some plant introductions do not threaten native habitats, approximately ten percent of the established non-native species are highly invasive, aggressive, and/or pose significant threats to Hawai‘i’s ecosystems and economy.

In addition to those introduced species already established in Hawai‘i, numerous species not known to occur in Hawai‘i are considered high-risk species known to represent a dangerous threat to island ecosystems. Because this risk is so acute for Hawai‘i, screening and search protocols are in place to monitor and intercept dangerous wildlife originating outside of Hawai‘i. Of particular concern is the brown tree snake (*Boiga irregularis*), which has contributed to the devastation of native avifauna and diversity in Guam. West Nile virus, Africanized honeybee (*Apis mellifera* hybrid), and marine organisms all present a high risk of ecological and economic impact and require increased vigilance.

Habitat Modifiers: Invasive Plants and Ungulate Grazers and Browsers

One of the major threats to Hawai‘i’s native species and forests is the uncontrolled spread of many non-native invasive plants. These plants displace Hawai‘i’s distinctive native flora, resulting in a loss of species diversity and eventually in more pronounced and permanent changes to ecosystem function such as alteration of primary productivity and nutrient cycling. Many invasive species completely replace native vegetation resulting in total loss of native habitats. Invasive plants such as fire-adapted fountain grass (*Pennisetum setaceum*), Guinea grass (*Panicum maxima*), and orchard grass (*Dactylis glomerata*) provide fuels for fires, have led to the increase in intensity and frequency of fires in Hawai‘i, and often increase in abundance after fires. A short list of invasive plant species that pose a significant threat to native plant communities and require aggressive management includes miconia (*Miconia calvescens*), fire tree (*Morella faya*), fountain grass, albizia (*Falcataria moluccana*), Formosan koa (*Acacia confusa*), blackberry (*Rubus argutus*), mangrove (*Bruguiera gymnorrhiza* and *Rhizophora mangle*), and strawberry guava (*Psidium cattleianum*). Because the seeds of many invasive plants persist for years, full eradication is exceedingly difficult and, after a species becomes established, the economic implications of long-term management and control efforts can become considerable. Some species such as mangrove, while protected and considered beneficial in many places in the world, are invasive and degrade wetlands and estuarine habitats and displace native plant communities in Hawai‘i.

Uncontrolled ungulates (hooved animals) are another major threat to native habitat. Ungulates in Hawai‘i include pigs (*Sus scrofa*), goats (*Capra hircus*), sheep (*Ovis aries*), mouflon sheep (*Ovis musimon*), Columbian black-tailed deer (*Odocoileus hemionus columbianus*), and axis deer (*Axis axis*), and to a lesser extent, feral cattle (*Bos taurus*). The Department of Land and Natural Resources (DLNR) has a dual mandate to conserve, manage, and protect indigenous wildlife and endangered species and their ecosystems, and to preserve, protect, and promote public hunting. These dual and often conflicting mandates involve managing indigenous wildlife and endangered species inhabitants that are essential for their long term viability, managing ungulate populations to control or eliminate them in habitat and places necessary to sustain and conserve native plants and wildlife, and managing game programs in appropriate areas that are not essential for

sustaining native plants, wildlife, and ecosystems. DLNR is authorized to manage and provide appropriate habitat for both these mandates. The focus of this plan is the conservation of native wildlife, endangered species, and their ecosystems; therefore, we focus on the damaging effects of ungulates and the ungulate control programs implemented by agency staff.

Ungulates directly and indirectly affect native ecosystems in a variety of ways. Effects include damage caused by grazing and browsing, trampling of seedlings and benthic aquatic invertebrates, non-native seed-dispersal, soil disruption, and increased erosion. These activities can affect the amount of light and moisture levels within forests, as well as nutrient cycling, and result in modified or destroyed plant and animal communities, decreased water retention of soils, erosion, and decreased water quality. In addition, pigs have been observed destroying the nests of ground-nesting native birds (e.g., nēnē). Pigs are also linked to the spread of mosquito-borne avian disease (i.e., pig wallows create mosquito breeding habitat) and the fungal pathogens *Ceratocystis lukuohia* and *C. huliohia*, which attack and can quickly kill native ʻōhiʻa (*Metrosideros polymorpha*), a tree species that comprises approximately 80% of Hawaiʻi's native forest.

Because Hawaiʻi's native plants evolved in the absence of ungulates, they lack common defenses such as thorns or toxins. Thus, grazing and browsing animals often prefer native plants over non-native plants, which has contributed to the extinction, decline, and extirpation of many native plant species and populations. Even low-intensity browsing can affect the species composition of habitats and encourage a shift in dominance from native toward non-native species. Non-ungulate herbivores, such as rabbits (*Oryctolagus cuniculus*) and rats (*Rattus* spp.), can also have significant impacts on native flora.

Soil disturbance by rooting animals (typically pigs) occurs throughout Hawaiʻi and favors the germination and establishment of alien plant species, many of which are adapted to such disturbances and may require disturbance to complete their life cycle. Conversely, native species are not adapted to such disturbances and tend to be negatively affected. This in turn affects the composition of plant communities, which indirectly affects the animals that depend on the community; effects on native invertebrates may be particularly acute due to their reliance on host plants for nutrients, shelter and reproduction. Removal of ungulates is often the first step in ecosystem restoration and usually results in the recovery of native habitat, as well as the decline of particular alien plants.

The effects of ungulates on native habitats varies across the landscape, dependent on population levels of animals and type and level of any control measures being used. Subalpine communities have been and continue to be affected by uncontrolled numbers of feral goats, mouflon sheep, and feral pigs. Montane and lowland mesic forests on Maui, Molokaʻi, and Lānaʻi are affected by the spread of axis deer. Dryland forests have suffered greatly because of cattle and goats. Feral pigs typically affect wetter communities, and their effects are widespread throughout the islands. Control of animal populations is difficult and expensive, given high rates of reproduction, the ability of these animals to hide and move, and limitations on access. Where effective control measures can be implemented, habitats can and do recover.

Invasive algae species have become a threat in recent years, affecting the marine ecosystems of all islands. These organisms can outcompete and overgrow native algae species, kill corals, and significantly alter the structure of local coral reef communities. Nearshore eutrophication (water pollution caused by excessive nutrients that stimulate excessive plant growth) from non-point source pollution or leaking cesspools and sewage systems may contribute to the explosive growth of non-native algae. Leeward areas of Maui and areas in Kāneʻohe Bay, Maunalua Bay, and Waikīkī, Oʻahu, have experienced algal blooms or have growing invasive algae populations. Another marine invasive, snowflake coral (*Carijoa riisei*), outcompetes and overgrows native coral species, possibly including precious black corals found in deeper waters off Maui.

Introduced Predators

Hawaiʻi's terrestrial animals evolved in the complete absence of mammalian predators and are extremely vulnerable to depredation by rats, such as the roof rat *(Rattus rattus*) and the Norway Rat (*Rattus norvegicus*), feral cats (*Felis catus*), and the small Indian mongoose (*Herpestes auropunctatus*). All of these species prey on eggs, nestlings, and adult birds. Rats are implicated in the severe decline in native bird and tree snail populations that occurred in the late 1800s and early 1900s. Rats are ubiquitous throughout the state, preying on seabirds, waterbirds, and forest birds. They readily climb trees to prey upon canopy-nesting bird species, native tree snails, and other native invertebrates. Rats also eat the seeds of a large number of native plant species, severely limiting their regeneration. Feral cats are extremely skilled predators and are responsible for the extinction of birds on islands worldwide. In Hawaiʻi, cats are widely distributed on all of the Main Hawaiian Islands (MHI) from sea level to high elevations. While a single cat can have a devastating effect on a breeding seabird colony, "cat colonies" pose an even greater threat to bird populations because of their concentrated numbers. Furthermore, cats (domestic and feral) are known carriers of toxoplasmosis, a parasitic infection that is easily spread via feces through watersheds, streams, and coastal waters and is considered a threat to nēnē and other wildlife, including Hawaiian monk seals. Although less arboreal than rats, mongooses also are efficient predators. With few rare exceptions, populations of nēnē, waterbirds, and seabirds do not persist long in areas where mongooses are present. Presently, high densities of feral cats, rodents, and mongooses are a major cause of mortality among native birds and may place similar pressures on native terrestrial invertebrates. In general, native bird species have low reproduction rates, so increased predation can be particularly problematic.

Other predators that pose ongoing threats to native bird species include feral and unleashed dogs (*Canis familiaris*), cattle egrets (*Bubulcus ibis*), barn owls (*Tyto alba*), bullfrogs (*Rana catesbeiana*), and pigs. Fortunately, snakes have yet to become established on the islands. Given that the brown tree snake effectively caused widespread extinction of Guam's avifauna, it is expected that the successful establishment of predatory snakes in Hawaiʻi would have equally devastating consequences. The introduced Jackson's chameleon (*Chamaeleo jacksonii*) preys on native snails and is an identified problem for endangered Oʻahu tree snail populations and native land snails on the other islands.

Introduced fishes have been documented to prey on native freshwater fishes and invertebrates. Tilapia (*Oreochromis mossambicus*) is a farmed aquaculture species that became invasive after it was intentionally introduced or escaped to streams, lakes and ponds. An incredibly hardy species in the family Cichlidae, Tilapia can survive in a diversity of aquatic habitat types and consumes

native fish and invertebrates. Mosquito fish (*Gambusia affinis)* is another species known to predate native aquatic invertebrates and has caused the local extirpation of native *Megalagrion* damselflies across their ranges. Introduced frogs such as the coqui (*Eleutherodactylus coqui*) and Japanese wrinkled frogs (*Glandirana rugosa*) prey on aquatic and terrestrial invertebrates, and bullfrogs prey on native freshwater fishes, invertebrates, and even waterbirds. Anchialine ponds and streams are threatened by introduced fishes and crustaceans that prey on native shrimp and amphipods and alter the habitat structure.

Over the last 200 years, introductions of invasive invertebrate predators have occurred extensively throughout the archipelago. Notably, no social insect species (ants, wasps, termites) are native to Hawai‘i, therefore the endemic flora and fauna have evolved in their absence. Ants are efficient generalist predators in every habitat in which they occur, and their presence in native Hawaiian ecosystems has wide-ranging effects. Yellow-crazy ants (*Anoplolepis gracilipes),* big-headed ants (*Pheidole megacephala*), and Argentine ants (*Linepithema humile*) are a few examples of species which have been documented to invade low, mid, and high-elevation (including subalpine and alpine ecosystems) ecosystems. Ants directly predate native arthropod species, as well as increase the success of non-native arthropod pests and weeds. This, in turn, can reduce the growth and survivorship of native host plants. Ants can also impact the survivorship of native vertebrate species. Yellow-crazy ant infestations in seabird nesting areas are correlated with long-term vision impairment or vision loss in chicks, and increased rates of nest abandonment by parents. Tropical fire ants (*Solenopsis geminata*) have been observed to sting and bite nesting seabird chicks, causing deformities which can result in mortality.

The western yellow-jacket wasp (Vespula pensylvanica) is another invasive social insect that preys on native arthropods. Their distribution across mid to high elevation forest habitat has been documented to have community-level ecological effects, as yellow-jackets not only predate native arthropods, but also compete with native pollinators for floral resources. A diversity of non-native parasitoid wasps have also been accidentally or intentionally introduced to Hawai‘i. Parasitoid wasps affect nearly every taxonomic insect group, and can utilize the egg, immature, or adult life stages. Generalist parasitoid wasps have been shown to be significant mortality factors for native moth species, reducing diversity and abundance in native ecosystems. Declines in native moths have been linked to subsequent declines in native birds that prey on them.

The introduced carnivorous snail (*Euglandina rosea*) and flatworm (*Platydemus manokwari*) prey on native tree snails and have decimated populations of endangered O‘ahu tree snails. *Euglandina rosea* is a carnivorous land snail native to the southeastern United States. It was introduced to Hawai‘i in the 1950s as a biological control agent to manage the invasive giant African snail (*Achatina fulica*). However, instead of targeting the intended species, *Euglandina rosea* began preying on native Hawaiian tree snails, including many species from the genus Achatinella, which are endemic to Hawai‘i and have been declining due to habitat loss, predation, and overcollection. *Platydemus manokwari* is a predatory land flatworm native to New Guinea. It has been spread to numerous Pacific islands, including Hawai‘i, primarily through the horticultural trade. The flatworm is known for preying on terrestrial snails and has contributed to the decline of many snail populations worldwide.

Disease, Disease Carriers, and Pathogens

Viral, bacterial, fungal and parasitic diseases affect native Hawaiian wildlife. The introduction of novel diseases, disease-vectors, and disease-causing parasites and pathogens is a significant risk to all native wildlife in Hawai‘i. Introduction of novel diseases such as West Nile Virus, or Avian Influenza (HPAI) could have devasting impacts on Hawaiian avian wildlife as well as having human health implications. Isolated islands and archipelagos like Hawai‘i can initially act as refuges from parasites and disease-carrying vectors. However, the introduction of these vectors can allow new diseases to become established or enable existing ones to spread. A notorious example is how island species, having evolved in isolation without exposure to many diseases, often lack natural resistance when novel pathogens are introduced. However, this can make species highly vulnerable when new diseases are introduced. Most notoriously, the introduction of mosquitoes (southern house mosquito, *Culex quinquefasciatus*) to the Hawaiian Islands in 1826. This, and the arrival of avian malaria in the early 20th century (*Plasmodium spp.*) had a profound effect on native forest birds and continues to affect the distribution and abundance of many bird species. By serving as vectors for avian malaria (*Plasmodium relictum*) and avian poxvirus (*Poxvirus avium*), the southern house mosquito and other mosquito species effectively spread these diseases throughout lowland areas. Many species of introduced birds now present in Hawai‘i as well as surviving native birds provide effective reservoirs for these diseases (Seidl, 2023), allowing them to persist and spread widely. For native birds that had evolved in the absence of these diseases for millions of years, the impacts have been severe. Since the introduction of mosquitoes over the last 200 years, many bird species have gone extinct due to the high mortality rate caused by avian malaria. Today, most of the remaining native forest birds only persist at elevations above 1,600 meters (5,200 feet), where cool temperatures limit mosquito and disease development, however, climate change and warming temperatures have expanded the elevational range of mosquitoes and effectively reducing the remaining malaria-free habitat available for forest bird refugia.

A few species of native birds have begun to recolonize lower elevations where avian malaria and poxvirus are common, indicating that at least some species may be developing resistance to these diseases. New vectors of mosquito-borne diseases are also of concern. On the islands of Hawai‘i, O‘ahu, Kaua‘i and Maui, the recent establishment of *Aedes japonicus*, the state’s first truly temperate mosquito, may further extend the range of some novel mosquito-borne disease (i.e., West Nile virus) into currently mosquito-free high elevation forests. This mosquito species also vectors several diseases of human concern, including Japanese encephalitis, Zika virus, dengue, and chikungunya. It’s important to note that avian pox can also affect other types of birds in addition to forest birds, and that spread among birds, like in the case of seabirds, can occur through direct bird to bird contact rather than via mosquito.

Avian botulism, a disease caused by a bacterial toxin, is an established disease that impacts native birds during periodic outbreaks. Avian botulism is the most prevalent disease in Hawai‘i for native waterbirds and a major threat due to the broad spectrum of species affected and the frequency and increasing geographic area of occurrence. The species most commonly affected by avian botulism include endangered waterbirds, and some botulism outbreaks have the

potential for mass die-offs of birds. Preparation and readiness for early detection of an outbreak and quick response is critical to minimize the impact on endangered species.

Avian Influenza (HPAI) was detected in Hawai‘i in 2024 in a private animal sanctuary as well as in wild ducks. Persistence in introduced bird species and further introduction via migratory birds or domestic animal import make this a disease of concern due to potential devasting impacts on native birds. Knemidokoptic mange has been diagnosed in Hawai‘i ‘amakihi (*Hemignathus virens*) on Hawai‘i island. Toxoplasmosis is a parasitic pathogen that requires an intermediate host such as cats. It is an easily transmitted pathogen and is considered a significant threat to nēnē, ‘alalā, and other native bird species. Toxoplasmosis can also infect and cause mortality in the Hawaiian monk seal, other marine mammals, and poses a significant risk for human health.

Viral, bacterial, and fungal pathogens which infect native insect species have also been introduced to Hawai‘i. The extent of such introductions is largely unknown, given that little historical or contemporary research has been conducted on entomopathogens of native species. However, extensive studies have been conducted to catalogue and study pathogens which affect the health of European honeybees (*Apis mellifera*) given the role they play in crop pollination services and honey production worldwide. This body of information allowed Hawai‘i researchers to conduct exploratory screenings of endangered, yellow-faced bees (*Hylaeus anthracinus*), resulting in the identification of several putative pathogens and two disease-causing pathogens from bee specimens: *Ascosphaera,* a genus of fungi which causes chalkbrood, and *Paenibacillus* a genus which includes bacteria that causes American foulbrood disease.

Disease threats are not limited to terrestrial fauna. Many species of corals are susceptible to disease and diseases affecting corals are increasing in Hawai‘i. There is also concern that some diseases may be associated with invasive species or other introduced vectors. Research suggests that reduced resiliency of corals affected by thermal and ultraviolet (UV) stress and bleaching events may amplify or exacerbate disease prevalence, all of which are believed to be associated with climate change. Many bacterial, fungal, and protozoan diseases are known to affect Hawaiian stony corals; these include cyanobacterium, black band disease, yellow band disease, and acute Montipora white syndrome. These diseases are occurring more frequently and are showing up in widespread portions of Hawai‘i, with severe recent outbreaks on Kaua‘i, Maui and in Kāne‘ohe Bay of Oahu. Green sea turtles, or hōnu (*Chelonia mydas)* in most areas suffer from fibropapilloma, a poorly understood tumor-causing disease associated with Chelonid herpesvirus 5 (ChHV5). With little natural resistance to disease, Hawai‘i’s native fauna is expected to be highly susceptible to these stressors, and preventing the establishment of new diseases is a top priority need.

Plant disease can threaten an entire watershed. Rapid‘ōhi‘a death (ROD), originally classified as *Ceratocystis fimbriata*, is now described as two new species: *Ceratocystis lukuohia* (a vascular wilt disease responsible for most ohia mortality) and *Ceratocystis huliohia* (a canker disease that's less aggressive), causes the native ‘ōhi‘a trees to die within a few weeks. While *C. lukuohia* has been detected in forests throughout Hawai‘i island, the only other island where it has established is Kaua‘i. *C. huliohia* has been detected once on Maui where it was removed, and in a dozen locations across O‘ahu. On Hawai‘i island where the disease has been found in most

forests, areas where feral animals have been managed through fencing and removal experience lower disease occurrence than areas with unmanaged animal populations. Invasive virulent diseases such as the rapid ʻōhiʻa death that affect keystone forest trees like ʻōhiʻa can be catastrophic, not just for the affected species but for the entire watershed.

Ecological Consequences of Climate Change

Global climate change is anticipated to have multiple and disastrous effects on Hawaiian wildlife. For example, sea level rise (SLR) will inundate the Northwestern Hawaiian Islands (NWHI), reducing habitat for nesting seabirds, native passerines, monk seals, and sea turtles, and altering coastal habitats throughout Hawaiʻi. Temperature increases will allow avian disease pathogens and vectors to expand their ranges to higher elevations, and will increasingly dry out wet forest habitat upon which kāhuli tree snails, picture-wing *Drosophila* and other invertebrates depend. Consequently, the small areas that currently support the last remaining populations of many rare native species will continue to shrink. Hawaiʻi could experience increased frequency of El Nino/Southern Oscillation (ENSO) events, resulting in amplified drought that could impact both wildlife and habitat. ENSOs may have implications for marine wildlife as well. Increases in ocean temperatures could affect invertebrate and fish populations, which would in turn impact seabird and other marine wildlife populations. Increases in seawater temperature also contributes to the phenomenon of coral bleaching, in which corals temporarily or permanently expel their symbiotic algae, potentially resulting in the death of the corals.

The boreal summer of 2024 caused unprecedented high sea-surface temperatures in the north Pacific. A widespread coral bleaching event occurred throughout the state when sea temperatures spiked at 86 degrees F (30 degrees C). Coral in shallow waters off Oʻahu, Kauaʻi, and Maui were most affected, and bleaching was also observed on several reefs in the NWHI. Increased carbon dioxide has caused the acidity of the ocean to increase, making it more difficult for corals and mollusks to form skeletons and shells. Increased UV radiation could also harm native wildlife and may be correlated with coral bleaching. Detrimental effects to Hawaiʻi's native wildlife and habitats because of global climate change are anticipated, in many cases have already begun, and are expected to continue and intensify. The anticipated effects are discussed below.

Marine and Estuarine Ecosystems

Altered food web. Coastal food webs will be affected by loss of coral reef or coral reef complexity (see discussions of ocean acidification and coral bleaching below), which are important components of habitat for fish. Most important to pelagic food webs will be the increased stratification of the upper water column that would come with increased sea-surface temperatures. With increased stratification, it is more difficult for nutrients to be incorporated into surface waters, causing decreased productivity. The changes in stratification in waters around the Hawaiian Islands would not be as great as in the western Pacific, where alteration of tuna life history is expected to be important. Regardless, there remains a huge amount of uncertainty about how climate change may affect fish populations and fisheries among the Hawaiian Islands (Nicol et al. 2014, Kenner et al. 2012). In response to warming ocean waters, the subtropical biome, in which the Hawaiian Islands are embedded, is expected to expand in area (Polovina et al. 2011).

Ocean acidification. As atmospheric CO_2 levels increase, more CO_2 is absorbed by the ocean, particularly in the cold regions. This leads to increased acidification of ocean waters, which, upon reaching critical levels, interferes with calcium carbonate formation and ultimately with the shell development of many planktonic organisms, shellfish, and corals. Such an effect would have negative implications for pelagic snails and pteropods found in subtropical and tropical waters, which represent important prey for some fishes and seabirds, and for coral formation.

Coral bleaching and disease. Healthy coral reefs provide habitat for marine organisms and protect coastal areas and oceanic islands from storm surges. A number of factors can affect coral health, but the one most related to climate change is coral thermal bleaching. Coral bleaching occurs when symbiotic zooxanthellae or the photosynthetic pigments of zooxanthellae are lost. This can lead to reductions in growth and reproduction, and, if severe, death. The most important factor leading to mass bleaching events is increased sea-surface temperature.

So far, most coral bleaching events in Hawai‘i are associated with the warm phase of ENSO when warming surface waters move into the central Pacific Ocean. The first documented, large-scale coral bleaching event occurred in 1996, and was most prevalent in Kāne’ohe Bay, O‘ahu; subsequent bleaching events occurred, mainly among the NWHI, in 2002 and 2004 when ocean temperatures reached 1–2ºC above normal (29ºC); research expeditions were implemented in response to the event to document the effects on NWHI coral reef ecosystems and determined that Kure, Midway, and Pearl and Hermes Reef were most affected. Within a few months, most of the affected coral was able to recover healthy pigment and growth capacity. Winter storms and large seas provided cooling ocean circulation and flushing of many shallow sections of low-lying reef systems, enabling normal temperature ranges to be reestablished. Smaller bleaching events continue throughout the Hawaiian Islands; a widespread incident was documented in the MHI in 2014 (DLNR 2014b). Sea-surface temperature increases are expected to continue in Hawai‘i. Most recently, coral bleaching again occurred in 2019. Researchers predict that bleaching events, which occur when average temperatures are 1ºC or more above average, will occur with increasing frequency and severity in Hawai‘i. Research suggests that corals affected by climate change–related bleaching events and thermal and UV stress may have reduced resiliency and be more susceptible to disease.

Flooding. The low-elevation NWHI, especially Midway, Laysan, and Kure, will be subject to increased flooding and storm surge associated with SLR (Keener et al. 2012, Reynolds et al. 2012). For example, modeled effects of SLR indicate that 12 percent of emergent land at French Frigate Shoals will be lost with a SLR of 1 meter (3.3. feet) (Reynolds et al. 2013). However, short-term flooding events are also important. In the last severe tsunami event of 2011, many seabird nests were lost among the NWHI; for example, an estimated 38 to 45 percent of active Laysan and Black-footed albatross (*Phoebastria immutabilis* and *Phoebastria nigripes*) nests were destroyed (Flint et al. 2011). Endemic species such as the Laysan duck (*Anas laysanensis*) would be vulnerable; beach habitat that is especially important to Hawaiian monk seals and sea turtles would be lost or severely altered as SLR-induced flooding becomes more frequent and acute.

In the MHI, increased frequency of flooding events affecting coastal estuaries will result in increased salinity in coastal wetlands and may affect many existing wetland wildlife sanctuaries, with consequent changes in the flora and fauna (Keener et al. 2012). Similar impacts will occur in anchialine pond complexes, which require mesohaline water to support existing biodiversity. The increasing frequency and intensity of storm surges will also facilitate movement of invasive species into previously uninvaded coastal areas. Altered coastlines are at increased risk of flooding, while undeveloped natural areas are naturally more resistant to flood events. During the tsunami event in 2011, the Kealia Pond National Wildlife Refuge on Maui received considerable ocean water injection and drained for two weeks through a surge channel, flooding the wetland and opening a direct connection to shoreline waters but causing no apparent harm to wildlife.

Terrestrial Ecosystems

Vegetation. The low islands among the NWHI contain endemic plant species and communities that are particularly vulnerable to climate-related impacts, owing to the islands' small area, low elevation, and homogeneous topography. Coastal plant communities in the MHI will also be impacted by rising sea levels and coastal erosion, in addition to factors such as rising temperatures, and changing rainfall and wind patterns, which all plant communities will be subject to. Climate change impacts are expected to interact with non-native species invasions (Walther et al. 2009, Mainka and Howard 2010), which will likely intensify impacts on island ecosystems and amplify the challenges of management and control of invasive species (Harter et al. 2015).

Habitat restriction. Among the higher-elevation MHI, a significant portion of native plants are threatened by future climate conditions, owing to shifts or even complete losses of climatic niches of some species (Fortini et al. 2013). Some native plant communities may be able to expand up to higher elevation ranges as temperatures warm, but those at the highest elevations may have no place to go. Likewise, coastal communities will not be able to shift fast enough to stay ahead of sea level rise, given that coastal strand habitat is generally bounded by residential or commercial development, agricultural or otherwise denuded or degraded lands. Whether at the lowest or highest elevations, such habitat loss will disproportionately impact rare native plant and invertebrate species, such as yellow-faced bees, kāhuli tree snails, picture-wing *Drosophila* and alpine arthropods, which are already restricted to tiny pockets of the existing habitat.

Drought. Climate change models of rainfall for the Hawaiian Islands through the remainder of the century predict, on average, a decrease in rainfall and reduced availability of freshwater resources (Timm et al 2015). The models predict that most areas will have a decrease in wet-season rainfall, with the exception of the trade wind–dominated wet regions along and above the eastern slopes of the mountains, which are expected to see slight increases or remain stable in rainfall amounts. The leeward, climatically dry areas of the islands are predicted to have dryer than normal conditions during both the wet and dry season.

Rare plants, arthropods (herbivores and pollinators in particular), kāhuli tree snails and birds are very susceptible to drought conditions and cumulative drought stress. Prolonged drought conditions affect wildlife populations by reducing native habitat vegetative structure and food production and are occurring now. On the leeward dry side of Maunakea in palila (*Loxioides*

bailleui) critical habitat, drought conditions occurred during 74 percent of months during an 11-year period (from 2000 to 2010), and in 52 of 54 months after June 2006 (Banko and Farmer 2014). Chronic drought conditions on Maunakea have contributed to the recent decline of the endangered palila and other native birds (Banko et al. 2013). Palila survival and reproduction are closely tied to the species' primary shelter and food source, māmane (*Sophora chrysophylla*). During the driest drought year, māmane seed pod production was reduced 76 percent in comparison to production during the wettest, drought-free year. Prolonged drought can also reduce the structure and density of dry forest trees, further reducing food and shelter availability.

Another impact associated with drought is the increased risk of wildland fire, which potentially has even greater catastrophic effects and may extirpate a species or population in one event. A large fire on Maunakea could sweep through the core habitat and core population of the palila, leading to the extinction of this species. Wildland fire running into forested areas on Oʻahu would similarly affect populations of endangered Oʻahu tree snails, now reduced in distribution and abundance to a single or a few isolated populations. Predicted drying conditions from climate change will increase the length and severity of drought and increase the risk of future wildland fire, affecting wildlife populations.

Disease. Native forest bird species, already having been largely extirpated owing in part to avian malaria, will continue to be affected by this disease. Most remaining native forest bird species are found only in the forested upper slopes of the MHI. Increasing temperatures, moving up slope, will greatly expand the higher-elevation viability and thus range of mosquitoes and the diseases they transmit (Benning et al. 2002, Atkinson and LaPointe 2009, Atkinson et al. 2014). This trend underscores the need to protect high elevation refugia for susceptible native birds and to conduct forms of mosquito control that reduce disease prevalence. Some populations of the ʻamakihi have developed infection survival mechanisms to malaria and now are found again in lowland habitats (Foster et al. 2007, Eggert et al. 2008, Atkinson et al. 2013, Neddermeyer et al. 2023), indicating disease resistance may evolve. This potential further emphasizes the need to protect, restore, and manage an elevational range of forests that provide habitat in which native birds can survive in the face of climate change.

Species Vulnerability Assessments in Response to Changing Climate

Current research efforts focus on two main approaches to determine the potential impacts of climate change on individual species: estimating species vulnerabilities and projecting responses of species to expected changes. Vulnerability assessments are essentially syntheses of available information that are used to determine the potential impacts of a threat (e.g., climate change) on species of interest. Typically, vulnerability assessments attempt to determine species' vulnerability by estimating species' exposure to climate change, their sensitivity to such changes, and their adaptive capacity to respond to change. Over the next several decades, Hawaiʻi's flora and fauna are expected to be affected by changes in temperature, precipitation, and sea level, and the effects of these changes will be greatly exacerbated by existing non-climate stressors, such as competition with and predation by non-native species, fragmentation of habitat resulting from expanding land uses, and disease.

Studies examining the effects of SLR on low-lying coastal wetlands in the MHI indicate that increased water levels, erosion, salinity, and flooding associated with SLR threaten habitats of

endangered waterbirds, sea turtles, Hawaiian monk seals, and migratory shorebirds. The rate of impact caused by SLR flooding is modeled to rapidly accelerate once the height of the sea surface exceeds a critical elevation. Estimating the critical elevation marking the end of slow flooding and the onset of rapid flooding will help wetland decision makers to plan and develop management strategies to meet the challenges presented by climate change.

Forest birds in Hawai‘i face an uncertain future as the effects of climate change exacerbate existing threats caused by disease and the steady loss of habitat. Increases in mean temperature, declining precipitation, and changes in stream flow associated with climate change appear to be allowing the upward spread of mosquitos and increased transmission of avian malaria to highly susceptible native forest birds. On Kaua‘i this situation is especially dire: populations of the endangered ‘akikiki (*Oreomystis bairdi*) and ‘akeke‘e (*Loxops caeruleirostris*) have declined to near-extinction and other more common native forest birds have retreated to the last high-elevation habitat (Paxton et al. 2016). This pattern is expected to occur across all the islands and increases in prevalence of malaria is occurring at even higher elevations on Hawai‘i at Hakalau National Wildlife Refuge (Freed et al. 2005). Native bird populations on the lower islands, such as Kaua‘i and Maui, are at increased risk; in particular, species with greater susceptibility to avian malaria are at extreme risk. Experts estimate that four species are expected to become extinct within the next decade: ‘akikiki and ‘akeke‘e on Kaua‘i and kiwikiu (*Pseudonestor xanthophrys*) and ‘ākohekohe (*Palmeria dolei*) on Maui (Paxton et al. 2022).

It cannot be overemphasized that effects of climate change are closely associated with, and often greatly exacerbate, the impacts associated with non-climatic anthropogenic-assisted stressors. Thus, future vulnerability assessments and management considerations need to consider this relationship in the development of management strategies to deal with climate change variables in Hawai‘i.

Natural Disaster

Because many Hawaiian plant and animal species persist in low numbers or in restricted ranges, natural disasters, such as hurricanes, volcanic eruptions, or tsunamis, can be particularly devastating. For example, several species of forest birds endemic to Kaua‘i suffered significant declines in population or have not been seen since Hurricanes Iwa (1982) and Iniki (1992), and volcanic eruptions from Maunaloa on the island of Hawai‘i in 1984 destroyed quality habitat for island-endemic forest birds. Additionally, as previously mentioned, up to 45 percent of albatross nests in the NWHI were destroyed by a tsunami in 2011 (Flint et al. 2011).

Overharvesting and Excessive Extractive Use

Excessive extractive use constitutes a threat to other wildlife as well. Certain reef fishes were harvested for sale in the aquarium trade, and freshwater and marine fishes and invertebrates were collected for subsistence, recreation, and commercial purposes. A 2015 incident of mass harvest of sea cucumbers (class *Holothuroidea*) from nearshore waters on Maui and O‘ahu prompted passage of an emergency rule to immediately stop the commercial harvest until the Division of Aquatic Resources (DAR) can better understand the impacts of large-scale removal of sea cucumbers on the fishery and aquatic environment. Commercial aquarium collection in Hawaii

has been illegal since January 30, 2023. This is the result of a court order that halted aquarium collection in West Hawai

Commercial and recreational harvest of other reef and marine species such as cowry (*Cypraea* spp.), sea urchins (class *Echinoidea*), and ʻopihi (*Cellana* spp.) is common. Native plants and snails that may be important food sources or habitat for native birds and invertebrates are illegally collected for lei making, flower arrangements, jewelry, or herbal use. Logging of native koa (*Acacia koa*), ʻōhiʻa (*Metrosideros polymorpha*), and hāpuʻu tree ferns (*Cibotium* spp.) removes important components of a native forest. These activities are not sustainable on a large scale and impact native wildlife.

Recreational Overuse and Tourism Effects

The cumulative impact of human interaction with native species and habitats is a growing concern. Most attention recently has centered on marine activities, including interacting with protected marine species such as dolphins and turtles. Excessive trampling of coral reefs, tide pools, and other shoreline areas by recreational users directly kill many marine organisms or indirectly kill their algal or invertebrate food sources. On land, recreational overuse is also an emerging concern. An increase in the popularity of guidebooks and Internet sites that reveal the locations of sensitive habitats to more people has increased visitation in these areas. Many sensitive habitats such as anchialine ponds, lava tube and cave systems, coral reefs, and offshore islands are compromised or outright destroyed by the presence of people. Off-road vehicles in coastal dune ecosystems degrade habitat for native plant communities and nesting seabirds.

Uneven Compliance with Existing Conservation Laws, Rules, and Regulations

Enforcement of conservation laws remains a concern for the well-being of native wildlife populations. Although the situation has improved markedly, the two areas contributing to wildlife threats—limited enforcement capacity and lack of public respect for protecting native wildlife—still present challenges for conserving fish and wildlife resources. Limited funding restricts the State's capacity to enforce existing laws, rules, and regulations protecting native wildlife and habitat. The DLNR Division of Conservation and Resource Enforcement (DOCARE) has historically been understaffed and underfunded for the mandates it must carry out. DOCARE's annual budget was $7.4 million with 124 positions in 2005, $10 million with 131 positions in 2012, $12.4 million with 143 positions in 2015, and $15.1 million with 153 positions in 2023. Funding is improving but still remains limited for the agency's vast responsibilities. DOCARE is responsible for patrolling and monitoring approximately 1.2 million hectares (3 million acres) of marine waters, the largest tropical forest in the nation, 485,600 hectares (1.2 million acres) of state-owned lands, 809,400 hectares (2 million acres) of regulated Conservation District lands, and 9,300 hectares (23,000 acres) of inland surface waters. Throughout the state, DOCARE officers serve more than 1.2 million of Hawaiʻi's citizens and more than 6 million visitors who use or visit these resources on a regular basis. At the same time, the agency is tasked with additional duties beyond resource conservation (e.g., Homeland Security actions).

Funding limitations affect the agency's ability to provide services and the public's perception of enforcement capability. During the economic downturn in 2008, the enforcement budget for fuel, vehicles, equipment, weekend, and night work was slashed from $2.1 million to $577,000.

Officers were not able to adequately respond to complaints, and consequently, there was severe criticism and public perception that the State was not able to effectively enforce conservation laws. As a result, voluntary compliance suffers as the public sees few consequences for violations. Within the past 15 years, there have been cases of shooting of monk seals on Kauaʻi, illegal introduction of axis deer to Hawaiʻi, and vandalism of 2 miles of ungulate-control fencing on Hawaiʻi. Poaching of native wildlife and other violations of conservation laws, rules, and regulations are a direct threat to native wildlife and their habitat.

Public support for protection of wildlife and natural resources has improved where community groups have taken responsibility for protection of resources. DOCARE has responded and developed new community outreach programs to increase enforcement capability. DOCARE started the Makai Watch program to train community volunteers to observe and report violations in their communities. The Makai Watch program is being expanded throughout the state. In 2013, DOCARE started the Maui Community Fisheries Enforcement Unit, a pilot program involving community support and increased DOCARE enforcement. DOCARE placed three officers, a Makai Watch coordinator, a program coordinator, and a data manager, on Maui's north shore to stop illegal netting activities through land and vessel patrols. Citations were issued and compliance increased dramatically. The program has since expanded to Hawaiʻi, Oʻahu, and Kauaʻi. In 2017, DOCARE launched the DLNRTip app, a smartphone application that allows members of the public to submit anonymous information about violations of any State resource conservation rules. The success of voluntary compliance depends heavily on local community involvement. DOCARE is expanding community-based education and management programs to give the local community an understanding of the importance and values of native wildlife and their habitat and a sense of pride and ownership that encourages community policing and voluntary compliance. In many locations, this level of community involvement is increasing.

Limited Information and Insufficient Information Management

A lack of information on the basic ecology and population dynamics for many Hawaiian native wildlife species was identified as a challenge in 2005. Much progress has been made. A great deal of field research and management has been done on forest birds on Maui, Kauaʻi, and Hawaiʻi, and on avian disease, seabirds throughout the islands, the Hawaiian hoary bat (*Lasiurus cinereus semotus*), monk seal, and invasive species. Yet resource managers are still faced with incomplete data and information on many species. Accurate population estimates for many Hawaiian waterbirds, seabirds, and fishes, and for most non-threatened or endangered invertebrate populations, are not available. Effective survey and monitoring techniques for many native invertebrates have not even been developed, making assessment of their populations and consideration of the consequences of proposed management actions or other activities problematic at best.

Huge gaps in knowledge exist for many native species. Population censuses cannot provide data on basic demographic parameters or determine threats to specific species. Such information is often necessary to direct management, especially for those species persisting at low populations. For example, for many Hawaiian species (some forest birds, Hawaiian hoary bat, and most invertebrates), virtually nothing is known about their reproductive behavior, demography, survival, or dispersal tendencies.

Gaps in information are often magnified by the challenges inherent in sharing information across institutions. Multiple agencies and organizations in Hawai‘i collect and manage data on a variety of species and habitats. This information is often collected in different formats and for different purposes. There are no comprehensive databases accessible to all. Building on existing efforts to centralize information storage in a spatial database could better identify data gaps, provide a more comprehensive view of the status of a particular species or habitat, and allow management decisions to be made using the most up-to-date and accurate information.

Management Constraints

While more than 50 percent of the land in Hawai‘i has been set aside for protection by the state or federal government or is managed as part of a watershed partnership, these lands are subjected to differing levels of conservation or management effort. Regardless of their jurisdiction and management goals, land managers face similar constraints, such as multiple use mandates, insufficient funds for day-to-day management, infrastructural challenges, regulatory hurdles, high numbers of visitors, and increasing demands for public access.

DLNR, the state agency charged with managing the state’s lands and waters, has multiple management responsibilities. For example, DLNR is charged with documenting and preventing illegal activities on public lands, conducting auctions to lease public lands, protecting and recovering indigenous wildlife and their habitats, preserving natural areas and protecting watershed resources, promoting public hunting, establishing and regulating public fishing areas, harvesting forest products, providing public lands for agricultural purposes, and generating revenue from the lease of state lands. While generally consistent, these multiple uses may not always facilitate strategic native wildlife conservation objectives. For example, a state lease for pasture use may degrade remnant native habitat or public hunting rules may not adequately control ungulate populations to meet the management needs for forest bird recovery and native plant protection. Efforts to identify inconsistencies in management guidelines and policies can be delayed by a lack of resources (technical, human, and financial) and the lack of effective working relationships with different resource user groups to jointly identify areas for dedicated conservation and areas for multiple use.

DLNR also is limited by infrastructural challenges; for example, the difficulty in recruiting and filling existing vacant positions on a timely basis and difficulty in getting legislative approval to add permanent personnel who coordinate new conservation actions is a significant constraint on management performance. Strict procurement rules and contracting procedures can delay the State’s ability to coordinate and carry out needed conservation actions. Other governmental agencies and non-governmental organizations face similar infrastructural challenges.

Unclear or lengthy regulatory processes constitute another management constraint. All state and federal projects require environmental review, and many may require state or federal permits. Obtaining state and federal endangered species take permits can be a lengthy and costly process for both public and private entities. Some progress has been made in streamlining environmental review processes. An exemption from the requirement to prepare a State Chapter 343 environmental analysis has been provided for most conservation fencing and invasive species control projects implemented by DLNR.

The converse of time-consuming and costly permitting is a lack of adequate regulation, which presents a problem when trying to keep non-native species out of the state. Non-native plants and animals too often gain entry and become established because screening requirements are not placed upon key industries that intentionally or inadvertently introduce invasive species, such as shipping and horticulture. On a positive note, over the past ten years, 56 Hawaiian species that qualified for federal listing as threatened or endangered were added to the state and federal lists of threatened and endangered species and now receive additional regulatory protection.

Inadequate Funding

Limited funding to implement priority management actions to protect or restore wildlife and their habitats on federal, state, and private lands, to hire staff to coordinate these projects, to conduct research and monitoring, and to enforce the laws is a significant constraint and challenge for effective wildlife conservation in Hawai‘i. This is complicated by grant programs that have varying eligibility requirements (such as private land ownership, former farmland, species extinction risk factors, agency geographical boundaries, or requirements of national initiatives like “save the pollinators”). These factors contribute to opportunistic conservation on a piecemeal basis based on funding availability, rather than addressing needs in order of biological priority. However, this is the reality of natural resource conservation program funding; the agencies, conservation partnerships, nongovernmental organizations (NGOs), communities, and interested members of the public need to work together to better coordinate program development, funding advocacy, outreach to funders and to the community for support, project implementation, and reporting to support all agencies and efforts. One of the roles of this State Wildlife Action Plan (SWAP) is to assist in that collaboration by identifying broad strategies, needs, and opportunities that can fit into various program funding initiatives and eligibility requirements.

The largest landowner of important habitat for native plants and animals in Hawai‘i is the State. However, as discussed earlier in Chapter 3, the amount of state funds dedicated to conservation of native wildlife and their habitats is conservatively estimated at $50 million dollars annually, while annual funding requirements estimated for the recovery of forest birds alone are more than twice this amount. Costs associated with the recovery of endangered marine mammals, sea turtles, seabirds, waterbirds, plants, and invertebrates would add tens of millions more per year. Although much of the state funding is matched by federal funds (e.g., Endangered Species Act Section 6 grants and State Wildlife Grant funds) to support conservation programs, it still is inadequate to address the current wildlife conservation needs in Hawai‘i, let alone effectively deal with future new threats and challenges, such as the introduction of new invasive species or impacts of climate change. It is yet to be seen if the federal government will rise to the challenge of adequately funding national programs to protect our current natural resource treasures, and also to provide the funding to meet the challenges of the future, such as mitigating the detrimental impacts of climate change. If that does happen, states will be expected to likewise rise to the challenge and meet match requirements to receive federal funds.

To fulfill the ultimate mission of this plan and the responsibilities of the natural resource management agencies to “ensure protection of Hawai‘i’s wide range of native wildlife and the diverse habitats that support them,” an adequate, stable, and dependable funding source is needed. There are many ways to achieve this; for example, dedicated funding sources such as a

share of a national or state revenue source can be established. The selected revenue sources could be linked to the benefits of having healthy and thriving wildlife and ecosystems—for instance, a portion of tourism revenue could be dedicated to wildlife conservation programs. Another method could be securing mitigation funding from an industry or activity that has a direct or indirect impact on wildlife and habitat—a portion of revenue from the transportation sector or energy production sector in the state could be dedicated to wildlife conservation programs.

In 2015, the Hawai‘i State legislature switched the funding base, from a dedicated special fund to annual general fund appropriations, for the Natural Area Reserve and watershed protection program, which provides a sizeable portion of state funding for wildlife conservation. This puts conservation programs in competition for funding with many other worthwhile general fund programs such as public health, public safety, and education. Although this switch provides a challenge to program managers by removing some of the certainty in funding and budgeting programs, it also provides an impetus to connect with the community and their representatives, talk about the reasons to fund core programs, and advocate and build the public support needed to retain and increase funding. It is yet to be seen whether the long-term support needed to fund natural resource conservation can be maintained and increased to meet the current and expanding needs identified in this plan.

With inadequate and variable levels of funding available for the implementation of this SWAP, objective and systematic planning to maximize outcomes is critical to success. Toward that aim, the 2025 update to this SWAP introduces a new approach to biodiversity conservation planning at the implementation level. The approach significantly advances effective conservation outcomes by developing a planning framework that enables managers to prioritize management areas and actions that will yield the highest conservation benefit per unit cost. The integrated landscape planning framework is presented in detail in Chapter 8, Implementation and Monitoring.

STATEWIDE CONSERVATION OBJECTIVES

The goal of this SWAP is to guide conservation efforts across the state to ensure protection of Hawai‘i’s Species of Greatest Conservation Need and the diverse habitats that support them. Given limited conservation dollars, implementation of conservation actions that benefit the largest numbers of the most vulnerable species and ecosystems are preferred. Hawai‘i’s SWAP update process reviewed the major threats affecting native wildlife and their habitat throughout the state and then defined major objectives and strategies to respond to these threats and improve native wildlife conditions. The following seven objectives have been identified as elements necessary for the long-term conservation of Hawai‘i’s native wildlife:

1) *Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive;*

2) *Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication;*

3) *Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs;*

4) *Strengthen existing and create new partnerships and cooperative efforts;*

5) *Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai'i;*

6) *Support policy changes aimed at improving and protecting native species and habitats; and*

7) *Enhance funding opportunities to implement needed conservation actions.*

Implementation of these seven objectives will allow resource managers and landowners to address the major conservation needs of Hawai'i's native wildlife. The objectives relating to the protection and restoration of habitats and the prevention and control of introduced species address many of the most direct biological threats to native plants and wildlife. The other objectives address somewhat more indirect needs arising from a lack of information, the need for improved coordination of efforts and funding, and management constraints. Because ecological problems are complex, there is overlap among these objectives. For example, much of habitat protection in the state involves invasive species control; more effective invasive species control requires more aggressive policies, cooperation among landowners, public support, and funding. This overlap underscores the necessity for a landscape-level, multiple-species approach to conservation of Hawai'i's wildlife. These seven objectives address the overall goal and the legislative mandate of the SWAP. Future assessment of their effectiveness as conservation tools is discussed in Chapter 8 (Implementation, Monitoring, and Adaptive Management).

Under each objective are listed specific strategies that encompass multiple direct conservation actions that must be applied in areas currently managed for wildlife conservation and in potential areas for future conservation management. All of the strategies are high priorities; however, those that are the highest priority are identified. Additional conservation strategies and actions are identified in Chapters 5 (Marine Conservation Needs), 6 (Island Conservation Needs), and 7 (Species of Greatest Conservation Need).

1. Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.

Protection of the remaining native species and ecosystems and restoration of additional native habitats are necessary to conserve Hawai'i's native wildlife for future generations.

<u>Highest priority</u>

- Adequately support the implementation of conservation management plans, guidelines, and actions within currently managed areas (e.g., National Parks, National Wildlife Refuges, National Marine Sanctuaries, Natural Area Reserves, Natural Area Partnership

Preserves, Forest Reserves, Watershed Partnership areas, Marine Protected Areas, landowner preserves, and other areas committed to native habitat and species conservation);
- For habitats on private land not currently protected and/or receiving management attention (e.g., middle reaches of stream corridors or coastal areas), encourage protection using appropriate tools, including acquisition, grant agreements, conservation easements, leases, technical assistance, development of safe harbor agreements or habitat conservation plans, and other tools; and
- Work with Commission on Water Resource Management to ensure net increase in number of streams with biological integrity and meeting Instream Flow Standards is sufficient to sustain viable native fish and invertebrate populations.

<u>High priority</u>
- Mitigate priority threats to prevent extinctions and recover species at risk of extinction, including feral ungulates, herbivores, predators, pests, competitors, diseases vectors, and pathogens.
- Remove introduced mammals (e.g., goats, pigs, deer, mouflon, rats, feral cats, mongooses) from important habitats to establish ungulate and predator free areas on each island;
- Develop and conduct mosquito control techniques in important forest bird habitats to minimize mosquito-borne disease transmission and mitigate extinction risk for native Hawaiian birds.
-
- Develop improved recovery and management plans to prioritize cost effective management, including multispecies implementation plans for species and ecosystems at risk;
- Implement effective habitat management through a variety of activities: landscape-level predator management; mosquito control, invasive plant control, fencing and ungulate removal, predator control, wetland enhancement, riparian restoration, native species out planting, fire threat mitigation, and management of human activity in sensitive areas;
- Identify and monitor populations of species at risk to ensure conservation actions achieve target objectives.
- Identify priority lands for which protection and management is needed to further the goals of this SWAP. Acquire those lands through purchase, donation, or set aside to be designated and managed conservation reserves.
- Relocate native wildlife species away from situations that pose a significant threat to public safety and to that of the wildlife species, to safe and appropriate locations;
- Support the development and implementation of statewide programmatic Safe Harbor Agreements and Habitat Conservation Plans;
- Decrease in number of stream diversions and channelized streams;
- Develop a handbook on restoration specific to Hawai‘i;
- More fully integrate conservation actions for plant. algae and invertebrate Species of Greatest Conservation Need (SGCN) into other plans that are being developed for resource management, including the Forest Action Plan, State Ocean Resources Management Plan, Watershed Partnership Management Plans, Species Recovery Plans, and future updates of the SWAP;

- Develop plans to respond to natural disasters and climate change; and
- Support the development of emergency preparedness and response to natural and man-made disasters such as oil and contaminant spills and diseases.

2. Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
Invasive alien species have the capacity to kill native species, degrade and destroy remaining native habitat, and eliminate native species. In January 2017, the Hawai‘i Invasive Species Committee (HISC) adopted Resolution 17-1 endorsing the Hawaii Interagency Biosecurity Plan and committing to its implementation. The Interagency Biosecurity Plan is the state's guiding document for biosecurity improvements over the coming decade. The HISC is responsible for tracking implementation of the Plan across agencies, and will report progress at least annually

<u>Highest priority</u>
- Increase inspection and biosecurity procedures and implement early detection and response measures to identify, prevent, and control high-risk invasive species and diseases (e.g., brown tree snake, West Nile virus) prior to entry into Hawai‘i or among neighbor islands. This must include implementation of appropriate measures for the vast online market, pet, poultry, agriculture, aquaculture, and horticulture and nursery industries, for domestic and international mail and shipments, especially from Asia, for military transport, and for the tourism industry.

<u>High priority</u>
- Continue coordination of invasive species prevention, management, and control programs for county, state, federal, and private sector entities through existing mechanisms, including the Hawai‘i Invasive Species Council, the Coordinating Group on Alien Pest Species, individual island invasive species committees, the Aquatic Invasive Species Management Plan, and topic-specific working groups (e.g., the Brown Tree snake Rapid Response Team);
- Review and revise existing screening procedures for the introduction of non-native plants and animals to move from a prohibition on specific listed taxa to a general prohibition on introduction except for identified taxa;
- Strengthen quarantine and treatment of imported plants, especially known vectors for non-native invertebrates. Continue the inspection, quarantine and treatment program developed for Christmas trees and expand to other similar situations;
- Provide adequate funding for effective statewide early detection and rapid response to new introductions of invasive species;
- Control already established priority invasive plants, such as fountain grass, miconia (*Miconia calvescens*), Himalyan ginger (*Hedychium gardnerianum*), Australian tree fern (*Cyathea cooperi*), mangrove, and others, to prevent the spread into pristine habitats;
- Decrease the number of invasive species or the total area of invasive species coverage in aquatic and marine ecosystems;
- Continue research on effective management methods and tools (e.g., control methods for introduced vertebrates (e.g., mongooses, rats, cats, mallards, barn owls, Jackson's chameleons), invertebrates (e.g., *Vespula* spp., wasps, ants, and carnivorous snails), and for introduced predatory fish;

- Support a coordinated statewide invasive species public outreach program with shared resources and responsibilities among cooperating entities; and
- Continue to support research on biocontrol (including prescreening to limit unintentional non-target impacts) as one method that addresses priority invasive species.

3. Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.

Existing knowledge on the statewide distribution, abundance, population trends, and limiting factors of native wildlife is inadequate for all species. Similarly, detailed information on vegetation structure and composition is lacking for many native habitats. Funding to adequately maintain and analyze data is frequently insufficient. Coordinating implementation of priority management actions across property boundaries and jurisdictions, and with land managers, industry, private landowners, and stakeholders is happening but can be improved. Addressing these shortfalls in monitoring, research, and information management is critical if resource managers and landowners are to take effective steps to conserve native wildlife.

<u>Highest priority</u>

- Identify priorities for research and monitoring to document distribution, abundance, population trends, limiting factors, demography, and behavior of native species in order to guide conservation management and recovery programs.
- Improve implementation-level planning. Develop analytical methods and user applications to enable managers to prioritize management areas and actions that will yield the highest conservation benefit per unit cost at the population and ecosystem scales.

<u>High priority</u>

- Establish and implement information collection and data sharing protocols through interagency cooperative efforts, building upon existing resources such as the Hawai‘i Biodiversity and Mapping Program, the Pacific Basin Information Node, the Western Pacific Fisheries Information Network, the Coral Reef Information System, the Bishop Museum Hawai‘i Biological Survey, and the HI- Gap Analysis program (GAP) and Hawai‘i Marine GAP projects;
- Development linkages of existing databases to create a central repository accessible to resource managers and the public containing biological information on native species and habitats and corresponding management-relevant information;
- Develop initial or update dated HI-GAP and Marine GAP analyses and integrate into the decision-making processes of federal, state, and local agencies, non-governmental organizations, and private landowners that manage significant tracts of land in the state;
- Develop initial or update dated stream GAP analysis program that quantifies stream habitats and organisms and adjacent land uses and management; and
- Develop standards for data collection for projects funded by conservation grants, through partnership and collaboration among funding agencies, to facilitate monitoring of progress and success across landscapes and across funding programs.

4. Strengthen existing and create new partnerships and cooperative efforts.

Several species of Hawai‘i’s native wildlife owe their continued existence to formal and informal partnerships among natural resource agencies, military agencies, other federal, state, and county

agencies, non-governmental organizations, academic researchers, private landowners, community organizations, and individuals. From watershed partnerships covering thousands of acres of land to single-species working groups, these cooperative efforts are valuable ways to share information, coordinate management actions, and pool resources for the benefit of Hawai‘i’s native wildlife.

Highest priority

- Expand and strengthen existing partnerships (e.g., by increasing communication, formalizing partnerships, or adding new partners).

High priority

- Establish new partnerships with private landowners, non-traditional partners, and with community groups to share information and facilitate implementation of identified conservation actions;
- Increase the scope of community involvement in local conservation efforts by identifying areas for community based management and developing any necessary rules to support resource management efforts (e.g., West Hawai‘i Regional Fisheries Management Council, community-based marine managed areas, and community-based subsistence fishing areas);
- Maintain the partnership between government agencies and the University of Hawai‘i (e.g., through the Pacific Cooperative Studies Unit or the Hawaii-Pacific Islands Cooperative Ecosystems Studies Unit) to implement many on-the-ground conservation and research projects;
- Explore areas of common ground and future collaboration with agricultural industries and research facilities (e.g., University of Hawai‘i College of Tropical Agriculture and Human Resources);
- Collaborate with the federal government, as an equal Co-Trustee, to implement the coordinated protections and management plans relating to the Papahānaumokuākea Marine National Monument;
- Enhance partnerships with federal enforcement agencies including the U.S. Marine Corps, U.S. Coast Guard, and NOAA Office for Law Enforcement;
- Coordinate with inter-state agencies and stakeholders in the U.S. Pacific Islands (Commonwealth of Northern Mariana Islands, Guam, American Samoa) and with Alaska to develop and support population goals for migratory shorebirds and seabirds;
- Improve coordination among and within funding agencies to strategically select projects for funding based on their contribution to overall native species and habitat conservation needs;
- Support and emphasize voluntary and incentive-based programs for native wildlife and habitat conservation on private lands;
- Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and identify areas where ungulate populations can be managed to provide for continued hunting opportunities; and
- Expand the partnership with the Department of Public Safety, Corrections Division to increase use of inmate work crews for conservation management projects where feasible.

- Collaborate with and support permitted wildlife rehabilitation organizations. These organizations could assist with first alerts for wildlife diseases and provide insight into hotspots of natural or human-caused wildlife impacts (artificial lighting, shooting, disease outbreaks, etc.), which would help with a strategy on the most effective targets for community outreach or corrective action. These organizations can also provide helpful guidance on how to be vigilant for signs of disease and how to prevent or minimize spread. Researchers, managers, biologists, or anyone working regularly with native wildlife should be trained on these basic protocols.

5. Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.

Comprehensive education, outreach, and information services programs contribute to a sense of responsibility for native wildlife conservation among the public and help to ensure voluntary compliance with conservation rules, regulations, and laws. Public support is critical to successful conservation management as well as to the continued protection of all of Hawai‘i’s natural resources. Education and outreach is vital to providing residents and visitors with the information needed to take action to protect Hawai‘i’s native wildlife for future generations.

<u>Highest priority</u>

- Increase public understanding of native wildlife by developing and implementing a strategic and comprehensive conservation education program (particularly for Hawai‘i’s lesser known species) that would include public awareness campaigns and working with potential partners (e.g., Department of Education and non-governmental organizations).

<u>High priority</u>

- Secure permanent dedicated funding for native wildlife conservation education and outreach;
- Provide lawmakers and citizens with the information necessary to effectively legislate and provide funding for the conservation of native species and their habitats;
- Encourage public participation and stewardship by expanding volunteer opportunities to contribute to native wildlife conservation, including invasive species control and participation in monitoring;
- Continue support for the Youth Conservation Corps, the Hawaiian Internship Program, and other youth programs, recognizing the value of these programs in teaching students about conservation in Hawai‘i;
- Build upon existing efforts to develop conservation management curricula for kindergarten through twelfth grade, compatible with current statewide educational requirements, and conduct training for teachers on how to use curricula in the classroom;
- Encourage and support business sector-led initiatives to incorporate native wildlife considerations into their business models, with a focus on renewable energy, agriculture, forestry, horticulture, aquaculture, fisheries, and tourism industries;
- Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive habitats and areas;
- Increase conservation education to residents and visitors on how to behave appropriately with native wildlife and provide guidance on how to deal with native wildlife populations like the nēnē as they continue to recover and spread into more populated areas; and

- Collaborate to increase compliance with existing laws through outreach and educational programs and support for increased enforcement capacity.

6. Support policy changes aimed at improving and protecting native species and habitats.
Adequate protection of native wildlife may require changes to existing policies. The changes range from enforcing existing rules that have a direct impact on the overall state of Hawai‘i’s native wildlife to developing new policies to address emerging threats.

Highest priority

- Increase conservation enforcement efforts on all state-owned land and waters through increased funding for trained enforcement officers;
- Collaborate with the Department of Agriculture on needed policy changes to prevent the introduction of non-native plant and animal species by air or water and to prevent spread of non-native species in state and beyond Hawai‘i’s borders; and
- Evaluate current management of state lands and waters and identify priority areas for changes in current use (e.g., unencumbered state lands of conservation quality or restoration potential).

High priority

- Review and evaluate existing state policies and Administrative Rules for gaps in protection;
- Review and revise existing rules and regulations dealing with extractive uses of aquatic animals, plants, and terrestrial snails;
- Review and revise existing rules and DOFAW management guidelines regarding game management to ensure consistency with this SWAP and other existing management plans and recovery plans and to reflect native species and habitat conservation needs;
- Support development and implementation of a comprehensive coastal policy;
- Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
- Identify species, particularly invertebrates, in need of additional protection and evaluate for inclusion on the state threatened and endangered species list;
- Collaborate with the Office of Conservation and Coastal Lands to update Conservation District rules to encourage conservation management activities while ensuring continued protection of Conservation District;
- Administer and award State Wildlife Grant funds through a joint partnership of DOFAW and DAR;
- Explore opportunities to streamline the EPA label process for new control methods for invasive species, such as broadcast uses of rodenticides;
- Identify constraints on research and management actions to control non-native pests in remote field operations and develop appropriate policies to minimize response time delay; and
- Improve coordination of policies and programs to meet the needs of native wildlife conservation, but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby maintain support of the broader community for natural resource and wildlife conservation.

7. Enhance funding opportunities to implement needed conservation actions.
Without sufficient, sustained, and long-term funding, the actions outlined in this SWAP cannot be implemented for the benefit of native species and their habitats.

Highest priority

- Develop new sources of funding to support and expand conservation management in the state, particularly on state lands and waters.

High priority

- Organize an interagency and stakeholder task force to examine and implement market-based conservation funding solutions, including review of recreational gear taxes, visitor taxes, airport landing fees, new or expanded license or user fees, and targeted tax breaks for conservation activities;
- Explore cooperative opportunities to accomplish needed conservation actions with existing funding, such as by training Transportation Security Administration inspectors to recognize priority invasive species;
- Support lobbying efforts to increase federal funds to states and to change the formula used to allocate federal funds to reflect the conservation realities of each state; and
- Secure additional funding dedicated to recovery priorities for listed species.

References:

Atkinson, C. T., & LaPointe, D. A. 2009a. Ecology and pathogenicity of avian malaria and pox. In M. T. K. Pratt, M. C. T. Atkinson, M. P. C. Banko, M. J. D. Jacobi, & M. B. L. Woodworth (Eds.), Conservation biology of Hawaiian forest birds: Implications for island avifauna (pp. 234–252). New Haven, CT: Yale University Press.

Atkinson, C.T., Utzurrum, R.B., Lapointe, D.A., Camp, R.J., Crampton, L.H., Foster, J.T.,Giambelluca, T.W. 2014. Changing climate and the altitudinal range of avian malaria in the Hawaiian Islands --- an ongoing conservation crisis on the islands of Kauai. Global Change Biology 20: 2426-2436.

Atkinson CT, Saili KS, Utzurrum RB, Jarvi SI. Experimental evidence for evolved tolerance to avian malaria in a wild population of low elevation Hawai'i 'Amakihi (Hemignathus virens). Ecohealth. 2013 Dec;10(4):366-75. doi: 10.1007/s10393-013-0899-2. Epub 2014 Jan 16. PMID: 24430825.

Banko, P. C., R.J. Camp, C. Farmer, K.W. Brinck, D.L. Leonard, and R.M. Stephens. 2013. Response of palila and other subalpine Hawaiian forest bird species to prolonged drought and habitat degradation by feral ungulates. Biological Conservation 157: 70-77.

Banko, P. C., and C. Farmer, editors. 2014. Palila restoration research, 1996–2012. Hawai‘i Cooperative Studies Unit Technical Report HCSU-046. University of Hawai‘i at Hilo. 493 pages.

Barker, G. M., & Efford, M. G. 2004. Predatory gastropods as natural enemies of terrestrial gastropods and other invertebrates. In G. M. Barker (Ed.), Natural Enemies of Terrestrial Molluscs (pp. 279–403). CABI Publishing. https://doi.org/10.1079/9780851993195.0000

Benning, T. L., LaPointe, D., Atkinson, C. T., & Vitousek, P. M. 2002. Interactions of climate change with biological invasions and land use in the Hawaiian Islands: Modeling the fate of endemic birds using a geographic information system. Proceedings of the National Academy of Sciences, 99(22), 14246–14249. doi:10.1073/pnas.162372399

Cesar H, Beukering P, Pintz S, Dierking J. 2002. Economic valuation of the coral reefs of Hawai‘i. Hawai‘i Coral Reef Initiative Research Program. Available at: http://www.hawaii.edu/ssri/hcri/rp/cesar/noaa_final_report_01-02/cesar_final_report-01-02.htm.

Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Chu, P.-S., Chen, Y.R., Schroeder, T.A. 2010. Changes in precipitation extremes in the Hawaiian Islands in a warming climate. J. Climate 23: 4881-4890.

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan, 2013: Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Davis SD, Heywood VH, Hamilton AC, editors. 1995. Centres of Plant Diversity. Oxford, (UK): Information Press, 550 pp.

Eggert, L.S., Terwilliger, L.A., Woodworth, B.L. *et al.* Genetic structure along an elevational gradient in Hawaiian honeycreepers reveals contrasting evolutionary responses to avian malaria. *BMC Evol Biol* **8**, 315 (2008). https://doi.org/10.1186/1471-2148-8-315

Eldredge LG, Evenhuis NL. 2002. Hawai‘i’s Biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. Bishop Museum Occasional Papers 76:1-28.

Engilis A., Naughton, M. 2004. U.S. Pacific Islands regional shorebird conservation plan. U.S. Shorebird Conservation Plan. Portland, (OR): U.S. Department of the Interior; Fish and Wildlife Service.

Flint, B., Leary, P., & Klavitter, J. (2011). Briefing paper to the US delegation to the Agreement on the Conservation of Albatrosses and Petrels (ACAP) presented at the Population Status and Trends and Breeding Sites Working Group meeting, Guayaquil, Ecuador.

Fortini, L.B., Price, J., Jacobi, J., Vorsino, A., Burgett, J., Brinck, K., Amidon, F., Miller, S., ’Ohukani’ohi’an III, S., Koob, G., Paxton, E. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Technical Report 044, Hawai’i Cooperative Studies Unit. University of Hawai’i, Hilo, HI, 45 pp.

Foster JT, Woodworth BL, Eggert LE, Hart PJ, Palmer D, Duffy DC, Fleischer RC. Genetic structure and evolved malaria resistance in Hawaiian honeycreepers. Mol Ecol. 2007 Nov;16(22):4738-46. doi: 10.1111/j.1365-294X.2007.03550.x. Epub 2007 Oct 17. PMID: 17944845.

Freed LA, Cann RL, Goff ML, Kuntz WA, Bodner GR (2005) Increase in avian malaria at upper elevation in Hawai‘i. Condor, 107, 773–764.

Gaudioso JM, LaPointe DA, Hart PJ. 2009. Knemidokoptic mange in Hawaii Amakihi (Hemignathus virens) on the Island of Hawaii. Journal of Wildlife Diseases. 45:497-501.

Hadfield, M. G., & Mountain, B. S. (1989). Predation by Euglandina rosea, the introduced carnivorous snail, on endemic Hawaiian achatinelline species. Biological Conservation, 47(2), 129–145. https://doi.org/10.1016/0006-3207(89)90014-7

Harter DEV, SDH Irl, B Seo, MJ Steinbauer, R Gillespie, KA Triantis, J-M Fernández-Palacios, C Beierkuhnlein. 2015. Impacts of global climate change on the floras of oceanic islands – Projections, implications and current knowledge. Perspectives in Plant Ecology, Evolution and Systematics 17: 160-183.

Hawai‘i Conservation Alliance. 2004. “Draft Hawai‘i biodiversity strategy.”

Hawai‘i Department of Agriculture. 2002. Kahului airport pest risk assessment. Maui. Available at: http://www.hawaiiag.org/PQ/KARA%20Report%20Final.pdf (accessed last 17 August 2005).

Hawai‘i Department of Land and Natural Resources. 2014a. http://dlnr.hawaii.gov/reefresponse/2014/10/06/latest-info-coral-bleaching/

Hawai‘i Department of Land and Natural Resources. 2014b. http://www.hawaiicoralreefstrategy.com/index.php/local-action-strategies/climate-change-and-marine-disease

Hawai‘i Department of Land and Natural Resources, US Fish and Wildlife Service, and The Nature Conservancy of Hawai’i. 1992. Hawai‘i's extinction crisis: a call to action.

Hawai‘i Department of Land and Natural Resources (DLNR). 2004. Statewide report on invasive species. Honolulu, (HI): DLNR.

Hawai‘i Department of Land and Natural Resources (DLNR). 2004. Hawai‘i’s priority invasive species. Honolulu, (HI): DLNR.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Conservation education and outreach program strategic plan - DRAFT. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2014. Report to the Twenty-Seventh Legislature Regular Session of 2014. Budgetary and Other Issues Regarding Invasive Species, Honolulu.

Hawai‘i Revised Statutes. Chapters 171, 183, 183D, 187A, 188, 190, 195, 195D. Honolulu, (HI).

Hawai‘i’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i State Legislature. 2005. House Bill 100, Conference Draft 1 (State Budget). Honolulu, (HI). Available at: http://www.capitol.hawaii.gov/sessioncurrent/bills/hb100_cd1_.htm (accessed on May 25, 2005).

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Holt JD. 1985. The art of featherwork in old Hawai‘i. Honolulu: University of Hawai‘i Press.

Jokiel, P.L. and E. Brown. 2004. Global warming, regional trends and inshore environmental conditions influence coral bleaching in Hawaii. Global Change Biology 10, 1627–1641.

Justine, J.-L., Winsor, L., Barrière, P., Fanai, C., & Gey, D. 2015. The invasive land planarian Platydemus manokwari in French Polynesia. PeerJ, 3, e1037. https://doi.org/10.7717/peerj.1037

Juvik, J.O. and S. Juvik, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kane, H.H., C.H. Fletcher, L.N. Frazer, and M.M. Barbee. 2014. Critical elevation levels for flooding due to sea-level rise in Hawai‘i. Reg Environ Change. DOI 10.1007/s10113-014-0725-6.

Keener, V.W., J.J. Marra, M.L. Finucane, D. Spooner and M.H. Smith. 2012. Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Island Press, Washington DC.

Kirtman, B., S.B. Power, J.A. Adedoyin, G.J. Boer, R. Bojariu, I. Camilloni, F.J. Doblas-Reyes, A.M. Fiore, M. Kimoto, G.A. Meehl, M. Prather, A. Sarr, C. Schär, R. Sutton, G.J. van Oldenborgh, G. Vecchi and H.J. Wang, 2013: Near-term Climate Change: Projections and Predictability. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.

Loope LL. Status and trends of the nation’s biological resources: Hawai‘i and the Pacific Ocean. U. S. Geological Survey. Available at: http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed 7 December 2004).

Maynard, J., R. van Hooidonk, C.M. Eakin, M. Puotinen, M. Garren, G. Willams, S.F. Heron, J. Lamb, E. Weil, B. Willis, and C.D. Harvell. 2015. Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. Nature Climate Change. DOI: 10.1038/NCLIMATE2625.

Meyer, W. M., & Cowie, R. H. 2010. Feeding preferences of two predatory snails introduced to Hawaii and their conservation implications. Malacologia, 53(1), 135–144. https://doi.org/10.4002/040.053.0106

Nature Conservancy of Hawai‘i. 2003. Last Stand: the Vanishing Hawaiian Forest.

Neddermeyer, J. H., Parise, K. L., Dittmar, E., Kilpatrick, A. M., & Foster, J. T. (2023). Nowhere to fly: Avian malaria is ubiquitous from ocean to summit on a Hawaiian island. *Biological Conservation*, *279*, Article 109943. https://doi.org/10.1016/j.biocon.2023.109943

Nicol, S., C. Menkes, J. Jurado-Molina, P. Lehodey, T. Usu, B, Kumasi, B. Muller, J. Bell, L. Tremblay-Boyer, K. Briand. 2014. Oceanographic characterisation of the Pacific Ocean and potential impact of climate variability on tuna stocks and their fisheries. Secretariat of the Pacific Community (SPC), 2014 ISBN: 978-982-00-0737-6. CIP data.

Paine JR. 1991. IUCN directory of protected areas in Oceania. Gland: International Union for Conservation of Nature and Natural Resources.

Palmer DD. 2003. Hawai‘i’s ferns and fern alies. Honolulu: University of Hawai‘i Press.

Paxton, E. H., Camp, R. J., Gorresen, P. M., Crampton, L. H., Leonard, D. L., & VanderWerf, E. A. 2016. Collapsing avian community on a Hawaiian island. Science Advances, 2(9). https://doi.org/10.1126/sciadv.1600029

Paxton, E. H., Laut, M., Enomoto, S., & Bogardus, M. 2022. Hawaiian Forest Bird Conservation Strategies for Minimizing the Risk of Extinction: Biological and Biocultural Considerations. 96720(808). http://hdl.handle.net/10790/5386

Polovina, J.J., Dunne, J.P., Woodworth, P.A., and Howell, E.A. 2011. Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming. ICES Journal of Marine Science. DOI: 10.1093/icesjms/fsq198.

Price JP. 2004. Floristic biogeography of the Hawaiian Islands: influences of area, environment and paleogeography. Journal of Biogeography 31(3):487-500.

Price JP, Wagner WL. 2004. Speciation in Hawaiian angiosperm lineages: cause, consequence, and mode. Evolution 58(10):2185-2200.

Pukui MK, Elbert SH. 1986. Hawaiian dictionary revised and enlarged edition. Honolulu: University of Hawai‘i Press.

Reynolds, M.H., P. Berkowitz, K.N. Courtot and C. M. Krause. 2012. Predicting sea-level rise vulnerability of terrestrial habitat and wildlife of the Northwestern Hawaiian Islands. Open-File Report 2012-1182, http://pubs.er.usgs.gov/publication/ofr20121182) (http://pubs.usgs.gov/of/2012/1182/of2012-1182.pdf)

Reynolds, M.R., K.N. Courtot, C. M. Krause, N.E. Seavy, P. Hartzell and J.S. Hatfield. 2013. Dynamics of seabird colonies vulnerable to sea-level rise at French Frigate Shoals, Hawai`i. Hawai‘i Cooperative Studies Unit Technical Report HCSU-037. https://pubs.er.usgs.gov/publication/70048507

Ricketts TH, et al. 1999. Terrestrial ecoregions of North America: a conservation assessment. Washington, DC: Island Press. 147 pp.

Scott MJ. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. United States Department of Interior, National Biological Survey. Available at: http://biology.usgs.gov/s+t/pdf/Hawai’i.pdf (accessed 3 December 2004).

Seidl, C. (2023). Quantifying the roles of temperature and host community in the transmission of avian malaria in Hawai‘i. *UC Santa Cruz*. ProQuest ID: Seidl_ucsc_0036E_12996. Merritt ID: ark:/13030/m520570s. Retrieved from https://escholarship.org/uc/item/65d0n1v7

Snow NP, Witmer G. 2010. American bullfrogs as invasive species: a review of the introductions, subsequent problems, management options, and future direction. Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.) Published at Univ. of Calif., Davis. 2010. Pp. 86-89.

Stone CP, Pratt LW. 1994. Hawai‘i’s plants and animals: biological sketches of Hawai’i Volcanoes National Park. Honolulu: Hawai‘i Natural History Association.

Sumiye J. 2002. Ko‘olau Mountains Watershed Partnership management plan. Ko‘olau Mountains Watershed Partnership.

Teel TL, Dayer AA. 2005. Preliminary state-specific results from the research project entitled “Wildlife values in the west 2004.” Fort Collins: Human Dimensions in Natural Resources Unit, Colorado State University.

Timm, OE, Giambelluca TW, and Diaz HF. 2015. Statistical downscaling of rainfall changes in Hawai‘i based on the CMIP5 global model projections, J. Geophys. Res. Atmos., 120, 92–112, doi:10.1002/2014JD022059.

Titcomb M. 1972. Native use of fish in Hawai‘i. Honolulu: University of Hawai‘i Press.

Titcomb M. 1978. Native use of marine invertebrates in old Hawai‘i. Pacific Science 32:325-386.

U.S. Department of the Interior, Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. 2003. 2001 National survey of fishing, hunting, and wildlife-associated recreation. available at: http://www.census.gov/prod/2003pubs/01fhw/fhw01-hi.pdf (May 24, 2005).

U.S. Fish and Wildlife Service. 2003. Draft revised recovery plan for the ‘Alala (Corvus hawaiiensis). Portland, (OR): U.S. Fish and Wildlife Service. Xi+78 pp.

U.S. Fish and Wildlife Service. 2003. Draft revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

U.S. Fish and Wildlife Service. 1999. Draft revised recovery plan for Hawaiian waterbirds, Second Revision. Portland, (OR): U.S. Fish and Wildlife Service. 107 pp.

U.S. Fish and Wildlife Service. 2004. Draft regional seabird conservation plan. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2024. Environmental Conservation Online System (ECOS). Listed species with spatial current range believed to or known to occur in Hawaii. Available at: https://ecos.fws.gov/ecp/report/species-listings-by-state?stateAbbrev=HI&stateName=Hawaii&statusCategory=Listed

Wagner WL, Herbst DR, Sohmer SH. 1999. Manual of the flowering plants of Hawai‘i, Revised Edition, Volumes 1 and 2. Honolulu: University of Hawai‘i Press and Bishop Museum Press.

Yamamoto M, Tagawa A. 2000. Hawai‘i’s native and exotic freshwater animals. Honolulu, (HI): Mutual Publishing. 200 pp.

Ziegler AC. 2002. Hawaiian Natural History, Ecology, and Evolution. Honolulu: University Press, 157 pp.

CHAPTER 5: MARINE AND FRESHWATER CONSERVATION NEEDS

Due to the large number and the varied geology of the islands, Hawai‘i has diverse marine habitats, which range from estuaries, tidepools, sandy beaches, and seagrass beds to nearshore deep waters, extensive fringing and atoll reef systems, and smaller barrier reef systems. Unfortunately, introduced mangroves have altered native coastal habitats in a number of places. The distribution of marine ecosystems in Hawai‘i is a result of island age, reef growth, water depth, exposure to wave action, geography, and latitude.

The marine habitats found on each island depend on the type of island: large and young, mature, or drowned islands and seamounts. Large and young islands such as the island of Hawai‘i have recent lava flows and few, living structural coral reefs. Beaches are rocky except around bays, and drowned reefs may be found in deep waters or off parts of the east coast of Maui. Mature islands, such as O‘ahu and Kaua‘i in the Main Hawaiian Islands (MHI) and Nihoa and Necker in the Northwestern Hawaiian Islands (NWHI) are the most diverse, with habitat types ranging from estuaries and sandy beaches to rocky beaches and fringing and barrier reefs to lagoons with patch or pinnacle reefs. Drowned islands, such as atolls in the rest of the NWHI, are the remains of volcanic islands with habitats ranging from coral islets and benches to caves and terraces along the slope of the atoll.

Because of Hawai‘i’s geographical isolation, many of its coastal and marine species are endemic. Approximately 15 to 20 percent of the marine species are endemic, one of the largest proportions of marine endemism for any island chain in the world. Yet because of the isolation, Hawai‘i has relatively low marine species richness, with approximately 450 different shallow reef fish in contrast to areas of the Pacific further west with thousands of species. In total though, Hawai‘i still has over 6,000 marine species.

OVERVIEW

Geology

The Hawaiian Archipelago consists of eight large islands and approximately 129 islands, islets, atolls, and shoals. Many smaller sandy islands in the northwest are intermittent, depending on storms, waves, and currents for their existence and are now threatened by climate change and associated rising sea levels. The MHI are high islands, meaning they are mountainous with rocky headlands, narrow coastal plains, and ringed by beaches or rocky coastline. These high islands are often surrounded by fringing coral reefs with barrier-like reefs off small sections of the coast of O‘ahu and Kaua‘i. The NWHI are low islands, worn down by subsidence and erosion. They remain only as rings of reef that encircle a lagoon. Although the State of Hawai‘i is forty-ninth in size, it has approximately 1,336 kilometers (830 miles) of coastline, giving it the fourth highest length of coastline among all the coastal states in the United States. Coastline length for each of the islands is as follows: Hawai‘i 428 kilometers (266 miles), Maui 193 kilometers (120 miles), Kaho‘olawe 47 kilometers (29 miles), Lāna‘i 76 kilometers (47 miles), Moloka‘i 142 kilometers (88 miles), O‘ahu 180 kilometers (112 miles), Kaua‘i 145 kilometers (90 miles), Ni‘ihau 72 kilometers (45 miles), and NWHI 50 kilometers (30 miles).

Climate and Oceanography

The waters surrounding Hawai‘i are affected by seasonal variations in climate and ocean circulation. The surface temperature of the oceans around Hawai‘i follow a north-south gradient and range from 24˚C (75˚F) in the MHI to 20˚C (68˚F) to 22˚C (72˚F) in the NWHI in winter and spring to 26˚C (79˚F) to 27˚C (81˚F) throughout all the islands in the late summer and fall. The depth of the thermocline, where water temperature reaches ten degrees Celsius (50˚F), is 450 meters (1,500 feet) northwest of the islands and 300 meters (1,000 feet) off the island of Hawai‘i. Variations may occur due to factors like ocean currents, El Niño/La Niña events, and local conditions. Surface currents generally move east to west and increase in strength moving southward. The seas are rougher between islands than in the open ocean, because wind and water are funneled through the channels. Waves generated by north Pacific low-pressure systems are larger in the winter months than in the spring and are generally bigger on the northern shores of the islands than the southern shores. Marine organisms have adapted to these general climatological and oceanographic conditions.

Land and Water Use

Most waters and submerged land from the shore out to at least 5 kilometers (3 miles) are technically owned by the State with some authority exercised by the federal government. Offshore waters from 19 to 322 kilometers (12 to 200 miles) are regulated by a variety of federal agencies. The Hawai‘i Department of Land and Natural Resources (DLNR) Division of Conservation and Resources Enforcement (DOCARE) is responsible for enforcing many of the State’s marine laws while federal enforcement authority is granted to the U.S. Coast Guard, the U.S. Navy, the U.S. Marines, and the National Oceanic and Atmospheric Administration (NOAA) Office for Law Enforcement. The DLNR Division of Boating and Ocean Recreation (DOBOR) regulates boating and commercial tourism activity.

Management authority for the nearshore marine waters is the responsibility of a variety of state and federal agencies including DLNR, the Hawai‘i Department of Transportation (DOT), the Hawai‘i Department of Health (DOH), NOAA’s National Marine Sanctuaries Program, U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and the U.S. Military. Much of the water surrounding Maui County and smaller areas off Kīlauea Point National Wildlife Refuge (NWR) on Kaua‘i, parts of the north and southeast coast of O‘ahu, and the northwest coast of the island of Hawai‘i are protected as a part of the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). Managed jointly by NOAA, USFWS, and the State of Hawai‘i, Papahānaumokuākea National Marine Sanctuary (PNMS) comprises all of the NWHI and waters out approximately 80 kilometers (50 miles) from the islands. Encompassing approximately 362,600 square kilometers (140,000 square miles), at the time of designation in 2006, PMNM represented the single largest conservation area under U.S. jurisdiction as the first Marine National Monument ever created. PMNM contains nearly pristine ecological conditions that support more than 7,000 marine species, large coral reefs, and apex predator–dominated communities. The islands provide essential breeding habitat for more than 14 million nesting seabirds, the endangered Hawaiian monk seal or ‘īlioholoikauaua (*Monachus schauinslandi*), and the threatened green sea turtle or honu (*Chelonia mydas*). PNMS also includes the NWHI Coral Reef Ecosystem Reserve, managed by NOAA, and the Midway Atoll NWR, Hawaiian Islands NWR, and Battle of Midway National Memorial, which are managed by USFWS. The Hawai‘i DLNR continues to manage conservation initiatives at the State Bird Sanctuary at Kure Atoll. USFWS helps manage hawksbill sea turtle or honu ‘ea nesting off the Keālia Pond NWR on

Maui. The NPS manages marine habitats off Kalaupapa National Historic Park (NHP), Kaloko-Honokōhau NHP, and Hawai‘i Volcanoes National Park. The U.S. Navy is responsible for Pearl Harbor and waters near Kāne‘ohe Marine Corps Base on O‘ahu, the Pacific Missile Range Facility off Kaua‘i, and other smaller training areas. Waters under military jurisdiction provide de-facto protection of species and habitats, because public access is often restricted.

The DLNR Division of Aquatic Resources (DAR) manages 44 regulated fishing areas statewide, which include various Marine Life Conservation Districts (MLCDs,) Fishery Management Areas (FMAs), Public Fishing Areas (PFAs), refuges, statutorily designated regulated areas, an ‘Ōpelu Fishing Area and a Limu Managment Area, in addition to implementing general, statewide fishing regulations. The DLNR Division of Forestry and Wildlife (DOFAW) manages the waters of ‘Āhihi Kīna‘u Natural Area Reserve (NAR) on Maui and Paikō Lagoon Wildlife Sanctuary on O‘ahu. The Kaho‘olawe Island Reserve Commission manages waters from the shores of Kaho‘olawe out to 3 kilometers (2 miles). The DOT-Harbors Division controls access to the ten commercial harbors in the state and numerous recreational harbors.

Cultural Landscape

The marine and freshwater environments of Hawai‘i, as well as the species that inhabit them, play an important role in the culture and livelihood of kānaka ‘ōiwi (native Hawaiians). Kānaka ‘ōiwi view the natural world as a divine system and a living entity that is greater than oneself. For centuries, this perspective and understanding allowed kānaka ‘ōiwi to live in balance and harmony with their ‘āina (land), and especially with their surrounding oceans. Through kilo (traditional scientific observation) kānaka ‘ōiwi were (and still are) able to identify, understand, and enhance Hawai‘i’s native coastal and marine organisms and ecosystems. Extensive sources of mo‘olelo Hawai‘i (Hawaiian stories and historical accounts), mele (chants and songs), hula (dance), and mo‘okū‘auhau (genealogy) demonstrate the indispensable and synergistic relationship between kānaka (humans) and kai (ocean). In many ‘ohana (Hawaiian families), it is customary for certain marine species such as manō (sharks), honu (turtles), hīhīmanu (rays), or others to be honored as an ‘aumakua (family god or deified ancestor who might assume the shape of the animal). By fostering and nurturing a deep connection with the natural world, as well as creating a familial connection, kānaka ‘ōiwi possess an innate kuleana (responsibility) to protect and preserve Hawai‘i and its resources for the future, ensuring the continued perpetuation of the Hawaiian culture and world view. Knowledge in natural systems, such as the creation of the Hawaiian islands and its living organisms, the water cycle, the weather patterns, the seasonal changes, the lunar cycles, the ocean currents, the life cycles, the spawning seasons, and so much more, weave together to create a system of Hawaiian cultural practices and traditions that strike a balance between maximizing productivity to sustain a large population while ensuring multi-generational sustainability of Hawai‘i’s resources.

Human Landscape

Hawai‘i’s marine and freshwater resources support kānaka ‘ōiwi families and livelihoods. The ahupua‘a (land division within which a community has access to every resource necessary to self sustain, generally extending from the uplands to the sea) is the foundation of Hawaiian daily life. This ahupua‘a is based on the natural allocation of resources from place to place and adjusted based on the productivity for any given area. Viewing the ahupua‘a as an interconnected system

and understanding that what happens in the uplands will directly affect what happens in the ocean, provided kānaka ʻōiwi with the knowledge and skills to manage their land and ocean successfully. To coordinate the management of resources, there was a konohiki, a traditional Hawaiian land manager or steward responsible for overseeing a specific ahupuaʻa. This role included responsibilities such as regulating fishing practices, monitoring resource usage, and resolving community conflicts and was vital for managing resources sustainably and maintaining balance. Traditional fishing practices as well as sophisticated aquaculture systems, such as loko iʻa (fishponds), allowed kānaka ʻōiwi to sustain human life while also furthering their marine resources. This unique form of hybrid aquaculture used natural conditions to trap, raise, and harvest fish while providing a sustainable, consistent, and reliable food source and food security for Hawaiian communities. When approaching marine and freshwater conservation in Hawaiʻi, it is important to identify the native Hawaiian people who continue to depend on the ocean and its resources for their survival.

Much of the state's economy is based on the island's coastal and marine resources. Tourism accounts for the majority of the state's economy, with a significant portion of the tourist activities associated with beaches and marine wildlife. Coastal development and land values have both increased with the growth in tourism. According to a study by Ceasar et al. (2004), Hawai'i's coral reef ecosystems offer numerous benefits to coastal communities, including fisheries and tourism. They also support a unique natural environment, rich in biodiversity, and hold significant scientific and educational value. Additionally, coral reefs act as natural barriers against wave erosion. While their intrinsic value is difficult to quantify, this paper demonstrates that, with proper management, coral reefs provide substantial contributions to Hawai'i's welfare through a range of measurable advantages. The net benefits to Hawai'i's economy are estimated at $360 million annually, with the total asset value of the state's 1,660 km² (410,000 acres) of potential reef area in the main Hawaiian Islands approaching $10 billion. According to the 2012 NOAA *Report on the Ocean and Great Lakes Economy of the United States*, Hawaiʻi's ocean economy then accounted for 92,160 jobs and over $2.5 billion in wages. Commercial fish landings in Hawaiʻi have increased annually since 2006 and NOAA reported total landings in 2013 were valued near $108 million dollars.

The military has a significant presence in Hawaiʻi with large Naval installations located on estuarine and coastal areas such as Pearl Harbor, Kāneʻohe Bay on Oʻahu, and the Pacific Missile Range Facility on the south shore of Kauaʻi. Point source pollution in the marine environment originates from a variety of sites including: Pearl Harbor, Hickam Air Force Base, oil refineries and terminals, power plants, storm drain wells, and cesspools. Discharges from cruise ships and tour boats are of current public concern. Hawaiʻi's DOH lowered their permit standards for injection wells, contributing to nutrient increases and algal blooms in some areas. Non-point source pollution from the agricultural sector has decreased as agriculture has declined; however, domestic non-point source pollution has increased.

SPECIES AND HABITATS OF IMPORTANCE

All marine habitats in Hawaiʻi are considered important for conservation, because each habitat has characteristic fish and invertebrate assemblages unique to that habitat. The marine habitats that are represented in Hawaiʻi include: tidepools, rocky beaches, sandy beaches, estuaries where

fresh and salt waters mix, seagrass beds, fringing reefs, barrier reefs, atolls, deep reefs, sand, pelagic (open near-surface water), mesopelagic (middle depths with some light and vertical migration of organisms living there), bathypelagic (deeper waters with no light), and deep bottom. A more detailed classification of habitats can be found in Maragos and Gulko (2002). Although outside the marine habitat, adjacent terrestrial habitats along the coast or within *ahupua'a* (watersheds) impact the ocean and play a large role in the health of marine habitats and species.

Appendices A and B provides information on the marine fauna and flora Species of Greatest Conservation Need (SGCN), with more specific natural history, taxonomic, and conservation needs provided in Chapter 7. Appendix A includes 138 marine fishes, 201 species of marine invertebrates, 26 species of marine mammals, 7 marine reptiles, 2 marine rays and 1 marine shark. Marine species in Hawai'i include over 1,200 species of fishes, with around 500 species adapted to live on coral reefs, and the rest adapted to the pelagic open surface waters, mesopelagic or bathypelagic zones (middle or deep waters), estuaries, or sandy bottoms. At the top of the food chain are the apex predators such as the many sharks and large predatory reef and pelagic fishes of Hawai'i. Over 5,000 marine invertebrates are known from Hawai'i and include over 100 species of hard, soft, and precious corals as well as hundreds of types of snails, crabs, shrimps and small numbers of worms, jellyfish, sponges, starfish, and tunicates. Five marine turtles occur in Hawai'i; two are common residents that nest on Hawai'i's beaches and three others are more occasional visitors. All sea turtles are listed as threatened or endangered under the Endangered Species Act (ESA). Approximately 26 species of marine mammals, mostly cetaceans, are considered resident or occasional visitors to Hawai'i. These include the humpback whale or koholā (*Megaptera noveangliae*), which migrates during the winter months to Hawaiian waters to breed and give birth each year before returning to feed in Alaskan waters during spring and summer, false killer whale (*Pseudorca crassidens*), and the spinner dolphin (*Stenella longirostris*) and bottlenose dolphin (*Tursiops truncatus*) or nai'a. Koholā (humpback whales), false killer whales, and 'īlioholoikauaua (Hawaiian monk seals) are common marine mammals in Hawai'i and are listed as endangered under the ESA. All marine mammals are protected by the Marine Mammal Protection Act. Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawai'i's coasts. In Appendix B, there are 78 species of endemic marine algae, 3 species of native marine algae, 24 species of endemic freshwater algae, and two aquatic plants included.

SUMMARY OF KEY THREATS AND CHALLENGES TO SPECIES AND HABITATS

Many general threats to native wildlife and habitats are discussed in Chapter 4 (Statewide Conservation Needs) including a discussion on threats common to both the terrestrial and marine environment. Threats that are more acute or specific to the marine environment are listed below.

- Climate change significantly threaten marine species and habitats in by causing coral bleaching due to rising ocean temperatures, ocean acidification which hinders coral growth, coastal erosion that destroys nesting and feeding grounds, and inundation of low-lying areas, including wetlands, due to sea-level rise.
- Localized excessive extractive use: technical "overfishing" (i.e., too much fishing effort in the fishery) has been declared for certain bottomfishes by the National Marine Fisheries Service (NMFS). Data to meet technical determination of overfishing is lacking for many species, and there are concerns about aquarium species, 'opihi (limpets), uhu

(parrotfishes), sea cucumbers, and other species. Extraction for research purposes may also lead to localized excessive extractive use;

- Fisheries bycatch includes commercial and personal use fisheries which incidentally take non-target reef fishes, sea turtles, Hawaiian monk seals, other marine mammals, and seabirds; active gear types known to cause bycatch include commercial longlines, lay gillnets, ulua (live) slide-bait fishing, and lines, traps, and ghost nets;
- Urbanization and coastal alteration, including harbors, seawalls and other structures, land reclamation, and commercial and residential development too close to streams and beaches;
- Introductions of alien species, including algae, fishes, and invertebrates, related to hull fouling of recreational boats and ballast water in commercial vessels, as well as intentional release of alien species;
- Marine debris such as nets, lines, and derelict fishing gear, which degrade very slowly and form large aggregate accumulations that present an entanglement risk capable of causing considerable harm to and loss of marine life, as well as plastic fragments and particles that are ingested by many species, especially seabirds;
- Pollution from upstream sources, oil and other contaminant spills, nearshore sewage, cruise ship wastes, tour boat discharge, and other waste;
- Sedimentation and eutrophication from upstream sources, sewage discharge, and coastal land use;
- Light pollution from coastal development and urbanization, which can cause light attraction and lead to disorientation and fatality for seabirds (especially fledglings) and sea turtles (hatchlings)—these animals are sensitive to anthropogenic light sources as they leave nests and move toward the ocean;
- Noise from vessels and boats, sonar, drilling and construction activities all affect marine life; acoustic research experiments such as the Acoustic Thermometry of Ocean Climate (ATOC) and other sound-emitting studies need to be studied and monitored to understand effects on marine mammals.
- Recreational overuse, including trampling, anchor damage, watercraft disturbance, and SCUBA;
- Dolphin and sea turtle watching, when excessive, that alters species' behavior or habitat use;
- Feeding coastal or marine wildlife, which can harm or alter the behavior of native wildlife;
- Increased interactions with monk seals due to increasing abundance in the MHI;
- Ship strikes that may kill or injure marine mammals or sea turtles;
- Ship groundings that can harm or destroy coral reef communities and result in oil or other toxic substance spills;
- Government's lack of information on Native Hawaiian cultural importance of and cultural practices surrounding ecologically important species of concern;
- Government's lack of information of historical management strategies including traditional Native Hawaiian marine resource management practices to enhance present-day management activities;

- Lack of a comprehensive strategic communications strategy to foster community understanding of and engagement in management activities and the importance of marine conservation efforts;
- Lack of enforcement of existing regulations and appropriate penalties for violations; and
- Lack of adequate funding for conservation and research.

MARINE STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) and throughout Chapter 6 (Island Conservation Needs), additional strategies for marine species and habitats include the following:

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in 'Management Needs' section;
    - Continue to develop and implement conservation programs for federally protected marine species and jointly managed conservation areas like PMNM in coordination with NOAA and USFWS, and the HIHWNMS in coordination with NOAA;
    - Expand current capabilities to improve rapid response to incidents in which protected species are stranded;
    - Increase documentation and removal of marine debris in the MHI;
    - Collaborate to better manage the effects of coastal development, reduce land-based sewage and pollution and the release of oil and other hazardous substances, minimize light pollution, and avoid ship groundings and strikes;
    - Maintain effective management of coastal and offshore aquaculture expansion, the aquarium fish industry, marine invertebrate harvest, collection, and marketing, and recreational whale watching; and
    - Review the status and effectiveness of Marine Life Conservation Districts (MLCDs), Fishery Management Areas (FMAs), fishery replenishment areas, Community-Based Fishing Areas (CBFAs) and other marine managed areas and consider modifying or expanding boundaries and management strategies as necessary.
2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Support the updating and continued implementation of Hawai'i's *Aquatic Invasive Species Management Plan* (2003) and other identified actions;
    - Increase inspection and other biosecurity measures to prevent high-risk invasive species and diseases from entering Hawai'i, or being introduced to any islands where they are not currently found;
    - Implement effective monitoring aimed at detecting non-native marine and aquatic species and formulate rapid response strategies to control and eradicate harmful invasive species;
    - Document success in reducing the number of invasive species and/or the total area of invasive species coverage in aquatic and marine ecosystems;
    - Encourage compliance with ballast water and hull-fouling regulations;

- Continue to fund and support research and development of methods to mitigate threats to habitats and species presented by invasive weed species; and
- Continue to support a coordinated statewide invasive species public outreach program with shared resources and responsibilities among cooperating entities.

3) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Develop database of all aquatic and marine species in order to track information on biology, ecology, threats, monitoring and conservation actions;
    - Continue the MHI RAMP (Research and Monitoring Program) cruises and other collaborations between NOAA and DAR to study and monitor MHI and NWHI coral reef ecosystems;
    - Revise the Hawai‘i Marine Gap Analysis for the MHI (2005) and maintain an integrated decision-making process to facilitate management of Hawai‘i’s marine resources;
    - Improve information sharing among agencies, non-governmental organizations, community-partners, and academia through support of programs such as the Hawai‘i Marine Gap Analysis program, the Western Pacific Fisheries Information Network, the Pacific Basin Information Node, the Community-Based Monitoring Hui, the Limu Hui, the Lawai‘a Pono Hui, and the Bishop Museum Hawai‘i Biological Survey;
    - Conduct research and compile foundational knowledge on Native Hawaiian traditional fishing practices, marine resource management (including traditional methods of habitat enhancement, limu propagation, and stock enhancement), and the cultural importance of marine species; and
    - Seek to expand funding for monitoring of other habitats (e.g., deep waters, sandy habitats, shallow water, estuaries, marshes, tide pools, anchialine pools, etc.).
4) Strengthen existing and create new partnerships and cooperative efforts.
    - Expand and strengthen existing partnerships and cooperative efforts by formalizing partnerships or by adding new partners;
    - Continue to exercise co-management of PMNM and strengthen collaboration with Co-Trustee agencies (NOAA and USFWS) and other institutions, including the Hawai‘i Institute of Marine Biology (HIMB), and NMFS, to implement coordinated scientific research and conservation initiatives that help ensure protection of marine species throughout the state; Continue to maintain and enhance partnerships with federal enforcement agencies including the U.S. Marine Corps, U.S. Coast Guard, and NOAA Office for Law Enforcement;
    - Maintain and improve community co-management efforts like such as in community-based subsistence fishing areas and encourage community-based management programs like the West Hawai‘i Regional Fisheries Management Council;
    - Continue support for the statewide watershed management partnerships and integrate projects that seek to document reductions of non-point source pollution;
    - Increase the scope of community involvement in local conservation efforts by consulting with kūpuna and collaborating with landowners to broaden opportunities that incorporate cultural knowledge and understanding into marine

and freshwater conservation policies and incorporate traditional Native Hawaiian management strategies;
    - Support the expansion and addition of community-based subsistence fishing areas;
    - Collaborate with DOH to protect other sensitive marine and estuarine ecosystems by improving water quality;
    - Collaborate to decrease the number of streams and coastal sites listed as impaired according to DOH water quality standards; and
    - Continue and enhance partnership among DLNR, HIHWNMS, the NMFS Pacific Island Regional Office, and the Pacific Islands Fisheries Science Center for marine wildlife conservation.
5) Expand and strengthen outreach and educational efforts to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Expand the statewide community Makai Watch program and enhance educational and training programs that promote stewardship responsibility and expand outreach initiatives through ocean users' workshops, newsletters, brochures, posters, school and community group visits, and public service announcements;
    - Include issues associated with marine debris and invasive species and the risks they represent for marine protected species in educational and outreach programs;
    - Encourage public participation and stewardship by expanding volunteer opportunities to contribute to native wildlife conservation;
    - Encourage and support business sector-led initiatives to effectively incorporate native wildlife considerations into their business models, with a focus on aquaculture, fisheries, and tourism industries;
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive habitats and areas; and
    - Collaborate to increase compliance with existing laws through outreach and educational programs and support for increased enforcement capacity.
6) Support policy changes aimed at improving and protecting native species and habitats.
    - Advance the ecosystem-based approach to species protection in the HIHWNMS by collaborating with NOAA in the planning and review process;
    - Review fishing regulations to ensure adequate protection and oversight of game and non-game species harvest;
    - Encourage regulations that would require permits or use licenses for the taking of all marine species;
    - Encourage regulation for blanket extractive limits for non-game species extracted for research, recreation, and commerce purposes;
    - Improve management and enforcement related to the use of lay gill nets in state waters;
    - Implement new or revised rules governing activities and restrictions in marine managed areas;
    - Collaborate to revise and implement policies on anchor damage and use, watercraft disturbance, recreational overuse, marine debris, use of biodiesel fuels, and boat pump-out stations;
    - Support development and implementation of a comprehensive coastal policy;

    - Increase conservation enforcement efforts on all state-owned waters through increased funding for trained enforcement officers; and
    - Strengthen regulations for import and export of aquatic, non-native species that rely on the precautionary principal.
7) Enhance funding opportunities to implement needed conservation actions.
    - Develop new sources of State funding to support and expand conservation management in state waters including identified management actions; and
    - Support increased funding for enforcement.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section. Many apply to the entire marine ecosystem.

- The *Ocean Resources Management Plan* was developed by a multi-agency effort in order to guide management of ocean resources. There are plans to update it in the near future. (Hawai‘i Department of Business, Economic Development, and Tourism (DBEDT) 2013);
- The Western Pacific Fisheries Management Council has fisheries management plans that guide fishing for bottomfish and seamount fisheries, precious corals, crustaceans, coral reef ecosystems, and pelagic species. Available at: www.wpcouncil.org;
- The *Aquatic Invasive Species Management Plan* produced by DAR in 2003 addresses prevention and eradication of marine invasive species. Available at: http://dlnr.hawaii.gov/dar/files/2014/04/ais_mgmt_plan_final.pdf;
- The Hawaiian Islands Humpback Whale National Marine Sanctuary has produced an updated Draft Sanctuary Management Plan and Draft Environmental Impact Statement. Available at: http://hawaiihumpbackwhale.noaa.gov/management/pdfs/mp2015_dmp_deis.pdf;
- The Co-Trustees (NOAA, USFWS, and State of Hawaii) produced a 15-year joint management plan in 2008 and more information is available at: http://www.papahanaumokuakea.gov/;
- The Hawai‘i Biodiversity and Mapping Program developed the Marine Gap Analysis project and produced a report in 2005 that contains information to facilitate management of near-shore natural resources by providing objective and comprehensive reporting on the status and distribution of resources and the elements of viable design for MPA networks. More information available at: http://www.researchgate.net/publication/265978485_Marine_Gap_Analysis_for_the_Main_Hawaiian_Islands.
- The Hawai‘i Biological Survey (HBS) is an ongoing natural history inventory of the Hawaiian Archipelago. It was created to locate, identify, and evaluate all native and non-native fauna and flora within the state, and to maintain the reference collections of that biota for a wide range of uses. It is managed by the Bishop Museum. Information and data available at: http://hbs.bishopmuseum.org/;
- The Western Pacific Fishery Information Network (WPacFIN) is a federal and state partnership for collecting, processing, analyzing, sharing, and managing fisheries data from American island territories and states in the Western Pacific. Information and data available at: http://www.pifsc.noaa.gov/wpacfin/

- NOAA Coastwatch uses a variety of satellite remote sensing datasets in an effort to better monitor and analyze the central Pacific Ocean. Information and data available at: http://www.nsof.class.noaa.gov/glossary/CWHAW.htm
- NOAA's Coral Reef Information System (CoRIS) is designed to be a single point of access to NOAA coral reef information and data products, especially those derived from NOAA's Coral Reef Conservation Program. Information and data available at: http://www.coris.noaa.gov/.
- The Holomua Marine Initiative is a call to action for communities to come together and design an island-based management strategy to ensure healthy reefs and abundant resources for future generations. More information is available at: https://dlnr.hawaii.gov/holomua/about/
- The State of Hawai'i Wetland Program Plan 2021 – 2025 was developed by the Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) with support from the Division of Forestry and Wildlife (DOFAW) and the U.S. Environmental Protection Agency (EPA). The mission of this Wetland Program is to align management priorities for wetlands within the DLNR, and to enhance, protect, conserve, and manage Hawai'i's wetland ecosystems statewide. More information can be found here: https://www.epa.gov/sites/default/files/2021-06/documents/hawaii_wetland_program_plan_2021.pdf

MANAGEMENT NEEDS

Current Management of Species and Habitats

Under section 190-1, Hawaii Revised Statutes, all marine waters of the state are within a "marine conservation area." Although this legislation provides no additional protection beyond authorizing the establishment of MLCDs, it does recognize the importance of marine waters to the well-being of the state and provides DLNR with the authority to manage ocean resources. The dedication of PNMS was a significant action that greatly facilitated the State's (with DLNR as the lead agency) capacity to more actively co-manage marine resources in the NWHI. As agency Co-Trustees, DLNR, NOAA, and USFWS are collectively charged with protecting, conserving, and enhancing fish, plant, and wildlife habitats, including coral reefs and other marine and terrestrial resources in the NWHI.

The following section addresses the management actions currently in place and identifies future needs of key habitats of Hawai'i's marine environment. Overall management needs that span across all key Hawai'i marine habitat environments are the needs to build and foster community partnerships and co-management efforts, to ensure management efforts are conducted in a way that maximizes community participation and input, and to understand and support holistic management frameworks rooted in Native Hawaiian cultural beliefs and values.

General fishing regulations, DAR

Species: Marine fishes and invertebrates including black corals.
Habitats: Marine ecosystems.
***Current Management*:** Limited take, gear, size, season, and area restrictions on some reef, bottom, and pelagic fishes, mollusks, crustaceans, and corals.

Future Needs: Reevaluate size and bag limits to ensure species have sufficient reproductive and recruitment potential to ensure sustainability and species survival in Hawai‘i. Review regulations dealing with non-game species, research, and other commercial uses.

Fishing regulations in federal waters, **Western Pacific Fishery Management Council and NOAA**

Species: Marine fishes and invertebrates including black and other precious corals.
Habitats: Marine ecosystems.
Current Management**:** Limited take, gear, size, season, and area restrictions on some coral reef organisms, bottomfish, pelagic fishes, crustaceans, and precious corals as outlined in Fishery Management Plans for these groups.
Future Needs: Fully comply with federal regulations and guidelines on developing and implementing Fishery Management Plans; establish workshop to evaluate management needs for precious corals; and continue to manage "Deep 7" bottomfish according to annual catch limits and the *Fishery Management Plan for Bottomfish and Seamount Groundfish Fisheries*.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), NOAA and DLNR**

Species**:** Humpback whale.
Habitats: Marine ecosystems.
Current Management**:** Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Hawaiian Islands NWR **(610,000 acres of marine habitat), USFWS**

Species**:** 18 seabirds, Hawaiian monk seals, green sea turtles, endemic coral reef organisms including some endemic only to NWHI, pelagic fishes, bottomfishes, sandy habitat organisms, spinner dolphins, and other marine mammals.
Habitats: Marine and coastal ecosystems of the NWHI (please refer to Chapter 6 Northwestern Hawaiian Islands for more detail).
Current Management**:** Limited access, limited take, reef monitoring, and turtle monitoring; collaboration with other marine researchers and PMNM; research, conservation actions, and education.
Future Needs: Update management plan. Coordinate actions with the State and the Coral Reef Reserve or Sanctuary, and additional monitoring.

***Papahānaumokuākea National Marine Sanctuary, State* of Hawai‘i, NOAA, and USFWS**

Species: Hawaiian monk seals, green sea turtles, seabirds, coral reef organisms (including some endemic only to NWHI), pelagic fishes, bottomfishes, sandy habitat organisms, other marine mammals.

Habitats: Marine and coastal ecosystems of the NWHI, including native Hawaiian cultural sites.

Current Management: Limited access by permit only; development and implementation of best management practices, collaboration on research, monitoring, conservation activities, native Hawaiian cultural studies, and traditional practices, outreach and education.

Future Needs: Continue to strengthen co-management capacity among the State, NOAA, USFWS, and the Office of Hawaiian Affairs (OHA) and ensure sufficiency of funding and support infrastructure to advance existing and future projects; continue to develop and implement projects to address climate change impacts, invasive species, and marine debris.

***Marine Life Conservation Districts,* DAR (10 Areas – O‘ahu: Hanauma Bay, Pūpūkea, Waikīkī; Lāna‘i: Mānele-Hulopo‘e; Maui: Honolua-Mokulē‘ia, Molokini Shoal; Hawai‘i: Kealakekua Bay, Lapakahi, Old Kona Airport, Wailea Bay)**

***Species*:** Species associated with shallow coral reef, sandy beach, and rocky habitats, Hawaiian monk seals, green sea turtles, and other marine mammals.

Habitats: Marine ecosystems including shallow coral reef, sandy beach, rocky habitats.

***Current Management*:** Both limited take and No Take provisions, dictated on a site-specific basis to encourage No Take activities such as recreation, research, and educational opportunities, and to enhance productivity of fish and other marine life in the MLCD.

Future Needs: Continue to evaluate, document, and report the purpose and management effectiveness for all MLCDs and consider the need for new marine protected areas.

***Fishery Management Areas,* DAR (22 Areas – Kaua‘i: Hā‘ena Community-Based Subsistence Fishing Area, Hanamā‘ulu Bay, Nāwiliwili Harbor, Port Allen, Waimea Bay and Waimea Recreational Pier; O‘ahu: Waikīkī-Diamond Head Shoreline, Maunalua Bay; Moloka‘i: Kaunakakai Harbor; Lāna‘i: Mānele Harbor; Maui: Kīpahulu Community-Based Subsistence Fishing Area, Kahekili Herbivore Management Area, Kahului Harbor; Hawai‘i: Miloli‘i Community-Based Subsistence Fishing Area, Hilo Bay, Wailoa River, and Wailuku River, Kailua Bay, Kawaihae Harbor, Keauhou Bay, Kīholo Bay, Kona Coast, Puakō Bay and Reef, West Hawai‘i Regional, and the North Western Hawaiian Islands Marine Refuge (all islands)**

***Species*:** Some or all regulated fish species.

Habitats: Marine and estuary ecosystems.

***Current Management*:** FMAs were mostly set up to manage user conflicts. They have restrictions on gear, size of fish, access, season, etc., that differ from general fishing regulations. The Waikiki-Diamond Head Shoreline FMA is closed to fishing on odd numbered years and open to fishing on even numbered years. Many FMAs are in harbors, bays, or canals.

Future Needs: Continue to evaluate, document, and report the purpose and management effectiveness for all FMAs and consider the need for modifications or refinement of existing regulations.

Statutorily Designated Regulated Areas, DAR (6 Areas - Kauaʻi: Kapaʻa and Waikaʻea Canals; Oʻahu: Heʻeia Kea Wharf, Honolulu Harbor, Pōkaʻi Bay, Waialua Bay, andAla Wai and Kapālama Canals

***Species*:** Some or all regulated fish species.
Habitats: Marine and freshwater ecosystems
***Current Management*:** Rules including limitations on the type and amount of fish you can catch, gear restrictions, size limits
Future Needs: Evaluate, document, and report the purpose and effectiveness of current management and consider the need for expansion or modification of existing rules and provisions.

***Public Fishing Areas (PFAs),* DAR (4 Areas - Kauaʻi: Kokeʻe, Wailua Reservoir; Oʻahu: Wahiwa; Hawaiʻi: Waiākea)**

***Species*:** Some or all regulated fish species.
Habitats: Marine and estuary ecosystems
***Current Management*:** Rules including limitations on the type and amount of fish you can catch, gear restrictions, size limits
Future Needs: Evaluate, document, and report the purpose and effectiveness of current management for PFAs and consider the need for expansion or modification of existing rules and provisions.

***South Kona ʻŌpelu Fishing Area,* DAR**

Species: ʻŌpelu.
Habitats: Marine ecosystems.
***Current Management*:** Gear and fishing area restrictions.
Future Needs: Evaluate purpose and management effectiveness and consider need for new marine protected areas.

***ʻEwa Limu Management Area,* DAR**

Species: Limu.
Habitats: Marine ecosystems.
***Current Management*:** Harvesting restrictions.
Future Needs: Evaluate purpose and management effectiveness and consider need for new limu management areas.

***Marine Wildlife Sanctuaries and Refuges,* DAR (Three Marine Areas – Coconut Island Refuge, Paikō Lagoon Widlife Sanctuary, and Kure Atoll Field Station)**

***Species*:** Species associated with coastal waters, shallow coral reef, sandy beach, and rocky habitats.
Habitats: Marine ecosystems including shallow and intermediate-depth coral reef, sandy beach, and rocky habitats.
***Current Management*:** Limited access and no take of fish or other wildlife.

Future Needs: Continue to evaluate, document, and report the purpose and management effectiveness and the sufficiency of funding for all Sanctuaries to ensure that existing and new projects are properly implemented, and consider additional areas for inclusion in the State Wildlife Sanctuary program.

Keʻehi Lagoon*, Hawaiʻi DOH *Bottomfish

***Species*:** All resident aquatic and marine species.
Habitats: Estuary.
***Current Management*:** A phytoremediation (plant-based clean-up) project was implemented in 2002 to remove nutrients and pollutants from estuary waters; DOT is collaborating with DOH on implementing and routinely updating provisions of the Storm Water Pollution Control Plan (SWPCP) at the Keʻehi Baseyard.
Future Needs: Continue clean-up efforts aimed at improving water quality and enhancing biological productivity of the estuary, monitor environmental parameters, continue to perform frequent review and revision of SWPCP, and expand remediation tools to minimize stormwater impacts.

***Kalaupapa NHP* (10,779 acres), NPS**

***Species*:** Invertebrates and fishes associated with shallow coral reef and rocky habitats, Hawaiian monk seals, and sea turtles.
Habitats: Shallow coral reefs, sandy beaches, and rocky habitats.
***Current Management*:** The Draft General Management Plan (GMP) and Environmental Impact Statement (EIS) present the management actions for Kalaupapa NHP's long-term management and progression over the next 15-20 years. The GMP includes provisions for expanded monitoring and research of marine resources.
Future Needs: Finalize the GMP and EIS and incorporate appropriate improvements in the ecological monitoring program for nesting sea turtles and Hawaiian monk seals; expand partnerships and collaborations to encourage development of new programs that address oceanographic processes and marine water quality, and continue to monitor the health of coral reef habitat, fish, and marine invertebrate communities.

***Keālia Pond NWR* (700 acres), USFWS**

***Species*:** Hawksbill sea turtle.
Habitats: Sandy beach for nesting.
***Current Management*:** Support for monitoring and protection of beach habitat and dune integrity for nesting hawksbill turtles on Sugar Beach and adjacent habitat; maintenance of beach berm fencing to prevent adult turtles and hatchlings from moving up the beach toward North Kihei Road; dune retention and restoration.
***Future Needs*:** Maintain existing management activities and expand the scope and effectiveness of longer-term measures related to minimizing vehicle collision risk for hawksbill turtles; develop dune restoration initiatives that strive to achieve a native species–dominated community that is linked to wetland functions.

***ʻĀhihi-Kīnaʻu NAR* (2,045 acres), DOFAW**

***Species*:** Species associated with shallow coral reef, sandy beach, rocky habitats, and anchialine pools, including green sea turtles, Hawaiian monk seals, humpback whales, and other marine mammals.
Habitats: Marine ecosystems, including shallow coral reef, sandy beach, rocky habitats, and anchialine pools.
***Current Management*:** Limited access and no take; many areas open to the public; anchialine pools are protected and monitored and an ungulate fence is being installed to protect native plants and resources from harm caused by feral ungulates (goats, deer); outreach is ongoing and efficiently directed based on concentrated use patterns.
***Future Needs*:** Add enforcement capacity and conduct additional research and monitoring. Evaluate, document, and report the purpose and effectiveness of management and integrate aquatic and marine components of the reserve with statewide conservation objectives for anchialine pools and nearshore reef communities.

***Kahoʻolawe Island Reserve*, Kahoʻolawe Island Reserve Commission**

***Species*:** Species associated with shallow coral reef, sandy beach, and rocky habitats, pelagic fishes, Hawaiian monk seals, green sea turtles.
Habitats: Marine ecosystems including shallow and deep coral reef, sandy beach, and rocky habitats.
***Current Management*:** Limited access and take, no commercial activity; monitoring and facilitation of research, restoration ecology, and erosion remediation to improve habitat quality for native species and water quality.
Future Needs: Continue monitoring and marine debris removal; increase education and outreach. Continue to evaluate, document, and report the purpose and effectiveness of management activities and the sufficiency of funding.

***Koloko-Honokōhau NHP* (1,161 acres), NPS**

***Species*:** Species associated with shallow coral reef and rocky habitat, including green sea turtle.
Habitats: Shallow coral reef and rocky habitats and sandy beach used for basking by turtles.
***Current Management*:** Reef ecosystem and sea turtle monitoring and research.
Future Needs: Continue existing management, implement biological and water quality monitoring.

***Hawai'i Volcanoes National Park* (323,431 acres), NPS**

***Species*:** Species associated with shallow coral reef and rocky habitat, hawksbill sea turtle.
Habitats: Shallow coral reef and rocky habitats and sandy beach used for nesting by hawksbill sea turtles.
***Current Management*:** Sea turtle research, monitoring, education, and protection.
Future Needs: Continue existing management and leverage further opportunities to secure stable funding for hawksbill sea turtle work; increase understanding of adjacent nearshore marine habitat to better evaluate impacts occurring on and adjacent to the park.

References:

Bishop, R.C., D.J. Chapman, B.J. Kanninen, J.A. Krosnick, B. Leeworthy, and N.F. Meade. 2011. Total Economic Value for Protecting and Restoring Hawaiian Coral Reef Ecosystems: Final Report. Silver Spring, MD: NOAA Office of National Marine Sanctuaries, Office of Response and Restoration, and Coral Reef Conservation Program. NOAA Technical Memorandum CRP 16. 406 pp.

Brown E. Personal communication, Marine Ecologist, Kalaupapa National Historic Park.

Cesar H, Beukering P, Pintz S, Dierking J. 2002. Economic valuation of the coral reefs of Hawai‘i. Hawai‘i Coral Reef Initiative Research Program. Available at: http://www.hawaii.edu/ssri/hcri/rp/cesar/noaa_final_report_01-02/cesar_final_report-01-02.htm.

Hawai‘i, U.S. Department of the Interior, and the U.S. Department of Commerce. 2006. Memorandum of Agreement Promoting Coordinated Management of the Northwestern Hawaiian Islands Marine National Monument.

Hawai‘i Department of Business, Economic Development, and Tourism (DBEDT).2013. Hawai‘i ocean resources management plan. Honolulu, (HI): DBEDT. 151 pp.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. (accessed 28 March 2005).

Hawai‘i Department of Land and Natural Resources (DLNR). 2003. Ahihi-Kinau NAR/Keoneo‘io plan of action draft for discussion purposes.

Hawai‘i Department of Land and Natural Resources and Division of Aquatic Resources (DAR). 2005. Marine protected areas in Hawai‘i. Honolulu, (HI): DAR. 14pp. Available at: http://www.hawaii.gov/dlnr/dar/pubs/M(PA)pub.pdf.

Hawai‘i Division of Aquatic Resources; Bottomfish fishing regulations. 2002. Available at: http://www.hawaii.gov/dlnr/dar/bottomfish/index.htm.

Hawai‘i Division of Aquatic Resources. 2004. Fishing regulations. Available at: http://www.hawaii.gov/dlnr/dar/fish_regs/index.htm.

Hawai‘i Division of Aquatic Resources. Hawaii’s marine life conservation districts. Available at: http://www.hawaii.gov/dlnr/dar/mlcd/index.htm.

Hawai‘i Division of Aquatic Resources. 1992. Marine life conservation district plan. Honolulu, (HI): DAR. 18 pp.

Hawai‘i Division of Aquatic Resources. 2003. State of Hawai‘i aquatic invasive species management plan. Honolulu, (HI): DAR. 205 pp. Available at: http://www.hawaii.gov/dlnr/dar/pubs/ais_mgmt_plan_final.pdf.

Hawai‘i Division of Forestry and Wildlife. 1992. ‘Ahihi-Kinau NAR management plan. Draft. Honolulu, (HI): DOFAW. 18 pp.

Hawai‘i Division of Forestry and Wildlife. Ahihi-Kinau Natural Area Reserve. Available at: http://www.dofaw.net/nars/images.php?reserve=010.

Hawai‘i Office of Planning. 2013. Hawai‘i Ocean Resources Management Plan. Hawai‘i Coastal Zone Management Program. 57 pp.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kaho‘olawe Island Reserve Commission. 1997. Ocean resources management plan. Available at: http://kirc.state.hi.us/public/komp.doc.

Maragos J, Gulko D, editors. 2002. Coral reef ecosystems of the Northwestern Hawaiian Islands: interim results emphasizing the 2000 surveys. Honolulu, (HI): U.S. Fish and Wildlife Service and Hawai‘i Department of Land and Natural Resources. 46 pp.

Mundy BC, Everson AR. Marine resources. *In* Status and trends of the nation’s biological resources. U.S. Geological Service. Available at: http://biology.usgs.gov/s+t/SNT/noframe/mr181.htm.

National Atlas of the United States. First.gov. Available at: http://nationalatlas.gov/articles/mapping/a_general.html#six accessed 11 July 2005.

National Oceanic and Atmospheric Administration (US) [NOAA]. 2004. Hawaiian Islands Humpback Whale National Marine Sanctuary. Available at: http://hawaiihumpbackwhale.noaa.gov/about/about_sanctuary.html.

National Oceanic and Atmospheric Administration (US) [NOAA]. 2013. Papahānaumokuākea Marine National Monument Permitted Activities 2013 Annual Report.

National Park Service (US) [NPS]. 2015. Kalaupapa National Historic Park, Draft General Management Plan and Environmental Impact Statement. Pacific West Region, Park Planning and Environmental Compliance.

National Park Service (US) [NPS]. Hawai‘i Volcanoes National Park. Available at: http://www.nps.gov/havo/index.htm.

National Park Service (US) [NPS]. Kalaupapa National Historic Park. Available at: http://www.nps.gov/kala/index.htm.

National Park Service (US) [NPS]. Koloko-Honokohau Hawai‘i Volcanoes National Historic Park. Available at: http://www.nps.gov/kaho/index.htm.

TenBruggencate J. 2005 July 11. New coastal guidelines sought. Honolulu Advertiser. Available at: http://www.honoluluadvertiser.com/apps/pbcs.dll/article?AID=/20050711/NEWS11/507110333/1021/NEWS

U.S. Fish and Wildlife Service. 1986. Hawaiian Islands National Wildlife Refuge master plan, Environmental Impact Statement. Honolulu, (HI): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. Kealia Pond National Wildlife Refuge. Available at: http://refuges.fws.gov/profiles/index.cfm?id=12531.

CHAPTER 6: ISLAND CONSERVATION NEEDS

Moving from a statewide perspective to an island region perspective, Chapter 6 addresses individual islands with regard to native wildlife and habitat priorities and strategies. Each island discussion will provide an overview section, identify habitats and species of importance, summarize key threats of particular importance to the island, outline island strategies linked with the seven statewide objectives, identify plans and tools to aid management, and finally, discuss existing management actions and highlight potential new areas for increased conservation management. The Northwestern Hawaiian Islands, also included in this chapter, will be treated as an entire region and follow a similar format for discussion. This chapter addresses elements 1-5 at the island level.

KAUA‘I

Kaua‘i is the northernmost and oldest of the eight Main Hawaiian Islands and is characterized by deep eroded canyons and valleys and steep cliffs. There is a wide diversity of unique natural communities, from montane bogs, montane wet forest, lowland mesic forest, lava tube caves, long stretches of sandy beach, and many streams and rivers. Because of the age of the island and its relative isolation, levels of endemism are higher on Kaua‘i than elsewhere in the state. Hurricanes Iwa (1982) and Iniki (1992) damaged forest cover and encouraged the spread and establishment of introduced invasive weeds. As the only island where the mongoose (*Herpestes auropunctatus*) has not become established, Kaua‘i hosts greater populations of several ground-nesting birds than other islands.

OVERVIEW

Geology and Hydrology

Most of the island was formed from the eruptions of a single shield volcano between 3.6 million and 5.6 million years ago. Since that time, rain, streams, and waves have eroded the 143,226 hectares (353,920 acres) island, creating steep sea cliffs, deep canyons, and valleys that extend from the interior of the island to the coast, a mountainous interior, and a broad coastal plain with deep soil and extensive beaches. Approximately 35 percent of the island is below 150 meters (500 feet) in elevation, and approximately 24 percent is above 610 meters (2,000 feet) in elevation. Kaua‘i has 61 perennial streams, 45 of which are continuous. Wailua and Hanalei have the largest discharges, 200 and 140 million gallons per day (mgd), respectively. Kaua‘i also has three offshore islets.

Climate

Elevation ranges from sea level to 1,598 meters (5,243 feet). Kaua‘i is directly exposed to the prevailing tradewinds that deliver rain, conditions which make Mount Wai‘ale‘ale one of the wettest spots on earth, with an average 1,120 centimeters (444 inches) of rainfall per year. However, not all the island is wet: average rainfall in Kekaha on the leeward side is only 52 centimeters (20 inches) per year.

Land and Water Use

Approximately 38 percent of the island remains dominated by native vegetation, and approximately 15 percent of the island has been designated as critical habitat for Kauaʻi plants. More than half the island (56% or 198,769 acres) is located in the State Conservation District, approximately 40 percent is in the State Agricultural (139,305 acres) or State Rural District (1,253 acres), and the remaining is in the State Urban District (100,730 acres). Twenty-five streams are diverted and 12 have altered channels. Kauaʻi has 16 impaired streams under the Environmental Protection Agency (EPA's) Clean Water Act standards. The Wailua canal system is the largest human-made stream system. Waita Reservoir is a significant human-made lake that is seven meters (23 feet) deep and 171 hectares (424 acres) in size.

Human Landscape

In 2020, the County of Kauaʻi had a population of 73,298 residents (U.S. Census Bureau 2021). The total County population amounted to approximately five percent of the state population, the smallest of the four counties. Most residents live in towns around the perimeter of the island, primarily along the east and south sides of Kauaʻi, with smaller populations living in towns on the north shore. The principal economic driving forces are tourism, agriculture, and defense expenditures. In 2023, Kauaʻi hosted over 1.4 million visitors (DBEDT 2024) Agriculture has shifted recently from primarily sugarcane, with the closure of all five plantations, to diversified agriculture and aquaculture. Kalo (*Colocasia esculenta* [taro]) has cultural and historic significance to native Hawaiians. The kalo fields in Hanalei are one of the largest growing areas in the State. Defense expenditures stem from the Pacific Missile Range Facility, located in the southwest corner of the island.

SPECIES AND HABITATS OF IMPORTANCE

Terrestrial habitats on Kauaʻi are composed of montane wet communities, montane mesic communities, lowland wet communities, lowland mesic communities, lowland dry communities, and coastal communities, resulting in a diverse range of natural vegetation. While just over one-third of the island remains dominated by native vegetation, many native-dominated areas contain smaller pockets of non-native invasive species that became established following Hurricanes Iwa and Iniki. The island has a network of perennial and intermittent streams and several rivers and estuaries. Kauaʻi's marine habitat consists of coral reefs, sand and mud. Within the coral reef structure type, there is pavement, spur and groove, individual patch reef, aggregate patch reef, aggregated reef, rock/boulder, pavement with sand channels, rubble, and scattered coral/rock. Unique habitat types and major associated landscapes for wildlife include the montane bogs located in the Alakaʻi Wilderness Preserve, montane wet forest, lowland mesic forest, lava tube caves, steep sea cliffs, wetlands, coastal zones, and long stretches of mountain streams. Three offshore islands, Lehua, Mokuʻaeʻae, and Kaʻula, are particularly important for nesting seabirds. In addition, a total of 21,524 hectares (53,188 acres) have been designated as critical habitat for threatened and endangered species on Kauaʻi; this total area includes critical habitat for 127 plant species; 321 hectares (794 acres) for the picture-wing fly (*Drosophila musaphila*); 6,952 hectares (17,193 acres) for the ʻakekeʻe (*Loxops caeruleirostris* [Kauaʻi ʻākepa]), ʻakikiki (*Oreomystis bairdi* [Kauaʻi creeper]), and Hawaiian picture-wing fly (*D. sharpi*); 110 hectares (272 acres) for the peʻepeʻe maka ʻole (*Adelocosa anops* [Kauaʻi cave wolf spider]) and Kauaʻi cave amphipod

(*Spelaeorchestia koloana*); and 1,812 hectares (4,479 acres) of riparian habitat and 20 kilometers (12 miles) of stream channels for the Newcomb's snail (*Erinna newcombi*). Three offshore islands support more than 15 species of breeding seabirds, including the largest ʻā (*Sula leucogaster* [brown booby]) colony in the state.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on Kauaʻi and its associated offshore islands. Species endemic to Kauaʻi include the puaiohi (*Myadestes palmeri*), ʻakikiki, ʻanianiau (*Hemignathus parvus* [lesser ʻamakihi]), ʻakekeʻe, Newcomb's snail, peʻepeʻe maka ʻole, Kauaʻi cave amphipod, and two species of picture-wing flies (*Drosophila musaphila* and *D. sharpi*). Additional forest birds include the ʻiʻiwi (*Vestiaria coccinea*), ʻapapane (*Himatione sanguinea*), and Kauaʻi ʻelepaio (*Chasiempis sandwichensis sclateri*). Waterbirds and migratory shorebirds use remnant wetlands, with 80 percent of the state's koloa maoli (*Anas wylvilliana* [Hawaiian duck]) population, and 50 percent of the state's nēnē (*Branta sandvicensis* [Hawaiian goose]) population found on Kauaʻi. Increasing numbers of nēnē, ʻalae ʻula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen], and ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]) are feeding in taro ponds in Hanalei Valley and causing significant damage to farmers crops.

Two Hawaiian endemic seabirds, the ʻaʻo (*Puffinus newelli* [Newell's shearwater]), ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), are known to breed in the steep mountainous interior of Kauaʻi in crevices and burrows often beneath dense understory of native ferns and canopy structure. The ʻakēʻakē (*Hydrobates castro* [band-rumped storm-petrel]), which also nests in the Galapagos Islands and off Japan are believed to nest in rock crevices and cavities in upper elevations and on sea cliffs but their nesting distribution on Kauaʻi is poorly understood. Kauaʻi is also home to a diverse number of terrestrial invertebrates, most of which have been poorly studied. Notable invertebrates include several endemic species of native bees in the genus *Hylaeus* and of native damselflies in the genus *Megalagrion*. In addition, diversity within most families of beetles (Coleoptera) is among the highest in the state. In recent years, the number of honu (*Chelonia mydas* [green sea turtle]) and ʻīlioholoikauaua (*Monachus schauinslandi* [Hawaiian monk seals]), basking on Kauaʻi's beaches has increased. Many species of coral that are endemic to the Hawaiian Islands can be found in the coral reefs surrounding Kauaʻi, including the threatened *Montipora flabellata*, *Porites brighami, Porites evermanni, Porites compressa, Porites duerdeni, Porites hawaiiensis, Pocillopora molokensis,* and *Pocillopora ligulata* among others. Finally, Kauaʻi is believed to have historically supported populations of the endangered Blackburn's sphinx moth (*Manduca blackburni*).

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats more acute or specific to Kauaʻi are listed below.

- Populations of feral pigs (*Sus scrofa*) and goats (*Capra hircus*) that distribute introduced invasive plants (such as strawberry guava [*Psidium cattleianum*]) and eat, trample, or uproot native plants, degrading habitat, contributing to soil erosion, and impairing stream quality. The State also manages the public hunting program to help control these animals and provide for subsistence and recreation in appropriate areas;

- Habitat-modifying invasive plants, including kāhili ginger (*Hedychium gardnerianum*), Australian tree fern (*Sphaeropteris cooperi*), strawberry guava, and mangrove (*Bruguiera gymnorrhiza* and *Rhizophora mangle*);
- Predation by introduced animals (e.g., populations of feral cats [*Felis catus* that kill waterbirds and ground-nesting seabirds, barn owls [*Tyto alba*] that prey on native seabirds and waterbirds, cattle egrets [*Bubulcus ibis*] that prey on native waterbirds and competes for nests with native seabirds on offshore islets, and rats [*Rattus* spp.] that prey on seabird eggs and forest bird nests);
- Predation by introduced rats, feral cats, pigs, and barn owls in seabird nesting colonies on offshore islands and in remote sites in the interior of the island;
- Disease spread by mosquitoes carrying avian malaria (*Plasmodium relictum*) and avian pox (*Poxvirus avium*) into high-elevation forests;
- Spread of invasive ants, in particular the yellow crazy ant (*Anoplolepis gracilipes*) and little fire ant (*Wasmania auropunctata*) to seabird and waterbird nesting sites on the main and offshore islands or to caves or other habitats supporting rare invertebrate populations:
- Introduced smallmouth bass and rainbow trout (*Oncorhynchus mykiss*), predatory fish, that eat a number of native stream fishes and invertebrates and may also compete with some of them;
- Potential introduction of non-established pests, such as the mongoose;
- Restricted mosquito-free habitat, making Kauaʻi's forest birds highly vulnerable to habitat degradation. Climate change and warmer temperatures will allow mosquitos to move up in elevation penetrating into the last remaining high elevation forests that are available on Kauaʻi;
- More frequent outbreaks of botulism in important managed wetlands;
- Challenges in managing endangered nēnē, Hawaiian moorhen, and Hawaiian coot in taro ponds on the Hanalei National Wildlife Refuge, where U.S. Fish and Wildlife Service regulations protecting endangered species on the refuge complicate dealing with bird depredation issues;
- Fatalities caused by collisions with wind turbines (for ʻōpeʻapeʻa (*Lasiurus cinereus* [Hawaiian hoary bat]), seabirds, nēnē, and waterbirds, and utility lines (for seabirds and waterbirds), and by seabird fallout associated with light
- Risk of nēnē-aircraft collisions at the Līhuʻe Airport and the resulting public safety hazard caused by high numbers of nēnē nesting near the airfield on the adjacent property;
- Stream diversions, dams, or channelizations;
- Insufficient in-stream flows to ensure the biological integrity of many stream systems;
- Development of formerly undeveloped areas and increased urbanization leading to loss and degradation of terrestrial, freshwater, and marine habitat (e.g., increased nutrients in coastal areas leads to non-native algal blooms which affect fish populations and coral habitats, sedimentation from development near stream corridors);
- Increased incidence and severity of coral bleaching events;
- Increased occurrence and spread of coral diseases;
- Hybridization between koloa maoli and introduced mallards;
- Recreational overuse in some areas along the Nā Pali Coast and in the Poʻipū area; and
- Human interactions with ʻīlioholoikauaua, which are much more common off Kauaʻi than the other Main Hawaiian Islands.

- Potential avian flu outbreak in seabird colonies on offshore islets, coast and remote interior of Kauaʻi
- Parasites (toxoplasmosis) spread by feral cats to threatened and endangered species
- Land based sources of pollution getting into the aquatic environment

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) (main bullet), additional island-specific strategies for Kauaʻi include the following (sub-bullet):

- Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in the Management Needs section;
    - Implement conservation actions identified in the Potential Areas for Enhanced Conservation Management subsection;
    - Develop, revise, and/or implement recovery plans for threatened and endangered species on Kauaʻi;
    - Control ungulates, predators, and mosquito populations in fenced and priority conservation areas of the Alakaʻi Plateau;
    - Continue or begin a captive propagation program for all rare forest birds that have high susceptibility to mosquito-borne avian disease;
    - Eradicate predators in key seabird nesting colonies in the interior of the island; and initiate innovative management strategies that exclude predators and enhance breeding performance of seabirds at presently known and potential nesting sites;
    - Strengthen biosecurity surveillance for offshore islets of Kauaʻi and develop and implement rapid response plans;
    - Continue to relocate nēnē away from Līhuʻe Airport to safe locations on other islands or at remote locations on Kauaʻi;
    - Protect remaining lava tube and cave habitats;
    - Control non-native insects, particularly wasps, ants, and predatory snails, that prey on native invertebrates. Develop captive propagation programs or predator-free enclosures to protect at-risk native species;
    - Increase active management in, or acquisition of, extremely rare habitats on Kauaʻi;
    - Increase the total acreage of ungulate-free and predator-free areas;
    - Implement fire suppression measures and protocols for post-fire restoration;
    - Decrease in number of stream diversions and channelized streams;
    - Work with Commission on Water Resource Management to ensure net increase in number of streams with biological integrity and Instream Flow Standards sufficient to sustain viable native fish and invertebrate populations;
    - Collaborate in efforts to reduce pollution threats from recreational boats and cruise ships;
    - Develop management plans for all marine managed areas; and

    - Support the Local Action Strategies project to deal with non-point source pollution in Hanalei Bay and support expansion of successful methods to other areas.
- Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Improve early detection and rapid response capacity for species not yet established in the islands (e.g., brown tree snake [*Boiga irregularis*], West Nile virus, red imported fire ant [*Solenopsis invicta*]), or that are present in the Main Hawaiian Islands but not yet established on Kauaʻi (e.g., mongooses);
    - Increase efforts to prevent establishment of priority invasive plants in pristine areas (e.g., kāhili ginger, Australian tree fern) and to eradicate from areas with recovery potential;
    - Decrease in the overall number of streams negatively impacted by invasive species; and
    - Support efforts to strengthen marine alien species prevention and control.
- Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Improve dissemination of research and data regarding native species populations and habitat condition;
    - Conduct surveys and inventories for invertebrates in currently managed areas;
    - Assess impact of eco-tourism activities on terrestrial and aquatic native wildlife and associated habitats;
    - Continue assessing and minimizing the impacts on seabirds, waterbirds and nēnē populations resulting from interaction with utilities and municipal infrastructure, public transportation sectors, and increased urbanization, and support efforts to develop and implement minimization and mitigation measures;
    - Develop an island-wide programmatic Habitat Conservation Plan (HCP) for nēnē to resolve conflicts with agricultural producers and property owners in developed rural and urban areas where nēnē may be increasing in numbers, to minimize and mitigate impacts on the species and speed its recovery; and
    - Develop an HCP with the airport manager to allow continued management of the nēnē population by reducing the threat of nēnē and aircraft collision and risk to public safety. Include any other species in the HCP for which the airport may need HCP permit coverage in order to continue airport operations and minimize and mitigate impacts on listed species.
- Strengthen existing and create new partnerships and cooperative efforts.
    - Continue implementation of the successful Save Our Shearwaters (SOS) program and complete and implement the SOS Procedures Plan;
    - Work to complete development of an island-wide or similarly programmatic HCP that will adequately address the incidental take of seabirds on Kauaʻi;
    - Work with project developers, landowners, and stakeholders to develop and implement HCPs to minimize and fully mitigate impacts on native wildlife and habitats and provide net environmental benefits to wildlife populations;
    - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and

identify areas where ungulate populations can be managed to provide for continued hunting opportunities; and
    - Collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.
- Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Maintain existing outreach and educational programs at managed conservation areas;
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive habitats and areas.
- Support policy changes aimed at improving and protecting native species and habitats.
    - Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
    - Assess ways to support increased enforcement capacities, including cross-deputation between agencies and expansion of community watch programs like the Makai Watch program initiated by the Department of Land and Natural Resources (DNLR);
    - Continue support of community-based marine managed areas on Kaua‘i and develop rules for community-based subsistence fishing areas as these partnerships develop;
    - Evaluate all current marine managed areas for purpose and management effectiveness and consider need for new marine managed areas;
    - Improve integration of policies to address linkages between terrestrial and marine habitats and their shared conservation threats and needs; and
    - Improve coordination of policies and programs to meet the needs of native wildlife conservation but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.
    - Support research to develop effective mitigation strategies for light pollution and to reduce light pollution related seabird mortalities.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section and include the following:

- Species Conservation Plans prepared by the U.S. Fish and Wildlife Service (USFWS), including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose* (2004), the *Newell's Shearwater and Hawaiian Petrel 5-Year Work Plan* (2011), Band-rumped storm-petrel (Oceanodroma castro) Hawai‘i Distinct Population Segment 5-Year Review (2021), the Recovery Plan for the Kaua‘i Cave Arthropods (2006), the *Recovery Plan for the Newcomb's Snail* (2006), the *Revised Recovery Plan for Hawaiian Forest Birds* (2006), the *Revised Recovery Plan for Hawaiian Waterbirds* (2011), and the *Recovery Plan for the Hawaiian Hoary Bat* (1998);

- Critical habitat designations by USFWS for the Kauaʻi cave arthropods, Newcomb's snail, picture-wing fly, ʻakekeʻe, ʻakikiki, Hawaiian picture-wing fly, and threatened and endangered plants on Kauaʻi.
- Management Plans for the State Natural Area Reserves (NARs): Kuia NAR (1989) and Hono o Nā Pali NAR (2011);
- The Division of Forestry and Wildlife's (DOFAW's) Management Guidelines, which coarsely rate vegetation quality and provide guidelines for land use (public hunting, recreation, and forest products) for state lands managed by DOFAW;
- The Kauaʻi Watershed Alliance Management Plan (2005);
- The National Tropical Botanical Gardens (NTBG) have developed a master plan for Limahuli Garden and Preserve;
- The Oʻahu Offshore Islet Seabird Sanctuaries project, described at http://hbmpweb.pbrc.hawaii.edu/dlnr/projects/offshore;
- The Hawai ʻi Invasive Species Council Strategic Plan 2015-2020 (2015) for invasive species prevention, control, research, and public outreach;
- DOFAW's *Snail Extinction Prevention Program Strategic Plan: 2015 – 2019* (2014);
- Coastal Zone Management plans, including *Section 309 Coastal Zone Assessment and Strategy* (2010) and the *Hawai ʻi Ocean Resources Management Plan* (2013);
- Bishop Museum has a comprehensive database of invertebrates; and
- The Audubon Society maintains a Sightings database of bird species observed in the state.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats and species on Kauaʻi. The discussion of future management needs is highlighted within each current managed area. Some areas on Kauaʻi are already under active management or protection through designation as a State NAR, State Wilderness Preserve, or National Wildlife Refuge (NWR). The Kauaʻi Watershed Alliance (KWA) was recently formed to identify and implement conservation actions needed to preserve Kauaʻi's watershed resources on both public and private land, and the natural and cultural resources within these watersheds. In addition, other partnerships, such as the Save Our Shearwaters program, the Kauaʻi Endangered Bird Recovery Team (KEBRT), the Kauaʻi Invasive Species Committee (KISC), the Kauaʻi Endangered Seabird Recovery Project (KESRP), the Kauaʻi Seabird Habitat Conservation Plan team (KSHCP), and the Kauaʻi Nēnē Habitat Conservation Plan team, have been formed to address specific species conservation needs.

Management Areas

The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Kauaʻi.

Honoʻo Nā Pali NAR (3,150 acres), DOFAW

***Species*:** Forest birds, pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), seabirds, ʻōpeʻapeʻa, terrestrial invertebrates, freshwater fishes, freshwater invertebrates, 46 rare plant taxa.
Habitats: Montane wet communities, lowland mesic communities, lowland wet communities, coastal communities, continuous perennial streams (Hanakāpīʻai, Hanakoa, Waiahuakua streams).
***Current Management*:** Management plan exists. Ungulate control through public hunting year-round, invasive weed species removal, predator control and exclusion through predator-proof fencing, monitoring.
Future Needs: Implement management plan. Expand existing collaborations and increase ungulate (particularly goat) control, invasive weed monitoring and control, rare plant monitoring, and baseline survey work in Waiahuakua stream.

***Kuʻia NAR* (1,636 acres), DOFAW**
Species: Forest birds, pueo, seabirds, ʻōpeʻapeʻa, terrestrial invertebrates, 28 rare plant taxa.
Habitats: Montane mesic system, lowland mesic system.
Current Management: Management plan exists. Small-scale fencing, ungulate control through public hunting seasons, invasive weed species removal, monitoring.
Future Needs: Construct proposed fencing. Increase ungulate control, weed species removal, outplanting, and monitoring. Identify areas of intact lowland mesic forest for protection. Identify T&E seabird activity and locate colonies if there is any.

***Alakaʻi Wilderness Preserve* (9,939 acres), DOFAW**
***Species*:** Forest birds, pueo, koloa maoli, terrestrial invertebrates, rare plant taxa.
Habitats: Montane wet communities.
***Current Management*:** Ungulate control through public hunting, invasive weed (including kāhili ginger, Australian tree fern) control, forest bird monitoring, fencing, forest bird research, predator control, captive propagation of endangered forest birds.
Future Needs: Construct fencing and continue ungulate control. Increase invasive weed species removal, weed monitoring, forest bird monitoring, fencing, forest bird research, predator control, and captive propagation of endangered forest birds.

***Kauaʻi Watershed Alliance* (142,000 acres), Public-Private Partnership (County of Kaua'i Department of Water, DLNR-DOFAW, DLNR-State Parks, DLNR-Land, Kamehameha Schools, McBryde Sugar Company, Ltd., Grove Farm Company, Inc., Līhuʻe Land Company, Kealia Ranch, LLC, B.A. Dyer, and Princeville Development, LLC)**
Species: Forest birds, seabirds, pueo, ʻōpeʻapeʻa, terrestrial invertebrates, freshwater fishes, freshwater invertebrates, rare plant taxa.
Habitats: Montane wet communities, lowland wet communities, lowland mesic communities, lowland dry communities.
Current Management: Management plan exists. Planned management includes fencing, ungulate control through variety of methods, suppression, containment, and eradication of priority and secondary weeds, monitoring (ungulate activity, weed distribution, vegetation cover, stream turbidity).
Future Needs: Secure adequate funding to implement management plan.

***Hanalei NWR* (917 acres), USFWS**

Species: Waterbirds, ʻōpeʻapeʻa.
Habitats: Lowland wet communities (wetlands).
Current Management: Management plan in development. Endangered species management (habitat enhancement, predator control, invasive weed control, monitoring).
Future Needs: Continue to manage for wildlife needs.

***Hulēʻia NWR* (241 acres), USFWS**

Species: Waterbirds, ʻōpeʻapeʻa.
Habitats: Lowland wet communities (wetlands).
Current Management: Management plan in development. Endangered species management (habitat enhancement, predator control, invasive weed control, monitoring).
Future Needs: Continue to manage for wildlife needs.

***Kīlauea Point NWR* (199 acres), USFWS**

Species: Waterbirds, seabirds, nēnē, migratory shorebirds.
Habitats: Coastal communities.
Current Management: Management plan in development. Feasibility study underway regarding acquisitions to refuge. Endangered species management (habitat enhancement, predator control, invasive weed control, monitoring), outreach and education. Complete construction and maintain predator-proof fence to provide predator-free nesting habitat for seabirds.
Future Needs: Study the efficacy of the predator-proof fence to provide a safe nesting area. Test ability of a newly created site to attract seabirds and provide secure habitat to breed. Test use of acoustic calls to attract seabirds into an unoccupied site and successfully breed. Acquire and manage additional habitat once feasibility study is complete.

***Kawaiele Wildlife Sanctuary* (37 acres), DOFAW**

***Species*:** Waterbirds, migratory shorebirds, seabirds, migratory waterfowl.
Habitats: Coastal communities.
***Current Management*:** Eliminate tilapia from ponds, habitat restoration through native plantings, public education, and monitoring of bird and plant populations.
Future Needs: Implement predator control and waterbird monitoring.

***Mānā Plains Forest Reserve* (105 acres), DOFAW**

***Species*:** Waterbirds, migratory shorebirds, seabirds, migratory waterfowl, nēnē.
Habitats: Coastal communities.
***Current Management*:** Elimination of tilapia from ponds, habitat restoration through native plantings, public education, and monitoring of bird and plant populations.
Future Needs: Implement predator control and waterbird monitoring. Coordinate with neighbor Pacific Missile Range Facility on nēnē and mōlī (*Phoebastria immutabilis* [Laysan albatross]) management.

***Limahuli Nature Preserve* (1,005 acres), NTBG**

Species: Forest birds, seabirds, pueo, rare plants.
Habitats: Lowland wet communities.
Current Management: Outplanting of native plants, fencing and ungulate removal, predator control.
Future Needs: Continue existing management. Implement fencing, predator control, and ungulate control.

Wainiha Nature Preserve **(7,050 acres), The Nature Conservancy and Alexander & Baldwin, Inc.**

Species: Forest birds, seabirds, freshwater invertebrates, rare plants.
Habitats: Lowland wet communities, freshwater stream.
Current Management: Fencing and ungulate removal, invasive weed removal, predator control, outplanting of native plants.
Future Needs: Continue existing management. Maintain fencing, predator control, ungulate control, and weed control.

State Seabird Sanctuary **(Three Offshore Islets: Lehua, Kaʻula, and Mokuʻaeʻae), DOFAW**

Species: Nesting seabirds: ʻuaʻu kani (*Puffinus pacificus* [wedge-tailed shearwater]), ʻou (*Bulweria bulwerii* [Bulwer's petrel]), ʻā (*Sula sula* [red-footed booby]), ʻā (*Sula leucogaster* [brown booby]), ʻā (*Sula leucogaster* [brown booby]), mōlī (Laysan albatross), kaʻupu *(Phoebastria nigripes* [black-footed albatross]), noio *(Anous minutus* [black noddy]), noio-kōhā *(Anous stolidus* [brown noddy]), ʻaʻo, koaʻe ʻula *(Phaethon rubricauda* [red-tailed tropicbird]).
Habitats: Coastal offshore communities.
Current Management: Surveys and monitoring, biosecurity surveillance, habitat restoration.
Future Needs: Continue monitoring of seabird populations, strengthen biosecurity surveillance on Lehua and Mokuʻaeʻae, and develop habitat restoration strategy for Lehua.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), Co-Managed by NOAA and DLNR**

Species**:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Kauaʻi, which serves as critical habitat for humpback whales.
Current Management**:** Humpback whale 91-meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

***Five Fishery Management Areas (FMAs),* DAR: Hā‘ena Community-Based Subsistence Fishing Area, Hanamā‘ulu Bay, Nāwiliwili Harbor, Port Allen, Waimea Bay and Waimea Recreational Pier**

***Species*:** Some or all regulated fish species.
Habitats: Marine and estuary ecosystems.
***Current Management*:** Limited take, gear, size, season, and/or area restrictions.
***Future needs*:** Evaluate all FMAs for management effectiveness and consider the need for new marine managed areas.

***One Statutorily Designated Regulated Area, DAR:* Kapa‘a and Waika‘ea Canals**

***Species*:** Some or all regulated fish species.
Habitats: Marine and freshwater ecosystems.
***Current Management*:** Limited take, gear, size, season, and/or area restrictions.
***Future needs*:** Evaluate management effectiveness and the consider need for new areas

***Two Public Fishing Areas (PFAs),* DAR (Koke‘e & Wailua Reservoir)**

***Species*:** Some or all regulated fish species.
Habitats: Freshwater ecosystems
***Current Management*:** Rules including limitations on the type and number of fish you can catch, gear restrictions, size limits
Future Needs: Evaluate, document, and report the purpose and effectiveness of current management for PFAs and consider the need for expansion or modification of existing rules and provisions

Species Conservation Management

The following projects and programs include state, federal, university, and private cooperative management efforts to address specific conservation needs of SGCNs on Kaua‘i and often involve island-wide research and management that extend across boundaries.

***Kaua‘i Resource Conservation Program*, Public-Private Partnership**

***Species/Habitats*:** All species and habitats present in Kōke‘e State Park and surrounding state lands affected by invasive species issues.
***Current Management*:** Invasive species removal and control.
Future Needs: Leverage adequate funding for ongoing and needed control actions.

***Kaua‘i Forest Bird Recovery Project*, DOFAW, USFWS, University of Hawai‘i**

Species/Habitats: Kaua‘i forest birds, primarily focused on the puaiohi, ‘akikiki and ‘akeke‘e. Montane-nesting forest birds, particularly endangered and critically endangered species and their habitats.
Current Management: Implementation of *Revised Recovery Plan for Hawaiian Forest Birds*.
Future Needs: Secure adequate funding to implement endangered species recovery plan and implementation plans. Implement captive propagation, reintroduction of captive-reared birds, predator control, and research.

***Kaua‘i Endangered Seabird Recovery Project,* DOFAW, USFWS, University of Hawai‘i**

Species: **‘**A‘o (Newell’s shearwater), ‘ua‘u (Hawaiian petrel), ‘akē‘akē (band-rumped storm-petrel).
Habitats: Mountainous interior, outer coastal areas, offshore islets.
Current Management: Seabird population research and monitoring, colony protection, predator control, and development of conservation strategies to slow the decline of ‘a‘o and ‘ua‘u.
Future Needs: Continue exploring poorly surveyed areas to locate accessible seabird colonies for further management; increase habitat restoration efforts for seabird habitat enhancement; implement research to understand the genetic diversity and structure of endangered seabird populations on Kaua‘i; advance methodologies to reliably estimate and monitor population size and trends of endangered seabirds on Kaua‘i; and advance long-term solutions that address predator control at nesting colonies. Strengthen existing partnerships.

***Kaua‘i Invasive Species Committee*, Public-Private Partnership**
***Species/Habitats*:** All species and habitats affected by invasive species issues.
***Current Management*:** Invasive species prioritization, control, and removal island-wide.
***Future Needs*:** Increase invasive plant and animal prevention capacity, improve detection and rapid response capacity, and secure additional resources to address established threats to native habitats.

***Save Our Shearwaters*, DOFAW, USFWS, Kaua‘i Island Utility Cooperative**
***Species*: ‘**A‘o (Newell’s shearwater), ‘ua‘u (Hawaiian petrel), ‘akē‘akē (band-rumped storm-petrel).
***Current Management*:** Revised SOS+ program coordinates recovery, treatment, and release into the wild of downed seabirds. During its first 26 years, the program recovered more than 29,000 Newell’s shearwaters, 220 Hawaiian petrels, and 15 band-rumped storm petrels, as well as a few wedge-tailed shearwaters and white-tailed tropicbirds. Overall, 92 percent of the birds were released back into the wild.
Future Needs: Implement *Save Our Shearwaters Implementation Guidelines and Operations Manual.*

Potential Areas for Enhanced Conservation Management
In addition to maintaining and enhancing existing conservation actions, additional efforts are needed for the long-term conservation of Kaua‘i’s native wildlife. The following section identifies areas where enhanced conservation management would significantly benefit native species or their habitats. Areas are discussed in habitat order from the mountains to the sea.

Montane Wet Forest
***Species*:** Puaiohi, ‘akikiki, ‘i‘iwi (*Drepanis coccinea*), Kaua‘i ‘elepaio, ‘anianiau, Kaua‘i ‘amakihi, ‘akeke‘e (Kaua‘i ‘ākepa), ‘apapane, pueo, ‘a‘o, terrestrial invertebrates, freshwater invertebrates, rare plants.
***Basis for Priority Designation*:** Identified in Forest Bird Recovery Plan as core area for conservation; DOFAW Management Guidelines recognize it as highest-quality native vegetation; identified for protection in *Kaua‘i Watershed Alliance Management Plan*. Last remaining suitable habitat for puaiohi, ‘akikiki; last known habitat for Kaua‘i

ʻakialoa (*Hemignathus procerus*), Kauaʻi nuku puʻu (*Hemignathus lucidus hanapepe*), Kauaʻi ʻōʻō (*Moho braccatus*), kāmaʻo (*Myadestes myadestinus*), and ʻōʻū (*Psittirostra psittacea*); habitat for ʻakekeʻe (Kauaʻi ʻākepa) and ʻapapane.
Potential Conservation Actions: Coordinate and implement existing management plans (*Revised Recovery Plan for Hawaiian Forest Birds*, *Kauaʻi Watershed Alliance Management Plan*, DOFAW Management Guidelines). Increase funding and staffing for implementation of identified actions, fencing, ungulate (pig and goats) removal, predator control, invasive weed control, habitat restoration through native plantings, and monitoring.

Wetland Habitat **(including Kīlauea River, Hanalei River Valley and taro fields, Lumahaʻi Valley, Wainiha River Valley and taro fields, Hāʻena State Park wetlands and loʻi, Mānā Plains, Waimea River and taro fields, Hanapēpē Coastal Ponds [Hanapēpē Salt Ponds, Kaumakani Gulch Ponds, Olokele Settling Ponds], Lāwaʻi Kai Estuary, Kōloa district reservoirs [Waita Reservoir], Waiopili Stream, Hulēʻia stream and associated watershed, Līhuʻe area wetlands [including Nāwiliwili wetlands, Pualu wetlands], Hanamāʻulu wetlands, Wailua River and associated watershed [including Opaekaʻa wetlands], Kapaʻa area wetlands)**

Species**:** Aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), ʻalae ʻula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), koloa maoli, nēnē; shorebirds, including the kōlea (*Pluvialis fulva* [Pacific golden plover]), ʻakekeke (*Arenaria interpres* [ruddy turnstone]), and hunakai (*Calidris alba* [sanderling]); freshwater fishes; freshwater invertebrates.
Basis for Priority Designation**:** Identified in *Revised Recovery Plan for Hawaiian Waterbirds* as core or supporting wetlands and identified by biologists as important potential wetland habitat. With the demise of sugar crops, wetland habitat is being reduced as former irrigation ditches are no longer maintained.
Needed Conservation Actions: Implement Waterbird Recovery Plan. Protect, restore, and manage additional wetland habitat through coordination with private or public landowners, removal of invasive plants, and institution of predator control. Remove threat of feral mallard and kola maoli hybridization by supporting research, outreach, regulation/legislation, and control of feral mallards. Research ecosystem function of taro loʻi to identify management actions that support both taro growth and high-quality wildlife habitat. Expand outreach efforts to neighboring landowners to encourage voluntary protection (conservation easements) or implementation of best management practices. Continue existing waterbird surveys.

Kōloa Lava Tube/Cave Ecosystem, **Private Landowners**

Species**:** peʻepeʻe maka ʻole, Kauaʻi cave amphipod.
Basis for Priority Designation**:** Designated as critical habitat for peʻepeʻe maka ʻole and cave amphipod, may be only known habitat. Areas near these caves are under consideration for development.
Potential Conservation Actions: Support current protection of existing inhabited cave on private land, continue to monitor population.

References:

Battista, T.A., Costa, B.M., and S.M. Anderson, S.M. 2007. Shallow-Water Benthic Habitats of the Main Eight Hawaiian Islands DVD). NOAA Technical Memorandum NOS NCCOS 61, Biogeography Branch. Silver Spring, MD.

Burgett J, et al. 2001. The Hawaiian endangered bird conservation program: Five-year workplan (2001 – 2005).

Decision Analysts Hawai‘i, Inc. and Research Solutions, LLC. 2002. Draft economic analysis of proposed Critical Habitat designations for threatened and endangered plants on Kaua‘i and Ni‘ihau. Hawai‘i revised determination. Honolulu, (HI): Available at: http://www.fws.gov/pacific/pacificislands/CHRules/KauaiPlantsEA4-30.pdf.

Engilis A, Naughtond M. 2004. U.S. Pacific Islands regional shorebird conservation plan. U.S. Shorebird Conservation Plan. Portland, (OR): U.S. Department of the Interior; Fish and Wildlife Service.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. (Accessed 28 March 2005).

Department of Business, Economic Development, & Tourism. Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 13 May 2024.

Hawai‘i Department of Land and Natural Resources. Undated. Interim State of Hawai‘i strategic plan for invasive species prevention, control, research and public outreach. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources. Draft management guidelines. Available at: http://www.state.hi.us/dlnr/dofaw/guidelines/mg_jw03/index.html.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Kuia Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2011. Hono o Nā Pali Natural Area Reserve (NAR) management plan. Honolulu, (HI).

Hawaii’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Health, Hawai’i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Holmes, N., H. Freifeld, F. Duvall, J. Penniman, M. Laut, and N. Creps. 2011. Newell’s shearwater and Hawaiian petrel recovery: A 5-Year Work Plan. Hawai‘i Department of Land and Natural Resources and U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Industrial Economics, Incorporated. 2002. Draft economic analysis of proposed Critical Habitat designation for the Kaua‘i Cave Wolf Spider and the Kaua‘i Cave Amphipod Island of Kaua‘i, Hawai‘i. Honolulu, (HI). Available at: http://www.fws.gov/pacific/pacificislands/CHRules/KauaiCaveEA110802.pdf.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

Pacific Missile Range Facility, Barking Sands. 1998. Pacific Missile Range Facility enhanced capability biological assessment. Kaua‘i, (HI). Available at: http://www.smdcen.us/pubdocs/files/pmrf_biological_assessment_final.pdf.

Puaiohi Working Group and Hawaiian Forest Bird Recovery Team. 2002. Draft Puaiohi five-year recovery work plan. Honolulu, HI.

Rana Productions and Planning Solutions. 2005. Preliminary draft – proposed operations manual. Save our Shearwaters Program. Calendar Year 2005. Honolulu, HI.

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai‘i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Census Bureau. 2021. QuickFacts. Kaua‘i County, Hawai‘i. Available at: https://www.census.gov/quickfacts/fact/table/kauaicountyhawaii/PST045223. Accessed 13 May 2024.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 20 August 2002. Final Rule: Designation of Critical Habitat for the Newcomb’s Snail. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/newcombssnailfch82002.pdf.

U.S. Fish and Wildlife Service. 2003. Final Rule: designation of Critical Habitat for the Kaua‘i cave wolf spider and Kaua‘i cave amphipod. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/kauaicavefinal.pdf.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation or non-designation of Critical Habitat for 95 plant species from the islands of Kaua‘i and Ni‘ihau, HI. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/kauaifinal.pdf.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland, (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2003. Draft recovery plan for the Blackburn’s Sphinx Moth (*Manduca blackburni*). Portland, (OR): U.S. Fish and Wildlife Service. Ix+113 pp.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. 2005. Pacific Islands – National Wildlife Refuges. Available at http://www.fws.gov/pacific/pacificislands/wnwr/kauainwrindex.html.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2006. Recovery plan for the Kauaʻi cave arthropods: the Kauaʻi cave wolf spider (*Adelocosa anops*) and the Kauaʻi cave amphipod *(Spelaeorchestia koloana*). Portland, (OR): U.S. Fish and Wildlife Service. 64pp.

U.S. Fish and Wildlife Service. 2006. Recovery plan for the Newcomb's snail *(Erinna newcomb*i). Portland, (OR): U.S. Fish and Wildlife Service. 52 pp.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

NIʻIHAU

Niʻihau is a small, privately owned island located approximately 27 kilometers (17 miles) west of Kauaʻi. The island's highest point is 390 meters (1,281 feet). Among Niʻihau's most unique natural features are several intermittent lakes, which provide habitat for ʻalae keʻokeʻo or Hawaiian coot (*Fulica alai*), aeʻo or Hawaiian stilt (*Himantopus mexicanus knudseni*), and koloa maoli or Hawaiian duck (*Anas wyvilliana*). Due to restricted access, there is limited biological information available about Niʻihau (e.g., the percent cover of native vegetation, the distribution and abundance of native species, and the condition of habitats used by wildlife species). While the seasonal lakes are known to be an important natural wetland feature for waterbirds, the use and importance of this island by other species groups, such as seabirds or invertebrates, is largely unknown.

OVERVIEW

Geology and Hydrology

Niʻihau was formed from a single shield volcano approximately 4.89 million years ago, making it slightly younger in age than Kauaʻi. It is approximately 18,130 hectares (70 square miles or 44,800 acres), and sea cliffs are a prominent feature of the eastern coast. Approximately 78 percent of the island is below 150 meters (500 feet) in elevation. Niʻihau has no perennial streams. Halulu Lake is a natural freshwater lake covering approximately 74 hectares (182 acres) and Halāliʻi Lake is an intermittent lake covering approximately 340 hectares (841 acres).

Climate

Located inside Kauaʻi's rain shadow, Niʻihau receives only about 50 to 100 centimeters (20 to 40 inches) of rain per year.

Land and Water Use

The entire island is located in the State Agricultural District. The primary economic activities are cattle and sheep ranching, commercial game hunting, and limited military training exercises.

Human Landscape

Part of the County of Kauaʻi, Niʻihau is privately owned. A Native Hawaiian community of approximately 170 people lives there in relative isolation. There are no resorts, and public access is allowed only with permission of the owners.

SPECIES AND HABITATS OF IMPORTANCE

Habitat on Niʻihau includes only lowland dry systems and coastal systems. It is thought that Niʻihau may have some of the best coastal habitats in the state.

Information on species' distribution on Niʻihau is limited. Appendix A provides information on the wildlife Species of Greatest Conservation Need present on Niʻihau. There are no wildlife species known to be endemic to Niʻihau. Known species present are primarily waterbirds, seabirds, migratory shorebirds, and marine species in the surrounding near waters. ʻĪlioholoikauaua (*Monachus schauinslandi* [Hawaiian monk seals]) regularly use the island's

beaches. The two wetlands on the island, Halulu Lake, a natural freshwater lake of 74 hectares (182 acres) in size, and Halāliʻi Lake, an intermittent lake covering approximately 340 hectares (841 acres) are identified as "core wetlands" for koloa maoli, ʻalae keʻokeʻo, and aeʻo in the 2011 waterbird recovery plan. Niʻihau is used by all three species and is important for koloa maoli conservation because it is thought to be one of the few remaining islands that has pure stocks of koloa that have not had significant hybridization with mallards.

The U.S. Fish and Wildlife Service (USFWS) has designated critical habitat for one plant, ʻālula or ʻōlulu (*Brighamia insignis).* A total of approximately 144 hectares (357 acres) of land in the north-central part of the island has been designated as critical habitat for ʻālula or ʻōlulu . ʻĀlula was historically known on Niʻihau from Kaʻali Cliff, but has not been observed since 1947, and no individuals are believed to be extant. Ungulates, invertebrate pests, and loss of native pollinators are identified as threats. Conservation goals are to protect current populations and establish additional populations to reduce risk of extinction. The species is widely distributed in botanical gardens and has the potential to be reestablished with conservation management.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats more acute or specific to Niʻihau are listed below. Because Niʻihau has no perennial streams, there are no identified threats specific to freshwater species on Niʻihau.

- Lack of permanent conservation status for known wetland habitat;
- Habitat degradation (loss of vegetation and subsequent erosion) caused by domestic and feral ungulates;
- Limited information on species presence or abundance, habitat conditions, or the importance of existing habitat for wildlife;
- Introduction or natural dispersal to Niʻihau of domestic mallards and hybridization of the koloa maoli gene pool;
- Introduction of invasive pests such as mongooses or freshwater aquatic weeds that would degrade wetlands;
- More frequent occurrence and severity of outbreaks of avian botulism;
- Predation in seabird nesting colonies on offshore islands or in any active nesting colonies on Niʻihau; and
- Climate change and sea level rise affecting coastal wetlands.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) (main bullet), additional island-specific strategies for Niʻihau include the following (sub-bullet):

- Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in 'Management Needs' section;

    - Develop and/or implement recovery plans for threatened and endangered species on Ni‘ihau; Eradicate predators on offshore islands used by seabirds for nesting and control predators at any active nesting colonies on Ni‘ihau;
    - Encourage long-term protection and management of known wetland habitat (including ephemeral playa lakes) for nesting waterbirds;
    - Encourage long-term protection of remaining native-dominated coastal or lowland vegetation from degradation by ungulates; and
    - Develop management plans for all marine managed areas.
- Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Inventory existing terrestrial and aquatic invasive species and prioritize control actions; and
    - Improve early detection and rapid response capacity for species not yet established on Ni‘ihau (e.g., brown tree snake [*Boiga irregularis*], West Nile virus, red imported fire ant [*Solenopsis invicta*]), or that are present in the Main Hawaiian Islands but not on Ni‘ihau (e.g., mongooses);
- Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Complete an inventory of native wildlife and plants;
    - Determine population estimates for rare or unique species of native wildlife; and
    - Coordinate research to assess threats and conservation needs of species.
- Strengthen existing and create new partnerships and cooperative efforts.
    - Establish a partnership with the private landowner to protect the wetland habitat and improve knowledge about native species and their habitats;
    - Explore opportunities for partnership with local community; and
    - Collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.
- Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Explore opportunities for community-based wildlife surveys and monitoring.
- Support policy changes aimed at improving and protecting native species and habitats.
    - Assess ways to support increased enforcement capacities, including more coordination agencies and the community;
    - Evaluate all current marine managed areas for purpose and management effectiveness and consider need for new marine managed areas; and
    - Support development of a community-based marine managed area.

PLANS AND TOOLS TO AID MANAGEMENT

No management plans and tools specific to Ni‘ihau exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section. The following statewide plans and tools are available:

- Species conservation plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), and *Revised Recovery Plan for Hawaiian Waterbirds* (2011).

MANAGEMENT NEEDS

Current Management of Species and Habitats

Unlike other islands, Niʻihau is entirely privately owned and has no state or federal management presence. There are no formalized or long-term conservation management actions currently occurring on terrestrial Niʻihau. In the marine waters surrounding Niʻihau, there is one Bottomfish Restricted Fishing Area (BRFA), which has been open since February 25, 2022.

References:

Engilis A, Naughtond M. 2004. U.S. Pacific Islands regional shorebird conservation plan. U.S. Shorebird Conservation Plan. Portland, (OR): U.S. Department of the Interior; Fish and Wildlife Service.

Hawaiʻi Department of Business, Economic Development, and Tourism. 2003. State of Hawaiʻi data book. Available at: http://www3.Hawai'i.gov/DBEDT/index.cfm?section=READ_Databook1075. (Accessed 28 March 2005).

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communications with staff. 2005.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawaiʻi Third Edition. Honolulu: University of Hawaiʻi Press.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation or non-designation of Critical Habitat for 95 plant species from the islands of Kauaʻi and Niʻihau, HI. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/kauaifinal.pdf.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

O‘AHU

O‘ahu is the most developed and populated island in the Hawaiian chain. As a result of the pressures of population and economics, native forest is found primarily along mountainous ridges unsuitable for development. These mountain ridges are highly dissected by erosion, resulting in a rich array of habitats (from montane wet forest to lowland dry forest) with localized distributions of many species, particularly of native invertebrates. O‘ahu contains several wetlands important to waterbirds and migratory shorebirds, including the Kawai Nui and Hāmākua Marsh complex. Thanks to grassroots support and community involvement, the Kawai Nui and Hāmākua Marsh complex was designated a Wetland of International Importance under the Ramsar Convention of Wetlands in 2005, the 22nd such designation in the United States and the first in Hawai‘i. A major wetland habitat restoration project was implemented in 2012 that created 24 acres of managed ponds. Several offshore islands and several protected and managed coastal sites support seabird colonies. O‘ahu also has a number of large estuaries and bays and one of only two barrier reef complexes in the state. Many areas managed for wildlife conservation are accessible to the public, giving residents and visitors the opportunity to view and appreciate examples of the native wildlife of the state.

OVERVIEW

Geology and Hydrology

The island of O‘ahu was created by two large shield volcanoes, the younger Ko‘olau volcano to the east and the older Wai‘anae volcano to the west. Subsequent extensive erosion has since fashioned these volcanoes into long, narrow, ridge-like mountain ranges, connected by the Schofield Plateau, also knows as the Leilehua Plateau. Nearly half (45%) of the island is below 150 meters (500 feet) in elevation, and for the most part, the island is surrounded by coastal plain and sandy beaches, rather than steep sea cliffs. Just under five percent of the island is over 610 meters (2,000 feet) in elevation; Mt. Ka‘ala in the Wai‘anae range, is the highest point on the island at 1,220 meters high (4,003 feet) high. The island has 57 perennial streams, 29 of which are continuous. Kahana and Waikele streams have the largest discharges, 35 and 27 million gallons per day (mgd), respectively. Wahiawā Reservoir (including Lake Wilson) and Nu‘uanu Reservoir are significant freshwater lakes on the island.

Climate

The Wai‘anae and Ko‘olau mountain ranges combine to produce distinctive windward and leeward climates. Average annual rainfall exceeds 635 centimeters (250 inches) per year on the crest of the Ko‘olau Range. In contrast, some areas on the leeward coast, located in the rain shadow of the Ko‘olau Mountains, receive less than 50 centimeters (20 inches) per year. The Ko‘olau Mountains form the primary watershed for the island, providing approximately 133 mgd of recharge to the Pearl Harbor aquifer.

Land and Water Use

O‘ahu is the third largest island at 156,284 hectares (386,188 acres). The island’s land area is almost evenly divided between the Conservation District (40%; 63,444 hectares or 156,776 acres), Agricultural District (33%; 51,678 hectares or 127,698 acres), and the Urban District (26%; 41,162 hectares or 101,715 acres) (DBEDTa, 2022). The Conservation District

encompasses most of the Koʻolau and Waiʻanae mountain ranges. About 19,351 hectares (47,819 acres), primarily in the Conservation District, are managed by the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) (12% of the total land area). Approximately 7,195 hectares (17,780 acres) of conservation-zoned forest land is under private ownership or management (DBEDTa, 2022). The Agricultural District covers primarily the plateau between the two mountain ranges. The Urban District covers the primary urban center of Honolulu, extending west along the leeward coast, east to include the developed areas of Kāneʻohe and Kailua, and north to include the developments along the H-2 Highway, such as Mililani.

Approximately 32,450 hectares (80,195 acres, 21% of the total land area) is under the control (through ownership or lease) of the federal government (DBEDTa, 2022). The largest private landowners are Kamehameha Schools and Dole Food Company.

Thirty-one streams are diverted and 31 have altered channels. The largest altered stream is Waikele, and the Waiāhole Ditch system is the largest man-made stream system. Oʻahu has 42 impaired streams under Environmental Protection Agency Clean Water Act standards.

Human Landscape

According to the 2020 Census, the total resident population of Oʻahu was estimated at 1,016,518, accounting for 70 percent of the state's population. This number is supplemented by an average daily visitor population of 111,309 (DBEDTb, n.d.). The population is spread around the island, with most residents living on the south side, east of Pearl Harbor on the coastal plain, valleys, and lower mountain ridges. Oʻahu is the state's governmental, service, commercial, and transportation center, and accounts for about 80 percent of the state's economic output. The large visitor industry, military activities, and to a lesser extent, agriculture contribute to this output. Oʻahu's sugar industry closed in 1996, and many former sugar lands have been converted to residential communities.

SPECIES AND HABITATS OF IMPORTANCE

Habitats on Oʻahu are composed of montane wet communities, lowland wet communities, lowland mesic communities, lowland dry communities, and coastal communities. The island has a network of perennial and intermittent streams, many of which have been altered. Habitat types include ʻakiʻaki (*Sporobolus virginicus*) coastal dry grassland, naupaka (*Scaevola sericea*) mixed coastal dry shrubland, ʻuki (*Cladium jamaicense*) lowland wet sedgeland, ʻōhiʻa (*Metrosideros polymorpha*) lowland wet and mesic forest, and wet cliffs. The dry to mesic habitats located in the Waiʻanae mountains are considered to contain high concentrations of federally endangered plant species, including both species that are naturally rare as well as species exhibiting human-induced rarity. A system of wetlands situated along the windward coast south to Pearl Harbor, or Puʻuloa, provide important habitat for endemic waterbirds and migratory shorebirds and waterfowl. Many of the seventeen offshore islands are important for nesting seabirds, with Moku Manu and Mānana supporting the greatest diversity of species and the highest number of individuals. Ulupaʻu Wildlife Management Area (at Kāneʻohe Marine Corps Base) supports one of the two colonies of ʻā (*Sula sula* [red-footed booby]) in the Main Hawaiian Islands. Approximately 17,322 hectares (42,804 acres) are designated as critical habitat for 121

endangered plant species and three Hawaiian damselflies, which partially overlaps with the 26,661 hectares (65,879 acres) designated as critical habitat for the Oʻahu ʻelepaio (*Chasiempis sanwichensis ibidis*). Habitat essential for the recovery of the Oʻahu tree snails (*Achatinella* spp.) has also been identified.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on Oʻahu and its associated offshore islands. Known taxa endemic to Oʻahu include the Oʻahu ʻelepaio (endemic at the subspecies level), Oʻahu ʻalauahio (*Paroeomyza maculata* [Oʻahu creeper], potentially extinct), Oʻahu ʻamakihi (*Hemignathus flavus*), several damselflies (*Megalagrion* spp.), several endemic bees (*Hylaeus* spp.), and the Oʻahu tree snails (*Achatinella* spp.). The endangered ʻōpeʻapeʻa (*Lasiurus cinereus semotus* [Hawaiian hoary bat]) occurs and has breeding populations on the island, as do the following birds: ʻapapane (*Himatione sanguinea*), ʻiʻiwi (*Vestiaria coccinea*) (state-listed as endangered on Oʻahu), and pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]) (state-listed as endangered on Oʻahu). Significant populations of endangered waterbirds occur on Oʻahu, including the aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), ʻalae ʻula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), and the koloa maoli (*Anas wyvilliana* [Hawaiian duck]). The seabird, ʻaʻo (*Puffinus auricularis newelli* [Newell's shearwater]), is believed to nest in the Koʻolau mountains, mōlī (*Phoebastria immutabilis* [Laysan albatross]) nest at Kaʻena Point Natural Area Reserve, ʻuaʻu kani (*Puffinus pacificus* [wedge-tailed shearwater]) nest at Kaʻena Point and on beach strands at other sites on the island, and eight species of seabirds nest on the offshore islands. Oʻahu is also home to a diverse number of terrestrial invertebrates, most of which have been poorly studied. Several species of land snails from the genera *Auriculella*, *Leptachatina*, and *Amastra* have been observed, while diversity within most families of beetles (*Coleoptera)* is among the highest in the state. ʻŌpaeʻula (*Holocaridina rubra*) occur in natural and man-made anchialine and aquaculture ponds. Native freshwater fishes, including several species of ʻoʻopu, native freshwater invertebrates, including *Oahuhawaiian kazukolinda*, and several species of crustaceans, are found within several stream systems. Finally, honu (*Chelonia mydas agassizi* [green sea turtles]), ʻīlioholoikauaua (*Monachus schauinslandi* [monk seals]), and koholā (*Megaptera novaeangliae* [humpback whale]) are regularly observed around the island and in nearshore waters.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife and habitats are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats that are more acute or specific to Oʻahu are listed below.

- Primary entry point for new invasive species into the state;
- Spread of invasive ants, in particular the yellow crazy ant (*Anoplolepis gracilipes*) and little fire ant (*Wasmania auropunctata*) to seabird nesting sites on the main and offshore islands;
- More frequent outbreaks of botulism in important managed wetlands;
- Sea level rise and storm damage on low-lying offshore islands and coastal areas (affecting seabird nesting sites);
- Insufficient acreage of managed wetland habitat to support expansion of waterbird populations;

- Wildfire, especially in drier leeward areas, due to humans and exacerbated by invasive non-native plants (increasing fuel loads) and drought induced by climate change, and fire spread into forested habitats with the last populations of critically rare tree snails;
- Recreational use of offshore islets, deterring seabird nesting or destroying existing nests and habitats;
- Predation by introduced animals (e.g., feral cat colonies and mongooses [*Herpestes auropunctatus*]) preying on waterbirds, shorebirds, and seabirds; introduced fish (e.g., tilapia [*Oreochromis mossambicus*]) preying on native freshwater species and terrestrial invertebrates; introduced rodents, snails, and Jackson's chameleons [*Chamaeleo jacksonii*] preying on native land snails);
- Disturbance of forested habitat and rare plants by feral pigs;
- Stream diversions, dams, or channelizations;
- Development of formerly undeveloped areas and increased urbanization leading to loss and degradation of terrestrial, freshwater, and marine habitat (e.g., increased nutrients in coastal areas leads to non-native algal blooms which affect fish populations and coral habitats, sedimentation from development near stream corridors);
- Fatalities caused by collisions with wind turbines (for ʻōpeʻapeʻa, seabirds, and waterbirds) and utility lines (for seabirds), and by seabird fallout associated with light attraction;
- Insufficient in-stream flows to ensure the biological integrity of many stream systems;
- Human impacts on anchialine ponds;
- Localized excessive recreational use at places like Hanauma Bay and Waikīkī;
- Localized point source pollution originating from recreational boats and cruise ships;
- Fisheries bycatch of green sea turtles and seabirds;
- Commercial and recreational harvest of marine invertebrate species like sea cucumber (*Holothuroids*), cowries (*Cypraea* spp.), and sea urchins (*Echinoids*);
- Commercial and recreational harvest of aquarium fish;
- Introduction of invasive marine species in ports and harbors;
- Introduction and spread of smothering invasive algae (seaweeds) on coral reefs;
- Human and boat interactions with marine mammals along the Waiʻanae Coast; and
- Land-based sources of pollution.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) (main bullet), additional island-specific strategies for Oʻahu include the following (sub-bullet):

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in 'Management Needs' section;
    - Implement conservation actions identified in the 'Potential Areas for Enhanced Conservation Management' subsection;

- Develop and/or implement recovery plans for threatened and endangered species on Oʻahu;
- Enhance resources to expand management capacity at existing protected wetland habitats (e.g., Pouhala Marsh, Kawai Nui Marsh, and Hāmākua Marsh);
- Increase active management in, or acquisition of, extremely rare habitats on Oʻahu;
- Protect remaining intact native forest, wetland habitat, and coastal areas from development through a combination of acquisition, conservation easements, or cooperative agreements with landowners;
- Increase the total acreage of ungulate-free and predator-free areas;
- Increase the number and distribution of predator-free snail enclosures using snail-predator-proof structures to protect critical populations of Oʻahu tree and land snails.
- Increase the number of at-risk snail species in captive propagation program.
- Decrease in number of stream diversions and channelized streams;
- Work with Commission on Water Resource Management to ensure net increase in number of streams with biological integrity and Instream Flow Standards sufficient to sustain viable native fish and invertebrate populations;
- Implement fire suppression measures and protocols for post-fire restoration to deal with worsening drought conditions and increased frequency of wildland fires;
- Protect remaining anchialine ponds;
- Collaborate in efforts to reduce pollution threats from recreational boats and cruise ships;
- Develop management plans for all marine managed areas; and
- Support ongoing projects to deal with non-point source pollution in Kāneʻohe Bay and other watersheds and support expansion of successful methods to other areas.

2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Improve prevention capacity through increased airport inspection and containment barriers around cargo unloading areas;
    - Improve early detection and rapid response capacity for species not yet established in the islands (e.g., brown tree snake [*Boiga irregularis*], West Nile virus, avian flu, Argentine fire ant [*Solenopsis invicta*]) or present in the Main Hawaiian Islands (MHI) but not yet established on Oʻahu (e.g., little fire ant, coqui frog [*Eleutherodactylus coqui*]);
    - Increase efforts to prevent establishment of priority invasive plants in pristine areas (e.g., miconia [*Miconia calvescens*]) and to eradicate from areas with recovery potential (e.g., mangrove in tidal flats);
    - Improve tools to control and eradicate invasive ants and other pests adversely affecting seabird nesting colonies and native invertebrates such as the Oʻahu tree snail;
    - Improve tools to control and eradicate non-native carnivorous snails (*Euglandina rosa* and *Oxychilus alliarius*), rats, Jackson's chameleons, and other pests adversely affecting Oʻahu native tree and land snails;
    - Expand control of mammalian predators (e.g., feral cats, mongoose, rats) in waterbird, seabird, and ʻelepaio habitat;

- Evaluate costs, maintenance requirements, and efficacy of "predator-proof fencing" in relation to other predator control tools to determine if it is the most appropriate tool for use in some habitats on O'ahu;
- Decrease in the overall number of streams negatively impacted by invasive species;
- Support efforts to strengthen marine alien species prevention and control; and
- Expand invasive algae control program that combines algae removal using the aquatic super sucker and introduction of native sea urchins on degraded coral reefs.

3) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
   - Improve dissemination of research and data regarding native species populations and habitat condition;
   - Establish a central depository, accessible to all potential users, of data collected on the natural history, status, and distribution of all wildlife and plant species;
   - Conduct surveys and inventories for invertebrates in currently managed areas;
   - Assess impact of eco-tourism activities on terrestrial and aquatic native wildlife and associated habitats; and
   - Assess impact of wind turbines on Hawaiian hoary bat populations and support efforts to develop and implement minimization and mitigation measures.
4) Strengthen existing and create new partnerships and cooperative efforts.
   - Formalize partnerships with military agencies to manage areas (including state land) for habitat conservation;
   - Encourage additional landowner participation and involvement in Ko'olau Mountains Watershed Partnership to facilitate conservation actions on these lands;
   - Develop new partnerships with non-traditional partners such as the Honolulu Board of Water Supply to expand watershed management into additional forested areas;
   - Develop new partnerships with non-traditional partners such as smart growth initiatives to address loss of habitat through development;
   - Work with renewable energy programs and project developers to develop and implement habitat conservation plans to minimize and fully mitigate impacts onnative wildlife and habitats and provide net environmental benefits to wildlife populations;
   - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and identify areas where ungulate populations can be managed to provide for continued hunting opportunities;
   - Expand the partnership with the Department of Public Safety, Corrections Division, to increase use of the male and female inmate work crews for conservation management projects where feasible;
   - Expand current firefighting capacity through greater interagency cooperation (e.g., sharing equipment, training, and fighting capacity); and
   - Collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.

5) Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Maintain existing outreach and educational programs at managed conservation areas (e.g., National Wildlife Refuges, Wildlife Sanctuaries);
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive habitats and areas;
    - Expand and broaden public education and outreach to take advantage of the large science and management community on the island, and leverage educational programs to provide resources or funding to support management activities at conservation areas like Kawai Nui Marsh;
    - Improve education regarding the destructive impact of nesting seabird disturbance and reef trampling;
    - Develop infrastructure, partnerships, and educational tools to respond to issues associated with increased interactions between the human community and wildlife in urban areas on O‘ahu (such as the Freeman Seabird Preserve at Black Point, Hāmākua Marsh, and Kawai Nui Marsh); and
    - Develop and provide technical support for the implementation of pilot or demonstration projects by citizen groups, small businesses, or landowners, in areas close to where people live to provide an opportunity to connect residents with O‘ahu’s native wildlife and their needs.
6) Support policy changes aimed at improving and protecting native species and habitats.
    - Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
    - Assess ways to support increased enforcement capacities, including cross-deputization between agencies and expansion of community watch programs like DLNR’s Makai Watch;
    - Continue development of community-based marine managed areas on O‘ahu and develop rules for community-based subsistence fishing areas as these partnerships develop.
    - Evaluate all current marine managed areas for purpose and management effectiveness and consider need for new marine managed areas;
    - Review other species and habitat for inclusion in Hawaiian Islands Humpback Whale National Marine Sanctuary, increase research, education, and enforcement.
    - Evaluate the need for a state and federal Incidental Take Permit for honu and ‘īlioholoikauaua bycatch;
    - Improved integration of policies to address linkages between terrestrial and marine habitats and their shared conservation threats and needs;
    - Develop and implement strategies and policies to encourage proper management of coastal dune system; and
    - Improve coordination of policies and programs to meet the needs of native wildlife conservation but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address many of the threats listed in the Summary of Key Threats to Species and Habitats section above. Current plans and tools include the following:

- Species Conservation Plans prepared by the U.S. Fish and Wildlife Service (USFWS), including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose* (2004), the *Revised Recovery Plan for Hawaiian Forest Birds* (2006), the *Revised Recovery Plan for Hawaiian Waterbirds* (2011), the *Recovery Plan for the Hawaiian Hoary Bat* (1998), and the *Recovery Plan for the Oʻahu Tree Snails of the Genus Achatinella* (1992);
- Critical habitat designations by the USFWS for the Oʻahu ʻelepaio and for threatened and endangered plants and invertebrates on Oʻahu;
- Management Plans for the State Natural Area Reserves (NAR): *Kaʻena Point NAR and Stewardship Area Action Plan* (2011) and the Mt. Kaʻala NAR (1990);
- Integrated Natural Resources Management Plans have been developed by the U.S. Army, U.S. Marine Corps, and U.S. Navy to cover their respective installations on Oʻahu;
- DOFAW Management Guidelines, which coarsely rate vegetation quality and provide guidelines for land use (public hunting, recreation, and forest products) for state lands managed by DOFAW;
- The *Koʻolau Mountains Watershed Partnership Management Plan* (2002);
- The Oahu Offshore Islet Seabird Sanctuaries project, described at <http://hbmpweb.pbrc.hawaii.edu/dlnr/projects/offshore>
- The Hawaiʻi Invasive Species Council Strategic Plan 2015-2020 (2015) for invasive species prevention, control, research, and public outreach;
- DOFAW's *Snail Extinction Prevention Program Strategic Plan: 2015–2019* (2014);
- Coastal Zone Management plans, including *Section 309 Coastal Zone Assessment and Strategy* (2010) and the *Hawaiʻi Ocean Resources Management Plan* (2013);
- Bishop Museum has a comprehensive database of invertebrates; and
- The Audubon Society maintains a sightings database of bird species observed in the state.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats and species on Oʻahu. The discussion of future management needs is highlighted within each current managed area. Some areas on Oʻahu are already under active management or protection through designation as a State NAR, State Wildlife Sanctuary, National Wildlife Refuge (NWR), or Marine Corps Wildlife Management Area. The Koʻolau Mountains Watershed Partnership (KMWP) and Waiʻanae Mountains Watershed Partnership (WMWP) were formed to identify and implement habitat conservation actions needed to preserve the watershed resources of the Koʻolau and Waiʻanae mountains. In addition, other partnerships, such as the Oʻahu Invasive Species Committee (OISC) have been formed to address specific species conservation needs.

Management Areas

The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Oʻahu.

Koʻolau Mountains Watershed Partnership **(97,760 acres), Public-Private Partnership (DLNR-DOFAW, DLNR-State Parks, Department of Hawaiian Home Lands, U.S. Army, USFWS, Honolulu Board of Water Supply, Agribusiness Development Corporation, Queen Emma Foundation, Kamehameha Schools, Bishop Museum)**

Species**:** Forest birds, pueo, terrestrial invertebrates (including land snails, damselflies, bees, beetles, spiders), freshwater fishes (ʻoʻopu), freshwater invertebrates, rare plants.
Habitats: Lowland wet communities, lowland mesic communities.
Current Management**:** Management plan exists. Fencing, ungulate control, invasive weed control, control of non-native predators of native snails.
Future Needs: Funding to implement management plan, fencing, ungulate control, invasive weed control, predator control, outplanting, development of four additional snail-predator-proof exclosures.

Waiʻanae Mountains Watershed Partnership **(46,518 acres), Public-Private Partnership (Honolulu Board of Water Supply, DLNR-DOFAW, Gill-Olsen Joint Venture, MA`O Organic Farms [Waiʻanae Community Re-Development Corporation], U.S. Army Garrison Hawaiʻi, U.S. Navy Region Hawaiʻi, Kaʻala Farms, Inc.)**

Species**:** Forest birds, ʻōpeʻapeʻa, terrestrial invertebrates (including land snails, bees, beetles, spiders), rare plants.
Habitats: Lowland mesic communities, lowland wet communities.
Current Management**:** Management plan exists. Fencing, ungulate control, invasive weed control, invasive ant surveys, fire presuppression and mitigation, native plant outplantings, control of non-native predators of native snails.
Future Needs: Funding to implement management plan, fencing, ungulate control, invasive weed control, predator control, outplanting, management of snail-predator-proof exclosures.

Waimea Valley Nature Preserve (1,875 acres), Office of Hawaiian Affairs **(OHA)**

Species: Waterbirds, forest birds, terrestrial invertebrates (including land snails), rare plants.
Habitats**:** Lowland wet communities, lowland mesic communities, riparian.
Current Management: Invasive weed control, predator control, rare plant restoration.
Future Needs: Continue management, including ungulate and predator control, weed control, outplanting of native plants.

Oʻahu Forest NWR **(4,525 acres), USFWS**

Species**:** Forest birds, pueo, terrestrial invertebrates including land snails, rare plants.
Habitats: Lowland wet communities, lowland mesic communities.
Current Management**:** Invasive weed control, ungulate control, predator control.
Future Needs: Continue management including ungulate and predator control, forest restoration.

***Pahole Natural Area Reserve* (658 acres), DOFAW**

***Species*:** Forest birds, terrestrial invertebrates (including land snails, spiders), rare plants.
Habitats: Low and mid elevation mesic forest ecosystem.
***Current Management*:** Pahole NAR management plan. Fence management, ungulate removal from fenced areas, predator control, invasive plant removal, outplanting, rare plant management, management of snail-predator-proof enclosure.
***Future Needs*:** Maintain existing ungulate exclusion fences and zero tolerance for ungulates, maintain and expand ecosystem restoration, expand predator control efforts, maintain snail enclosures, monitor and respond to new ecosystem treats, increase wildfire protections, continue and expand outreach programs, especially volunteers and student involved programs.

Pia Natural Area Reserve

Species Forest birds, terrestrial invertebrates (including land snails, spiders), rare plants.
Habitats Unique mesic forest type, high in biodiversity of plants and animals.
Current Management: Ecosystem restoration, rare plant management, 'elepaio monitoring and protection,
Future Needs: Fencing, ungulate removal, weed control, ecological restoration, recreation management (Hawaii Loa Ridge trail)

Kaluanui Natural Area Reser

Species Forest birds, terrestrial invertebrates (including land snails), rare plants, stream resrouces.
Habitats: lowland forests and the Kaluanui Stream
Current Management: Fence management, ungulate removal from fenced areas, predator control, invasive plant removal, outplanting, rare plant management,
Future Needs: Rare Snail enclosure, increased stream resource management, ecological restoration and weed control

***Mt. Ka'ala Natural Area Reserve* (1,100 acres), DOFAW**

***Species*:** Forest birds, terrestrial invertebrates (including land snails, spiders), rare plants.
Habitats: Montane wet communities, lowland wet communities, lowland mesic communities, lowland mesic and dry communities.
***Current Management*:** Management plan exists. Fence management, ungulate removal from fenced areas, predator control, invasive plant removal, outplanting, rare plant management, management of snail-predator-proof exclosure.
***Future Needs*:** Maintain existing ungulate exclusion fences and zero tolerance for ungulates, maintain and expand ecosystem restoration, expand predator control efforts, maintain snail enclosures, monitor and respond to new ecosystem treats, increase wildfire protections, continue and expand outreach programs, especially volunteers and student involved programs.

***Honouliuli Forest Reserve* (3,540 acres), DOFAW**

***Species*:** Forest birds, terrestrial invertebrates, rare plants.
Habitats: Lowland and mesic communities.

***Current Management*:** Fencing, fire prevention, predator (rat) control, invasive weed removal, ungulate control, habitat restoration, rare plant management, monitoring, research, control of non-native predators of native snails.
***Future Needs*:** Continue habitat and rare plant management, tree snail management, ungulate and predator control, development of snail predator-proof enclosures.

***Kawailoa Training Area*, U.S. Army**
Species: Birds, snails, rare plants.
Habitats: Lowland wet communities, lowland mesic communities.
Current Management: Management plan exists, ungulate control, fencing.
Future Needs: Implement Integrated Natural Resources Management Plan (INRMP).

***Kawai Nui and Hāmākua Marsh Complex* (850 acres), DOFAW**
***Species*:** Waterbirds, migratory shorebirds, ʻoʻopu, ʻōpae kalaʻole (shrimp).
Habitats: Lowland communities.
***Current Management*:** Hydrologic studies, habitat restoration, including invasive plant removal and native wetland planting, predator control.
***Future Needs*:** Continue existing management, secure adequate funding to support expanded management (increased predator control, invasive weed removal, habitat restoration, educational opportunities).

***Nuʻupia Pond Wildlife Management Area* (482 acres), U.S. Marine Corps Base Hawaiʻi**
***Species*:** Waterbirds, migratory shorebirds, seabirds, particularly ʻuaʻu kani (wedge-tailed shearwater).
Habitats: Wetlands and ponds.
***Current Management*:** Implementation of INRMP: predator control, invasive plant (e.g., mangrove) removal, wetland improvements, monitoring.
Future Needs: Continue existing management.

***James Campbell NWR* (222 acres), USFWS**
***Species*:** Waterbirds, migratory birds, terrestrial invertebrates, anchialine pond fauna.
Habitats: Lowland communities, coastal communities.
***Current Management*:** Habitat restoration and endangered species protection: predator control, weed control, monitoring.
***Future Needs*:** Continue existing management. Increase the area protected and managed in order to accommodate growing populations of endangered waterbirds and migratory birds. Restore lowland wet and other coastal plant species.

***Pearl Harbor NWR* (62 acres), USFWS**
***Species*:** Waterbirds, migratory birds, terrestrial invertebrates, ʻōpaeʻula (anchialine pond shrimp).
Habitats: Lowland communities, anchialine pools.
***Current Management*:** Habitat restoration and endangered species protection: predator control, weed control, monitoring.
***Future Needs*:** Continue existing management.

***Paikō Lagoon* (40 acres), DOFAW**

***Species*:** Migratory shorebirds.
Habitats: Coastal communities.
***Current Management*:** Volunteer opportunities to participate in non-native plant (e.g., mangrove) control, trash removal, predator control, outplanting.
***Future Needs*:** Continue existing management.

***Pouhala Marsh Wildlife Sanctuary* (70 acres), DOFAW**

***Species*:** Waterbirds, particularly Hawaiian stilt.
Habitats: Lowland communities.
***Current Management*:** Habitat management: predator control, trash removal, mangrove removal, pond restoration.
Future Needs: Continue existing management.

***Ka‘ena Point Natural Area Reserve* (36 acres), DOFAW**

***Species*:** Seabirds, particularly nesting mōlī (Laysan albatross) and ‘ua‘u kani (wedge-tailed shearwater), migratory shorebirds, monk seal, rare plants.
Habitats: Coastal communities.
***Current Management*:** Maintanance of predator-proof fencing u, management of human access and activities, invasive weed removal, rare plant management, predator control, outplanting, monitoring, research.
***Future Needs*:** Continue existing ecosystem management, maintain predator control fence, increase outreach, monitoring and visitor education.

***Ulupa‘u Wildlife Management Area* (23 acres), U.S. Marine Corps Base Hawai‘i**

***Species*:** Seabirds, particularly ‘ā (red-footed booby).
Habitats: Coastal communities.
***Current Management*:** Implementation of INRMP: fire risk reduction, habitat enhancement.
Future Needs: Continue existing management.

***State Seabird Sanctuary* (13 offshore islets), DOFAW**

***Species*:** Seabirds: ‘ua‘u kani (wedge-tailed shearwater), Christmas shearwater (*Puffinus nativitatis*), ‘ewa‘ewa (*Onychoprion fuscatus* [sooty tern]), pākalakala (*Onychoprion lunatus* [gray-backed tern]), noio (*Anous minutus* [black noddy]), noio-kōhā (*Anous stolidus* [brown noddy]), manu-o-Kū (*Gygis alba* [white tern]), bonin petrel (*Pterodroma hypoleuca*), ‘iwa (*Fregata minor* [great frigatebird]), ‘ā (red-footed booby), ‘ā (*Sula leucogaster* [brown booby]), ‘ā (*Sula dactylatra* [masked booby]), koa‘e ‘ula (*Phaethon rubricauda* [red-tailed tropicbird]), koa‘e kea (*Phaethon lepturus* [white-tailed tropicbird]), mōlī (Laysan albatross), ka‘upu (*Phoebastria nigripes* [black-footed albatross]), ‘ou (*Bulweria bulwerii* [Bulwer’s petrel]), migratory shorebirds.
Habitats: Coastal communities, marine ecosystems.
Current Management: Ongoing surveys; predator removal; invasive weed control; control and eradication of yellow crazy ants, tropical fire ants, mice, and rats; monitoring of the impacts of ants, rats, and barn owls (*Tyto alba*).

Future Needs: Continue existing management, identify priority islands for predator eradication and implement, include offshore waters as part of marine managed area.

Three Marine Life Conservation Districts (MLCD), **DLNR Division of Aquatic Resources (DAR): Hanauma Bay, Pūpūkea, Waikīkī**

Species**:** Species associated with shallow coral reef, sandy beach, and rocky habitats, Hawaiian monk seals, green sea turtles, spinner dolphins, and other marine mammals.
Habitats: Marine ecosystems including shallow coral reef, sandy beach, rocky habitats.
Current Management**:** Limited access in most MLCDs, eight MLCD include at least some no-take areas, and fish monitoring.
Future Needs: Evaluate all MLCDs for purpose and management effectiveness and consider need for new marine managed areas.

One Fishery Management Areas (FMAs), **DAR*: Waikīkī-Diamond Head Shoreline***

Species**:** Some or all regulated fish species.
Habitats: Marine and estuary ecosystems.
Current Management**:** Waikīkī-Diamond Head Shoreline is a no-take area. Limited take, gear, size, season, and/or area restrictions in other FMAs.
Future Needs: Evaluate all FMAs for purpose and management effectiveness and consider need for new marine managed areas.

Five Statutorily Designated Regulated Areas, DAR: **He‘eia Kea Wharf, Honolulu Harbor, Pōka‘i Bay, Waialua Bay, Ala Wai Canal & Kapālama Canals**

Species**:** Some or all regulated fish species.
Habitats: *Marine and Freshwater ecosystems*.
Current Management**:** Limited take, gear, size, season, and/or area restrictions.
Future needs**:** Evaluate management effectiveness and the consider need for new areas

One Public Fishing Area (PFA), **DAR: Wahiwa**

Species**:** Some or all regulated fish species.
Habitats: Freshwater ecosystems
Current Management**:** Rules including limitations on the type and amount of fish you can catch, gear restrictions, size limits
Future Needs: Evaluate, document, and report the purpose and effectiveness of current management for PFAs and consider the need for expansion or modification of existing rules and provisions

‘Ewa Limu Management Area, **DAR**

Species: Limu.
Habitats: Marine ecosystems.
Current Management**:** Harvesting restrictions.
Future Needs: Evaluate purpose and management effectiveness and consider need for new limu management areas.

Nearshore waters surrounding Kāne‘ohe Marine Corps Base, **U.S. Marine Corps Base Hawai‘i**

Species: Marine invertebrates, coral reef fishes, and sea turtles.
Habitats: Marine ecosystems: seagrass bed, coral reef.
Current management: 150-meter (500-foot) safety buffer around Kāneʻohe Marine Corps Base enforced for public safety due to proximity to firing range.
Future Needs: None at this time.

Hawai'i Marine Laboratory Refuge (Coconut Island Marine Sanctuaries) **(64 acres), DAR**
***Species*:** Marine species.
Habitats: Marine ecosystems: shallow coral reef, sandy beach, and rocky habitats.
***Current Management*:** Limited access. No take. Site being evaluated for inclusion in the Heʻeia National Estuarine Research Reserve System.
Future Needs: Evaluate all sanctuaries for purpose and management effectiveness and consider need for new marine managed areas. Participate in the National Estuarine Research Reserve program.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), Co-Managed by NOAA and DLNR**
***Species*:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Oʻahu, which serves as critical habitat for humpback whales.
***Current Management*:** Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Species Conservation Management
The following program is a cooperative management effort to address conservation needs of SGCNs on Oʻahu, and involves island-wide research and management that extend across boundaries and jurisdictions.

***Oʻahu Invasive Species Committee*, Public-Private Partnership**
Species/Habitats: All species and habitats affected by invasive species.
Current Management: Identification of priority invasive species, then implementation of control and/or eradication. Current priority species include coqui frog, cape ivy (*Delairea odorata*), coconut rhinoceros beetle (*Orycetes rhinoceros*), fountain grass (*Pennisetum setaceum*), devil weed (*Chromolaena odorata*), fireweed (*Senecio madagascariensis*), cane tibouchina (*Tibouchina herbacea*), glory bush (*Tibouchina urvilleana*), Himalayan blackberry (*Rubus discolor*), pampas grass (*Cortaderia jubata, C. selloana*), little fire ant, and miconia.
Future Needs: Adequate funding to support priority OISC actions.

Potential Areas for Enhanced Conservation Management

In addition to maintaining and enhancing existing conservation actions, additional efforts are needed for the long-term conservation of O‘ahu’s native wildlife. The following section identifies areas where enhanced conservation management would significantly benefit native species or their habitats. Areas are discussed in habitat order from the mountains to the sea.

Ko‘olau forested watershed

***Species*:** Forest birds, terrestrial invertebrates, bats, rare plants.

***Basis for Priority Designation*:** Habitat for rare species, significant acreage of intact lowland wet forest, tracts of remnant lowland dry forest, opportunities for partnership with numerous private landowners.

Potential Conservation Actions: Expand participation in KMWP, facilitate conservation on private lands through technical assistance and funding opportunities, increased ungulate management through fencing and control, invasive weed control and removal, rodent control.

Mānoa stream riparian corridor

Species: *Oahuhawaiiana kazukolinda*.

***Basis for Priority Designation*:** Few intact stream corridors remaining statewide.

Potential Conservation Actions: Secure additional protection, fencing, support voluntary and incentive-based programs for conservation on private lands.

Wetland habitats

Species: Waterbirds, migratory shorebirds and waterfowl, terrestrial invertebrates, freshwater fishes, freshwater invertebrates

***Basis for Priority Designation*:** Insufficient number of protected and managed wetlands to support growth of endangered waterbird populations.

Potential Conservation Actions: Increase active management of areas currently used by waterbirds using predator control, invasive plant removal, and wetland restoration, identify priority areas for protection and management, secure adequate funding for management and restoration of estuary, wetlands, and adjacent marine habitats. Support efforts of emerging partnership of landowners (DLNR, Hawai‘i Community Development Authority, Kamehameha Schools, nongovernmental organizations [NGOs] and community groups) at He‘eia to establish a National Estuarine Research Reserve and reestablish an *ahupua‘a* (from the mountains to the ocean) system of estuary management.

References:

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. (Accessed 28 March 2005).

Hawai‘i Department of Business Economic Development and Tourism (DBEDTa). 2022. State of Hawai‘i Data Book. Available at: https://dbedt.hawaii.gov/economic/databook/. (Accessed 2 July 2024).

Department of Business, Economic Development, & Tourism, Visitor Statistics (DBEDTb), Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 13 May 2024.

Hawai‘i Department of Land and Natural Resources. 2014. Division of Forestry and Wildlife Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Honolulu.

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2005. Hawai‘i GAP Analysis. Personal communication.

Hawaii’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Health, Hawai’i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2014. 2014 State of Hawaii Water Quality Monitoring and Assessment Report. Available at: http://health.hawaii.gov/cwb/files/2014/11/Final-2014-State-of-Hawaii-Water-Quality-Monitoring-and-Assessment-Report.pdf (accessed June 30, 2015).

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kaiser B, Krause N, Roumasset J. 1999. Environmental valuation and the Hawaiian economy. Honolulu: University of Hawai’i Economic Research Organization.

Ko‘olau Mountains Watershed Partnership. 2002. Ko‘olau Mountains Watershed Partnership management plan. Available at: http://www.state.hi.us/dlnr/dofaw/wmp/koolau/KMWPMP.PDF (accessed on April 18, 2005).

Nature Conservancy of Hawai‘i. Hawaiian High Islands Ecoregional Plan.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Census Bureau. 2021. QuickFacts, Honolulu County, Hawai‘i. Available at: https://www.census.gov/quickfacts/fact/table/honolulucountyhawaii/POP010220. Accessed 13 May 2024.

Nature Conservancy. Undated. Honouliuli Preserve master plan. Honolulu, (HI).

Smith D. Wildlife Biologist. Division of Forestry and Wildlife. Personal communication.

Sustainable Resources Group International, Inc. 2002. Marine Corps Base Hawai‘i: invasive species management study: Draft Report. Honolulu, HI.

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai‘i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O‘ahu Tree Snails of the genus *Achatinella*. Portland, (OR): U.S. Fish and Wildlife Service. 64 pp. + 64 pp. of Appendices + 5 figures.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 2001. Determination of Critical Habitat for the Oahu Elepaio (*Chasiempis sandwichensis ibidis*): Final Rule. Honolulu, (HI): U.S. Fish and Wildlife Service. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/elepaiofr.pdf.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland, (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation or non-designation of Critical Habitat for 101 plant species from the island of O‘ahu, Hawai‘i. Honolulu, HI. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/oahufinal.pdf.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Marine Corps Base Hawai‘i. Natural resources conservation – small installations. FY01-03. Available at: https://www.denix.osd.mil/denix/Public/News/OSD/SecDef03/NRC/nrc_Hawai’i.pd

MOLOKA‘I

Moloka‘i is the fifth largest of the Main Hawaiian Islands. While fairly small in geographic size, the island supports a wide range of native habitats and a diversity of native wildlife. The mountains of eastern Moloka‘i are cut into deep valleys by perennial streams, and due largely to their inaccessibility, these valleys contain high-quality native habitat for stream fauna, forest birds, montane-nesting seabirds, and native snails and insects. The coastal strand along the island’s northwest coast contains one of the state’s last intact dune systems and is important to nesting seabirds and marine animals. Habitat community types found on Moloka‘i include lava tube caves, montane bogs, coastal strand, wetland, and wet, mesic, and dry forests. Important geographic features include the state’s third largest perennial stream, and the highest sea cliffs in the world.

OVERVIEW

Geology and Hydrology

Moloka‘i is approximately 1.8 million years old and 68,000 hectares (170,240 acres) in size. Three shield volcanoes comprise most of the island, with the East Moloka‘i Mountains making up half of the island area. The highest point on the island is 1,515 meters (4,970 feet), and steep cliffs characterize the northern windward coast with inaccessible deep valleys dissecting the coastal area. The leeward slopes descend to a narrow coastal plain fronting an extensive shallow offshore reef flat. The terrain of western Moloka‘i was formed by an older volcano and has a maximum elevation of 421 meters (1,351 feet). This side of the island is typically dry and windy. The Kalaupapa peninsula, formed by the third volcano, extends from the north-central coast, below the steep sea cliffs of eastern Moloka‘i. Approximately 37 percent of the island is below 150 meters (500 feet) in elevation, and about 18 percent of the island is above 610 meters (2,000 feet) in elevation. Moloka‘i has 36 perennial streams, 16 of which are continuous. Wailau, Pūlena, and Pelekunu have the largest discharges: 27 and 25 million gallons per day (mgd), respectively. Moloka‘i has nine offshore islets.

Climate

Annual rainfall ranges from 406 centimeters (160 inches) at the top of the East Moloka‘i Mountains, to 38 centimeters (15 inches) along the coasts of the leeward side of the island.

Land and Water Use

The majority of land on the island is in the State Agricultural District (67% or 44,651 hectares/111,627 acres). Approximately 30 percent (or 19,907 hectares/49,768 acres) is in the State Conservation District, primarily covering the East Moloka‘i mountains and the coastlines. The remaining land is either in the urban (2% or 1,016 hectares/2,539 acres) or rural (1% or 746 hectares/1,866 acres) districts. Ten percent of the island (6,412 hectares/16,030 acres) is in Forest Reserve. There are also 10,308 hectares (25,769 acres) of Department of Hawaiian Homelands (16% of the island). Within native dominated landscapes, major landowners include the State of Hawai‘i and private entities such as The Nature Conservancy of Hawai‘i, Kamehameha Schools, and Moloka‘i Ranch. One stream (Kamalō) has an altered channel. The Waikolu canal in the northeast is the largest man-made stream system at five mgd. Kualapu‘u

Reservoir is a significant man-made lake at 15 meters (50 feet) deep and 40 hectares (100 acres) in area.

Human Landscape

Total resident population on the island in 2020 was estimated at 7,369 (U.S. Census Bureau, 2021) and hosted over 45,000 visitors in 2023 (Department of Business, Economic Development, & Tourism 2024). A majority of the resident population is centered in the Kaunakakai and Hoʻolehua areas in central Molokaʻi. Molokaʻi has the second highest percentage of Native Hawaiians in the state, and many of these residents engage in traditional practices of subsistence gathering. In 1999, the island was named an "Enterprise Community" through the U.S. Department of Agriculture (USDA) Empowerment Zone program, a designation which provides federal funds to support economic growth and community development. Although the Empowerment Zone program ended in 2014, Molokai continues to focus on economic and community resilience. The major industries are now diversified agriculture, sustainable tourism, and renewable energy initiatives. Ranching, once a longstanding industry and tradition on Molokai, has seen a decline in large-scale commercial operations, though small-scale ranching and farming efforts continue as part of the island's focus on sustainable food systems and cultural preservation

SPECIES AND HABITATS OF IMPORTANCE

The south shore of Molokaʻi is home to the longest continuous fringing reef of the U.S. and its holdings. The University of Hawaiʻi's Coral Reef Assessment and Monitoring Program reports that Molokaʻi has sites with the best coral coverage in the main Hawaiian Islands (Storlazzi 2022). Marine ecosystems are a primary source of food for local communities on Molokai, with hunting, fishing, and farming accounting for 33% of the island community's food needs, with coral reefs providing one of the major food sources for Molokaʻi's subsistence economy (Coral Reef Alliance).

Unfortunately, Molokaʻi is also home to many invasive species that negatively impacts many of their ecosystems and for this shoreline, Gorilla ogo (*Gracilaria salicornia)* and mangrove (*Rhizophora mangle)* are the top two marine invasives that have huge impacts on the marine ecosystem of south Molokaʻi.

Molokaʻi is home to a variety of habitats. Major habitat types include montane wet forests and shrublands, coastal system (including dunes and grasslands), perennial streams, lava tubes and caves, cliffs, bog communities, and nine offshore islets. Molokaʻi contains recovery habitat identified by the U.S. Fish and Wildlife Service (USFWS) for the kiwikiu or Maui parrotbill (*Pseudonestor xanthophrys*) and ʻākohekohe or crested honeycreeper (*Palmeria dolei*). Approximately 1,246 hectares (3,105 acres) on Molokaʻi has been designated by the USFWS as critical habitat for the Blackburn's sphinx moth (*Manduca blackburni*), and 3,556 hectares (8,788 acres) for the Hawaiian picture-wing fly (*Drosophila differens*), both of which partially overlap with 9,733 hectares (24,333 acres) designated as critical habitat for 41 endangered plants on Molokaʻi. In addition, critical habitat was designated in 2016 for 60 plant species (many of the species are also included in previously designated critical habitat) and two forest bird species (ʻākohekohe and kiwikiu), which significantly increased the total area of critical habitat on Molokaʻi.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on Molokaʻi and its associated offshore islands. Most of Molokaʻi's endemic forest birds are likely extinct; however, the ʻiʻiwi or Scarlet honeycreeper (*Vestiaria coccinea*), ʻamakihi or Kauaʻi creeper (*Hemignathus virens*), and the ʻapapane (*Himatione sanguinea*) still persist at low numbers. In addition, Molokaʻi supports populations of several endangered and threatened species, such as the ʻōpeʻapeʻa or Hawaiian hoary bat (*Lasiurus cinereus semotus*), nēnē or Hawaiian goose (*Branta sandvicensis*), aeʻo or Hawaiian stilt (*Himantopus mexicanus knudseni*), ʻalae keʻokeʻo or Hawaiian coot (*Fulica alai*), ʻuaʻu or Hawaiian petrel (*Pterodroma sandwichensis*), ʻaʻo or Newell's shearwater (*Puffinus auricularis newelli*), and the Blackburn's sphinx moth (*Manduca blackburni*). Other species groupings that can be found on Molokaʻi are terrestrial invertebrates, freshwater fishes, freshwater invertebrates, seabirds, migratory birds, and raptors.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native plants, wildlife and habitats are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats that are more acute or specific to Molokaʻi are listed below. Large numbers of goats (*Capra hircus*) occur at mid-elevations on the south slope of east Molokaʻi, denuding vegetation, pushing back the forest line, and contributing to soil erosion and runoff onto the nearshore reefs, thereby affecting both forest and marine species;

- Range expansion by invasive plants threatens the native-dominated core of east Molokaʻi;
- The presence of pigs (*Sus scrofa*) and axis deer (*Axis axis*) in areas of native forest degrades important habitat for the remaining arthropods, forest birds, and snails. The State also manages the public hunting program to help control these animals and provide for subsistence and recreation in appropriate areas;
- The relative isolation and small size of forest bird populations makes these species extremely vulnerable to disturbances and unexpected disasters such as hurricanes and wildfires that could lead to their extinction. The degree to which this is also true for arthropods and snails is unknown;
- Development of formerly undeveloped areas (especially along the southeastern coast) leading to loss and degradation of terrestrial, freshwater, and marine habitat (e.g., increased nutrients in coastal areas leads to non-native algal blooms which affect fish populations and coral habitats, sedimentation from development near stream corridors);
- Erosion and sedimentation from upland habitats that impacts coastal, wetland, and marine ecosystems downstream.
- Introduced predators (vertebrate and invertebrate) in native landscapes that prey on native birds, snails, and other invertebrates either directly, or indirectly, through competition for food and other resources;
- Rats, slugs, and other seed and herbivorous pests that kill or harm native plants, especially those species that are rare or at risk of extinction.
- Nesting burrow usurpation, or trampling by ungulate and human traffic, and disease by arthropod vectors for seabirds;
- Wildfire;
- Lack of enforcement for existing rules and regulations;

- Expanding eco-tourism activities that disrupt animal behaviors and habitats;
- Mangrove expansion on to adjacent coral reefs and habitat degradation; and
- Gorilla ogo ability to grow from fragments allows them to spread easily and form large, thick mats over the reef, overgrowing and killing coral and other seaweeds. It also affects larger animals by changing the bottom habitat by growing over access to holes and crevices.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs), additional island-specific strategies for Molokaʻi include the following:

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Complete development and implement the Maui Landscape Conservation Plan to provide implementation-level guidance to enable managers to improve conservation outcomes for species and ecosystems at risk, to include:
        - Identification of species at risk
        - Spatial framework of recovery areas based on suitable habitat and recovery targets
        - Systematic guidance for cost effective recovery actions based on species groups and areas
        - Comprehensive guidance for management and restoration of ecosystems sufficient to stabilize and conserve biodiversity
        - Monitoring and adaptive management
    - Develop, revise, and update applicable planning documents, including endangered species recovery plans and reserve management plans.
    - Continue and build on existing conservation management and implement future needs as identified below in the Management Needs section;
    - ;
    - Implement conservation actions identified in the Potential Areas for Enhanced Conservation Management subsection;
    - Continue development and updates to inventory of lands in need of conservation protections and management to prioritize acquisition of lands through purchase, donation, and set aside, to be designated as conservation reserves to support the goals of this SWAP.
    - Prevent extinctions of at risk plants, invertebrates, and birds through mitigation of priority threats;
    - Continue collection and nursery propagation of imperiled land snail and plant species at risk of extinction;
    - Implement the Maui Axis Deer Action plan to establish and achieve spatially explicit population targets for axis deer on Molokai;
    - Increase the Division of Forestry and Wildlife's (DOFAW's) capacity to support on-site management through improved coordination with Molokaʻi partners;

- Develop additional community wildfire protection plans, as necessary, and implement fire suppression measures and protocols for post-fire restoration;
- Increase the total proportion of managed area that is free of ungulates and predatory mammals and that is separate from existing game management units;
- Seek opportunities for mauka to makai management connectivity to improve the condition of habitats and natural resources, reduce erosion that impacts coastal and coral reef ecosystems, and improve resilience of marine ecosystems and fish ponds.
- Assess potential reintroduction of native birds historically found on Molokaʻi;
- Work with the Commission on Water Resource Management to ensure net increase in number of streams with biological integrity and Instream Flow Standards sufficient to sustain viable native fish and invertebrate populations and meet Environmental Protection Agency (EPA) and Department of Health (DOH) water quality criteria;
- Continue to support/update plans for all marine managed areas;
- Encourage and support Local Action Strategies projects to deal with non-point source pollution off the south coast and support expansion of successful methods to other areas.
- Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
- Improve biosecurity programs, early detection, and rapid response capacity for high-risk species that may circumvent biosecurity networks and are not yet established in the Hawaiian Islands (e.g., brown tree snake, West Nile virus, Argentine fire ant) or that may be present in the Main Hawaiian Islands, are not yet established on Molokaʻi, yet pose a severe threat (e.g., *Tibouchina herbacea* and *Miconia calvescens*);
- Continue to support increased efforts to prevent establishment of high-priority invasive plants in pristine areas and to eradicate these species from areas with significant native species recovery potential; and
- Support efforts to strengthen marine alien species prevention and control;
- Continue efforts to work with local fishermen and the community to regulate and monitor fishing to avoid overexploitation of species, particularly in nearshore waters;
- Continue to support the existing protected zones around critical marine habitats is key to preserving biodiversity or marine protected species. Community-based subsistence fishing areas (CBSFAs) are being promoted to ensure sustainable fishing practices and protect marine species;
- Continue addressing land-based pollution (such as sediment runoff from agriculture) that can smother coral reefs and disrupt marine ecosystems;
- Continue supporting wetland restoration initiatives aim to reduce invasive species and restore native vegetation to improve habitat quality for birds and support the ecosystem services that these wetlands provide;
- Continue restoring traditional kalo farming practices.

- Continue reviewing strategies for traditional ahupua‘a management; and
- Continue engaging local communities, schools, and visitors in stewardship activities.

2) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
   - Continue to improve the dissemination of research information and data regarding native species populations, threats, and habitat condition;
   - Conduct increasingly systematic surveys and inventories for invertebrates in currently managed and unmanaged areas;
   - Increase Hawaiian hoary bat surveys to better assess bat abundance and distribution; and
   - Assess the impact of eco-tourism activities on native terrestrial, aquatic, and marine wildlife and habitats.
3) Strengthen existing and create new partnerships and cooperative efforts.
   - Support ongoing and future projects to address non-point source pollution;
   - Support community-based management of terrestrial, aquatic, and marine habitats and resources;
   - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and identify areas where ungulate populations can be managed to provide for continued hunting opportunities; and
   - Continue to collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.
4) Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
   - Maintain and expand existing outreach and educational programs at managed conservation areas; and
   - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive species and habitats and areas.
5) Support policy changes aimed at improving and protecting native species and habitats.
   - Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
   - Assess ways to support increased enforcement capacities, including the use of new technologies and increase interagency enforcement capacity;
   - Evaluate all current marine resource management areas for purpose and management effectiveness and consider the need for new management areas;
   - Improve integration of policies to address linkages between terrestrial and marine habitats and their shared conservation threats and needs; and
   - Improve coordination of policies and programs to meet the needs of native wildlife conservation but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section and include the following:

- Maui Nui Landscape Conservation Plan (in prep.)
- Species conservation and draft and final recovery plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Nēnē or Hawaiian goose* (2004), the *Revised Recovery Plan for Hawaiian Forest Birds* (2006), the *Hawaiian Endangered Bird Partnership for Captive Propagation Five Year Workplan* (2002), the *Revised Recovery Plan for Hawaiian Waterbirds* (2011), the *Recovery Plan for the Hawaiian Hoary Bat* (1998), and the *Draft Recovery Plan for the Blackburn's Sphinx Moth* (2003); *Maui Nui plants* (1997, 21 taxa), `1*Molokai plants* (1996, 16 taxa), *Multi-island plants* (1999, 26 taxa) and *Addendum* (2002, + 10 spp.), *Hawaiian Ferns* (1998, 4 taxa), *Kokia cookei* (1998), *Gardenia brighamii* (1993), *Phyllostegia hispida* (2013), *Chamaesyce sp*. (draft), *Gouania hillebrandii* (1993); each of these management plans must be revised and updated or new, updated versions that address advancements and current knowledge need to be drafted to guide recovery initiatives;
- Critical habitat designations by USFWS for the Blackburn's sphinx moth and for ecosystems on Molokaʻi (2016);
- Management Plans for the State Natural Area Reserves (NARs): Olokuʻi NAR (1991) and Puʻu Aliʻi NAR (1991);
- Management plan for Molokai Forest Reserve (2009);
- Management plans for state Wildlife Sanctuaries;
- Management plans for partner reserves, including National Park Service, US Fish and Wildlife Service, and Hawaii Land Trust;
- East Molokai Watershed Partnership management plan;The Aloha+ Challenge, a statewide initiative that includes a focus on watershed protection, aiming to reverse natural resource loss by increasing freshwater security, protecting watersheds, and managing invasive species, with a target to protect 30% of priority watershed forests by 2030;
- Long-range management plans for Natural Area Partnership Preserves (NAPPs): Moʻomomi NAPP, Kamakou NAPP, and Pelekunu NAPP;
- DOFAW Draft Management Guidelines, which coarsely rate vegetation quality and provide guidelines for land use (public hunting, recreation, and forest products) for state lands managed by DOFAW;
- A summary of research and information on individual offshore islands, prepared by the Offshore Island Restoration Committee;
- The *Interim State Strategic Plan for Invasive Species Prevention, Control, Research, and Public Outreach*;
- Coastal Zone Management plans, including the *Hawai'i Implementation Plan for Polluted Runoff Control* and *Unified Watershed Assessment*;
- Ongoing initiatives that support Hawai'i's *Local Action Strategy to Address Land-based Pollution Threats to Coral Reef*s (first published in 2004);
- Bishop Museum's comprehensive species inventory database;

- The Audubon Society and others maintain Sightings database of bird species observed in Hawai‘i;
- The Community-Based Subsistence Fishing Area (CBSFA) designation is part of a larger effort to protect nearshore resources, restore sustainable fishing practices, and preserve the cultural connection to marine resources;
- Wetland restoration projects continue to be implemented to enhance critical habitats for endangered species such as the Hawaiian stilt (ae‘o) and Hawaiian coot (‘alae ke‘oke‘o), as well as to restore ecological function in Molokai’s watersheds;
- The Hawaiian Islands Humpback Whale National Marine Sanctuary Management Plan (2020), which encompasses the waters around Molokai, was updated in 2020 and includes measures to protect the North Pacific humpback whales that migrate through Hawaiian waters;
- The Molokai Coral Reef Management and Restoration Plan (ongoing), which aims to protect the extensive fringing coral reef system on Molokai's south shore. Since 2015, more focused efforts have been made to address coral health in response to climate change, ocean acidification, and land-based pollution;
- The Molokai Aquatic Invasive Species (AIS) Management Plan (2016) outlines a strategy for the control and eradication of invasive aquatic species that threaten Molokai’s freshwater and marine environments;
- The East Molokai Watershed Management Plan (2018) focuses on protecting freshwater resources and aquatic ecosystems in the East Molokai watershed and addresses water quality issues and the health of streams, wetlands, and the coastal reef; and
- The Ahupua‘a-Based Management Initiatives (Post-2015) which have been initiated to restore the natural flow of water from the mountains to the sea, promoting healthier aquatic environments.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats and species on Moloka‘i. The discussion of future management needs is highlighted within each current managed area. Some areas on Moloka‘i are already under active management or protection through designation as a State NAR, NAPP, National Park, or National Wildlife Refuge (NWR). The East Moloka‘i Watershed Partnership (EMoWP) extends similar conservation management over private lands, resulting in conservation actions that encompass about 17,800 hectares (44,100 acres) and include the protection of a contiguous 760-hectare (19,000-acre) block of exceptionally intact native-dominated landscape. The Moloka‘i subcommittee of the Maui Invasive Species Committee (MoMISC) addresses high-risk invasive species on an island-wide basis. Additional conservation management benefiting native wildlife occurs on a more localized basis, based on funding availability and landowner or community support. Examples include re-introduction of nēnē on private lands and Mo‘omomi coastal strand restoration. Finally, DOFAW, working collaboratively with USFWS, has developed an approved programmatic Safe Harbor Agreement (SHA) for nēnē on Moloka‘i, allowing the agency to enroll individual landowners who express a desire to enhance, restore, or maintain habitat that will benefit nēnē. The provisions of the SHA protect participant landowners from otherwise

burdensome Endangered Species Act regulatory risks in the event nēnē numbers increase on their land due to their voluntary conservation actions.

Management Areas
The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Molokaʻi.

East Molokaʻi Watershed Partnership (EMoWP) **(44,100 acres), Public-Private Partnership (14 partners including the National Park Service, The Nature Conservancy [TNC], DOFAW, Kamehameha Schools, Kapualei Ranch, Kawela Plantation, Ke Aupuni Lōkahi**

Species: ʻŌpeʻapeʻa, forest birds, pueo, kōlea (*Pluvialis fulva* [Pacific golden plover]), nēnē, ʻuaʻu , kāhuli, and hundreds of endemic terrestrial, aquatic, and semi-aquatic arthropods, and rare plants.

Habitats: Montane and lowland wet, mesic and dry native forest communities containing recovery habitat for more than 100 species at risk.

Current Management: Effective management of more than 40% of the partnership lands with fencing, ungulate control, invasive weed control, threat abatement for species at risk, and education and outreach.

Future Needs: Leverage additional funding opportunities to facilitate expanded management into other native-dominated forests within the partnership boundaries (e.g., Makawao Forest Reserve) and expand monitoring to include stream ecosystems and water quality, consistent with the guidance from the Maui Nui Landscape Conservation Plan. Incorporate new lands acquired in Puaahala, Makolelau into the partnership to secure mauka to makai connectivity under effective management.

Enterprise Community Governance Board, individual private landowners, Hawaiʻi Department of Health, Maui County, Maui County Department of Water Supply, Molokaʻi-Lānaʻi Soil and Water Conservation District, USDA, U.S. Geological Survey, U.S. Environmental Protection Agency)

Species: All species found on the partner lands.

Habitats**:** Montane wet communities, lowland communities, coastal communities, marine systems.

Current Management: Long-range management plan currently in place and revised every five to six years. Major fencing projects on 23 distinct land units along the north, east, and south slope of the East Molokaʻi Mountains.

Future Needs: Continue to expand management activities and fence network to exclude ungulates and predators from high value native habitat areas of East Molokaʻi mountains and fully. Implement the 2015 weed control plan.

Kalaupapa National Historic Park **(10,779 acres, plus two offshore islets), National Park Service**

Species: ʻAmakihi, ʻapapane, ʻiʻiwi, ʻuaʻu, ʻaʻo, koaʻe kea or white-tailed tropicbird (*Phaethon lepturus)*, koaʻe ʻula or red-tailed tropicbird (*Phaethon rubricauda*), ʻā or brown booby (*Sula leucogaster*), ʻou or Bulwer's petrel (*Bulweria bulwerii*), ʻuaʻu kani or wedge-tailed shearwater (*Puffinus pacificus*), cave invertebrates, ʻīlioholoikauaua or

Hawaiian monk seal (*Monachus schauinslandi*), honu and honu ʻea or green and hawksbill sea turtles, respectively, five native diadromous fish species (gobies), and native snails and shrimp.
Habitats: Montane wet communities, lowland communities, coastal communities. Kauhakō Crater contains only known low-elevation dryland forest in the state.
Current Management: Surveys and resource inventories for ʻōpeʻapeʻa, herpetofauna, vascular plants, anchialine pond fauna, and marine fishes. Invasive plant control, fencing, ungulate control, water quality monitoring. Marine and terrestrial monitoring protocols are under development (covering fishes, fisheries, marine benthos, freshwater animals, selected birds, bat, terrestrial invertebrates, vegetation, land use changes in and adjacent to park, invasive species, and water quality). ʻOpihi and reef monitoring and research, Hawaiian monk seal monitoring, and coral recruitment project.
Future Needs: Continue existing management actions. Establish a monitoring program for nesting sea turtles and marine water quality. Continue monitoring coral reef fishes, benthic fishes, and invertebrates. Develop educational programs and more comprehensive outreach on ecological functions.

Kalaupapa National Historical Park Marine Ecosystem, NPSSpecies: Coral reef species, marine invertebrates, Hawaiian monk seals.
Habitats: Coastal and coral reef ecosystems.
Current Management: Protection of natural marine habitats with a focus on ecological and cultural conservation.
Future Needs: Continued invasive species control and enhancement of community-based stewardship programs.

Kamakou Preserve **(2,774 acres), TNC**
Species: ʻAmakihi, ʻapapane, ʻiʻiwi, five rare native land snails, native insects.
Habitats: Montane wet communities, lowland mesic communities.
Current Management: Fence maintenance, ungulate control, invasive plant control and eradication, fire prevention, monitoring, rare species outplanting, community outreach.
Future Needs: Continue existing management and expand as necessary to meet objectives.

Pelekunu Preserve **(5,714 acres), TNC**
Species: ʻIʻiwi, ʻapapane, ʻamakihi, ʻaukuʻu or black-crowned night-heron (*Nycticorax nycticorax*), ʻūlili or wandering tattler (*Tringa incana*), koaʻe kea, *Partulina mighelsiana, P. tessellata*, *Megalagrion santhomelas, M. pacificum*, beetles, five native freshwater fishes, freshwater snail, hīhīwai (*Neritina granosa*), two native crustaceans, ʻōpae kalaʻole (*Atyoida bisulcata*), ʻōpaeʻoehaʻa (*Macrobrachium grandimamus*), rare aquatic insects, and *Campsicnemus ridiculus.*
Habitats: Montane wet communities, lowland communities, coastal communities. Free-flowing streams.
Current Management: Ungulate control, invasive plant monitoring and control, natural resource and water quality monitoring.
Future Needs: Continue existing management.

***Oloku‘i NAR* (1,620 acres), DOFAW**

Species: ‘Apapane, ‘amakihi, ‘i‘iwi, koa‘e kea, ‘a‘o, ‘ua‘u, native insects (crickets, katydid, flies, spiders), and rare tree snails (*Achatinella* spp., *Partulina mighelsiana*, *P. tessellata, P. dwightii, Newcombia cinnamomea*).

Habitats: Montane wet communities, montane mesic communities, lowland wet communities, coastal communities, perennial streams.

Current Management: Aerial and ground monitoring for feral ungulates and invasive plants.

Future Needs: Continue existing management efforts to maintain Oloku‘i NAR in a unique, nearly pristine condition and expand outreach and community education programs to bring attention to factors that contribute to ecological balance in the NAR and ongoing efforts to minimize exposure to threats. Strategic fencing and animal control in Wailau valley in the Forest reserve, and adjacent private lands reduce animal numbers and pressure on Olokui NAR.

***Pu‘u Ali‘i NAR* (1,330 acres), DOFAW**

Species: Oloma‘o or Moloka‘i thrush (*Myadestes lanaiensis*), ‘i‘iwi or scarlet Hawaiian honeycreeper (*Vestiaria coccinea*), pueo Hawaiian short-eared owl (*Asio flammeus sandwichensis*), ‘apapane (*Himatione sanguinea*), ‘amakihi (*Hemignathus virens*), ‘a‘o, ‘ua‘u, native invertebrates (crickets, drosophilid flies, happyface spiders, Tornatellinid snails, Succinid snails, four species of *Achatinella* land snails, *Partulina tessellata, P. redfieldii, P. proxima, P. mighelsiana*).

Habitats: Perennial streams, montane wet shrublands and forests, upper half has most intact communities.

Current Management: Ungulate control, fence maintenance, invasive plant control.

Future Needs: Expand fencing efforts in Waikolu valley. Remove ungulates from Pelekunu valley to reduce pressure on the NAR.

***Kakahai‘a NWR* (45 acres), USFWS**

Species: Ae‘o, ‘alae ke‘oke‘o, and migratory shorebirds.

Habitats: Contains 15-acre freshwater pond, 7-acre impoundment, and marshy thicket of bulrushes.

Current Management: Environmental education, habitat restoration, invasive species removal.

Future Needs: Continue existing management and diversify and expand education and outreach.

***Mo‘omomi Preserve* (921 acres), TNC**

Species: Pueo, hunakai or sanderling (*Calidris alba*), kōlea or Pacific golden plover (*Pluvialis fulva*), ‘iwa or great frigatebird (*Fregata minor*), mōlī or Laysan albatross (*Phoebastria immutabilis*), ‘īlioholoikauaua or Hawaiian monk seal, honu or green sea turtle.

Habitats: Coastal communities.

Current Management: Nonnative species control, weed control, native plant reestablishment, resource monitoring, community outreach, and rare species protection.

Future Needs: Maintain and expand existing level of management and public outreach and education; promote research opportunities and cultural traditions.

State Wildlife Sanctuaries **(Seven Offshore Islands), DOFAW**

Species: ʻAukuʻu, ʻuaʻu kani, ʻou, koaʻe kea, koaʻe ʻula, ʻā or brown booby, kōlea, ʻūlili, ʻakekeke or ruddy turnstone (*Arenaria interpres*), and nalo meli maoli or yellow-faced bees (*Hylaeas* spp.).
Habitats: Coastal communities.
Current Management: Habitat and species monitoring, surveys.
Future Needs: Remove small mammalian predators and restore native vegetation habitat.

One Fishery Management Areas (FMA), **DAR: Kaunakakai Harbor**

Species: Some or all regulated fish species.
Habitats**:** Marine and estuary systems.
Current Management**:** Limited take, gear, size, season, and/or area restrictions.
Future needs**:** Evaluate purpose and management effectiveness and consider need for additional management.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), Co-Managed by NOAA and DLNR**

Species**:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Molokaʻi, which serves as critical habitat for humpback whales.
Current Management**:** Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Molokai Community-Based Subsistence Fishing Area (CBSFA), DLNR

Species: Nearshore fish species (e.g., uhu, moi), invertebrates, and algae.
Habitats: Nearshore marine ecosystems.
Current Management: Gear restrictions, seasonal closures, and size limits for sustainable harvest.
Future Needs: Ongoing community engagement and monitoring of fish populations.

Aliʻi Fishpond and Other Traditional Fishponds, Local Management

Species: Native fish species (e.g., awa, ʻamaʻama), invertebrates.
Habitats: Fishpond ecosystems (loko iʻa).
Current Management: Restoration of fishpond walls and enhancement of aquaculture practices.
Future Needs: Continued collaboration on fishpond restoration and strengthening of traditional aquaculture practices.

Ahupua‘a-Based Resource Management Areas, Community-Led

Species: Integrated species management across ecosystems (fish, birds, plants).
Habitats: Mountain-to-sea (mauka to makai) ecosystems, including freshwater and marine.
Current Management: Traditional Hawaiian resource management practices integrating cultural and ecological stewardship.
Future Needs: Expansion of ahupua‘a-based management and stronger enforcement of sustainable resource use.

Molokai Special Management Area (SMA), CZM Program

Species: Coastal marine species and habitats (coral reefs, seagrass beds).
Habitats: Coastal zones, nearshore marine habitats.
Current Management: Regulation of coastal development to prevent habitat degradation.
Future Needs: Increased oversight on land-use activities that impact coastal and marine ecosystems.

Species Conservation Management

The following projects and programs include state, federal, university, and private cooperative management efforts to address specific conservation needs of SGCNs on Moloka‘i, and often involve island-wide research and management that extend across boundaries and jurisdictions.

***DOFAW Maui Branch,* DOFAW and Conservation Partners Maui Nui wide**

Species: All species at risk, including birds, plants, and invertebrates.
Habitats: All habitats and ecosystems.
Current Management: Management of species at risk, including birds, plants, and invertebrates. Inventory and monitoring, threat abatement for feral ungulates, weeds, predators, and pests, construction of predator-proof exclosures.
Future Needs: Expand to the full MNLCP network of sites for recovery of all 416 species at risk.

***Plant Extinction Prevention Program*, USFWS, DOFAW, University of Hawai‘i**

Species/Habitats: Plant species at risk of extinction.
Current Management: Inventory and monitoring, collection and propagation, research, threat abatement for feral ungulates, weeds, predators, and pests, construction of predator-proof exclosures.
Future Needs: Expand to the implement the full MNLCP network of sites for recovery of all 197 plant species at risk.

***Snail Extinction Prevention Program*, USFWS, DOFAW, University of Hawai‘i**

Species/Habitats: Snail species at risk of extinction.
Current Management: Inventory and monitoring, collection and propagation, research, construction of 20 predator-proof exclosures, threat abatement for feral ungulates, weeds, predators, and pests.
Future Needs: Expand to the implement the full MNLCP network of exclosures for recovery of all snail species at risk.

***Maui Nui Seabird Recovery Project,* DOFAW and University of Hawai‘i**

Species: Seabirds.

Habitats: Montane and coastal nesting habitats.

Current Management: Monitoring of colonies, identification of threats, control of predators, and facilitation of research.

Future Needs: Leverage adequate funding, develop new partnerships with public and private stakeholder groups to advance conservation initiatives.

***Moloka‘i Invasive Species Committee*, Public-Private Partnership**

Species/Habitats: All species and habitats affected by invasive species.

Current Management: Invasive species prevention, early detection, response, and control.

Future Needs: Increase program support to identify, implement rapid response measures for, and eradicate and control high-priority invasive species; increase prevention surveillance capacity; and expand public awareness and outreach.

Potential Areas for Enhanced Conservation Management

In addition to maintaining and enhancing existing conservation actions, additional efforts are needed for the long-term conservation of Moloka‘i’s native wildlife and habitats. The following section identifies areas where enhanced conservation management would significantly benefit native species or their habitats.

***Moloka‘i Forest Reserve* (16,030 acres), DOFAW**

***Species*:** Forest birds terrestrial plants, and invertebrates.

***Basis for Priority Designation*:** Some native forest, contains lowland mesic shrubland; currently part of EMoWP managed area adjacent to core forested areas; little active management for native wildlife conservation. Recent acquisitions in Puaahala and Makolelau extend conservation lands from the summit to the sea, providing opportunities for improved management of species at risk, ecosystems, and coastal and marine ecosystems.

Potential Conservation Actions: Extend fences and management of invasive species to the shoreline, restore dry and mesic forest habitats. Control invasive plants; continue field testing of biocontrol measures to halt the spread of *Clidemia* to pristine areas and document the effectiveness of treatment to determine subsequent needs, and increased management in the upper Waimanu and Mokomoko sections.

Watershed area east of Kapualei

***Species*:** Forest birds and terrestrial invertebrates.

***Basis for Priority Designation*:** Relatively intact native habitat; implementing measures to protect the area against browsing by feral goats would reduce vegetation loss and soil erosion, thereby reducing sedimentation onto nearshore reefs.

Potential Conservation Actions: Assess future partnership opportunities and create incentives for conservation management.

Stream corridors **(Wailau)**

Species**:** Freshwater fishes, freshwater invertebrates, terrestrial invertebrates. Marine Area of Kamalō, Kamiloloa, and Palaʻau

Basis for Priority Designation**:** One of the major stream corridors on the island not presently impacted by ungulates and invasive plants.

Potential Conservation Actions: Monitor stream health, assess for future management needs, encourage research, and develop education and community awareness.

Cave ecosystems **(Kalaupapa and montane rainforest on the slopes of Kawela)**

Species**:** Native invertebrates.

Basis for Priority Designation**:** Unique ecosystems – only existing habitat for certain endemic invertebrate species.

Potential Conservation Actions: Continue efforts to protect these areas from human intrusion, invasive alien species, harmful or invasive microorganisms, wildfires, and ungulates.

Coastal wetlands **(Paialoa Pond, Pālāʻau wetlands, Kaunakakai Sewage Treatment Plant, ʻŌhiʻapilo Playa, coastal fishponds, Kualapuʻu Reservoir, Hoʻolehua wetlands)**

Species**:** Waterbirds, migratory birds, native plant communities.

Basis for Priority Designation**:** These areas have been identified by USFWS and the Pacific Coast Joint Venture as core habitats that support waterbird recovery.

Potential Conservation Actions: Habitat restoration and management: create increased open water surface area, establish permanent water sources, control weeds, restore native vegetation, conduct predator control, and monitor effectiveness.

North and west shore coastal strand

Species**:** Seabirds, ʻīlioholoikauaua, honu.

Basis for Priority Designation**:** Important, heavily used habitat for seabirds, migratory shorebirds, and marine animals.

Potential Conservation Actions: Restore native vegetation, limit human disturbance, and control predators.

ʻĪlio Point, **state land**

Species**:** Seabirds.

Basis for Priority Designation**:** Lithified sand dunes support quality intact mixed coastal shrubland. Used by nesting seabirds. Threatened by axis deer, invasive plants, dogs, feral cats, rats, and pigeons. High restoration potential for coastal strand ecosystem and seabird habitat.

Potential Conservation Actions: Address unexploded ordnance remediation, which currently limit conservation activities. Construct deer-proof fencing and control predators.

References:

Duvall, F. Wildlife Biologist, Division of Forestry and Wildlife. Personal communication. 2005.

East Moloka‘i Watershed Partnership. East Moloka‘i Watershed Partnership Strategic Plan: for the south slope FY1998-FY2003 Summary, FY2004-2009 Projections.

Wong-Stone, K. Aquatic Biologist, Division of Aquatic Resources. Personal communications 2024.

Storlazzi C. (2022, March 21). Coral Reef Project: Moloka‘i. USGS Pacific Coastal and Marine Science Center. https://www.usgs.gov/centers/pcmsc/science/coral-reef-project-molokai

Beebe, K. (2023, December 8). Protecting Molokai’s Coral Reefs with the Restoration of Ancient Hawaiian Fish Ponds. Coral Reef Alliance. https://coral.org/en/blog/protecting-molokais-coral-reefs-with-the-restoration-of-ancient-hawaiian-fish-ponds/

Gorilla Ogo. (n.d.). https://dlnr.hawaii.gov/hisc/info/invasive-species-profiles/gorilla-ogo/

Hawaii’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Business, Economic Development, & Tourism, Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 27 June 2024.

Hawai‘i Department of Health, Hawai’i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. (accessed 28 March 2005).

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2005. Hawai‘i GAP Analysis. Personal communication.

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Howarth FG. 2002. An assessment of the conservation status of the terrestrial cave fauna occurring on the Islands of Maui and Moloka’i, Hawai’i. Honolulu, (HI): U.S. Fish and Wildlife Service, Pacific Islands Office.

Hughes G. Natural Resource Manager, National Park Service. Personal communication.

Kakahaia National Wildlife Refuge. Available at: http://www.fws.gov/pacific/pacificislands/wnwr/mkakahaianwr.html (accessed 22 March 2005).

Kalaupapa National Historic Park. Available at: http://www.nps.gov/kala/docs/start.htm (accessed 7 April 2005).

Lau T, Misaki E. Nature Conservancy Molokaʻi. Personal communication.

Loope LL. Status and trends of the nation's biological resources: Hawaiʻi and the Pacific Ocean. U. S. Geological Survey. Available at: http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed 7 December 2004).

Natural Area Reserves System Program, Division of Forestry and Wildlife. 1991. Puʻu Alii Natural Area Reserve management plan. Hawaiʻi Department of Land and Natural Resources. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 6 April 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. Olokui Natural Area Reserve management plan. Hawaiʻi Department of Land and Natural Resources, March 1991. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 6 April 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. 2003. Final environmental assessment: natural resources conservation project, Kanaio Natural Reserve. Hawaiʻi Department of Land and Natural Resources.

Nature Conservancy of Hawaiʻi. Hawaiian High Islands Ecoregional Plan.

Nature Conservancy of Hawaiʻi. 2003. Pelekunu Preserve, Molokaʻi, Hawaiʻi: long range management plan fiscal years 2004-2009. Honolulu, (HI): Department of Land and Natural Resources, 2nd revision. Available at: http://www.state.hi.us/dlnr/dofaw/pubs/LRPPelekunu_rev2.pdf (accessed 6 April 2005).

Nature Conservancy of Hawaiʻi. Kamakou Preserve, Molokaʻi, Hawaiʻi: long range management plan fiscal years 2001-2006. Honolulu, Hawaiʻi: Department of Land and Natural Resources.

Nature Conservancy of Hawaiʻi. Moomomi Preserve, Molokaʻi, Hawaiʻi: long range management plan fiscal years 2001-2006. Honolulu, Hawaiʻi: Department of Land and Natural Resources.

Paine JR. 1991. IUCN directory of protected areas in Oceania. Gland: International Union for Conservation of Nature and Natural Resources.

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawaiʻi Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Census Bureau. 2021. QuickFacts, Maui County, Hawaiʻi. Available at: https://www.census.gov/quickfacts/fact/table/mauicountyhawaii/PST045223. Accessed 27 June 2024.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland, (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2003. Final designation and non-designation of Critical Habitat for 42 plant species from the islands of Molokaʻi, Hawaiʻi : Final Rule. 68 FR 12982. Honolulu, HI.

U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn's Sphinx Moth: final rule. 68 FR 34710. Honolulu, (HI).

U.S. Fish and Wildlife Service. 2003. Draft recovery plan for the Blackburn's Sphinx Moth (*Manduca blackburni*). Portland, (OR): U.S. Fish and Wildlife Service. Ix+113 pp.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

LĀNAʻI

Lānaʻi is the third smallest of the Main Hawaiian Islands. Because of a history of overgrazing by cattle, goats, and axis deer, much of the island has suffered from extensive soil erosion and few native-dominated natural communities remain. Though many species once native to Lānaʻi are no longer present, the last major remnant of the olopua/lama dryland forest that once covered large portions of the lowlands of Maui Nui (composed of Maui, Lānaʻi, Molokaʻi, and Kahoʻolawe) occurs on Lānaʻi. This forest provides habitat for several taxa of native invertebrates. The upland area surrounding the island's highest point, Lānaʻihale, contains most of the remaining native-dominated mesic forest and provides habitat for the ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), ʻapapane (*Himatione sanguinea* [Hawaiian honeycreeper]), and rare native land snails. Waterbird species rely primarily on human-made reservoirs (e.g., golf-course ponds, the Lānaʻi Sewage Treatment Plant), rather than natural wetlands.

OVERVIEW

Geology and Hydrology

Lānaʻi was formed from a single dome-shaped shield volcano that last erupted over 1 million years ago. Only 29 kilometers (18 miles) long and 21 kilometers (13 miles) wide, the island is approximately 36,520 hectares (90,500 acres). The highest point is Lānaʻihale, at 1,027 meters (3,370 feet). The northeastern coast is fringed with broad sandy beaches, while the southwestern coast is marked by sea cliffs. Approximately 25 percent of the island is below 150 meters (500 feet) in elevation and only 6 percent of the island is above 610 meters (2,000 feet) in elevation. Lānaʻi has five offshore islets and there are no perennial streams or lakes.

Climate

Located in the rain shadow of Maui, Lānaʻi is generally dry, with an average rainfall of 75 to 100 centimeters (30 to 40 inches) over Lānaʻihale, and less than 25 centimeters (10 inches) on the southwestern (leeward) side of the island. A large portion of the water in the island's aquifer comes from "fog drip," moisture pulled from clouds by trees and ferns in upper elevations. Strong tradewinds funneled from Maui and Molokaʻi increase evaporation of moisture and contribute to soil erosion, particularly on the western side of the island.

Land and Water Use

Approximately 42 percent (15,457 hectares or 38,197 acres) of the island is in the State Conservation District, located primarily around Lānaʻihale and on the western end of the island. This area partly overlaps the Lānaʻi Cooperative Game Management Area. Most of the remaining acreage is in the Agricultural District (52%), with about four percent in the Urban District (concentrated around Lānaʻi City, Mānele Bay and the airport), and two percent in the Rural District (located primarily along remote coastlines). Nearly the entire island (98%) is privately owned by Lānaʻi Resorts LLC and managed by Pūlama Lānaʻi. Four of the five offshore islands are in the State Seabird Sanctuary. Approximately 12,140 hectares (30,000 acres) are leased by State Division of Forestry and Wildlife (DOFAW) for use as the Lānaʻi Cooperative Game Management Area.

Human Landscape

In 2020, Lānaʻi had a population of 3,367 residents (U.S. Census Bureau 2020). A majority of the population is centered in Lānai City. In the early 1990s, with the closure of a large pineapple plantation and opening of two resorts at Kōʻele and Mānele Bay, the island's economic base shifted from agriculture to tourism and resort-residential development. The number of annual visitors was approximately 68,270 in 2023 (Dept. of Business, Economic Development, and Tourism 2024).

SPECIES AND HABITATS OF IMPORTANCE

Habitats on Lānaʻi are primarily lowland dry communities and coastal communities. While few areas of native-dominant vegetation remain, there are opportunities for habitat restoration through a combination of fencing to exclude ungulates, outplanting of native species, and invasive plant control.

Appendix A provides information on the wildlife Species of Greatest Conservation Need present on Lānaʻi and its associated offshore islands. Species endemic to Lānaʻi include several species of Lānaʻi tree snails (*Partulina* spp.). Although once abundant, these species are currently near extinction due to loss of habitat, recreational collecting, and predation by non-native carnivorous snails. Waterbirds and migratory shorebirds use remnant wetlands. The ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]) colony on Lānaʻihale, which received little attention for many years, was rediscovered and confirmed active in 2006. Considerable effort to characterize the colony has been ongoing and nesting has been confirmed on the less accessible steep slopes and ridges of Lānaʻihale. Historically, Lānaʻi was home to eight species of forest birds. Although several are now extinct, the possibility exists for re-introduction of ʻiʻiwi (*Drepanis coccinea*) and ʻamakihi (*Hemignathus virens*). The U.S. Fish and Wildlife Service (USFWS) has proposed 320 hectares (789 acres) of critical habitat on Lānaʻi for three plant species: pamakani (*Tetramolopium remyi),* poʻe or ʻihi makaole (*Portulaca sclerocarpa*), and koʻokoʻolau (*Bidens micrantha kalealaha* [Kalealaha beggarticks]).

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats more acute or specific to Lānaʻi are listed below. Because Lānaʻi has no perennial streams, there are no identified threats specific to freshwater species on Lānaʻi.

- Habitat degradation caused by feral ungulates, specifically axis deer (*Axis axis*), sheep (*Ovis aries*), and goats (*Capra hircus*), which contributes to erosion and sedimentation of near-shore reefs;
- Introduction of invasive species via the passenger ferry from Maui, on cargo vessels entering the commercial port at Kaumalapaʻu Harbor, and aboard private aircraft and vessels;

- Degradation of habitat by introduced plant species, with kāhili ginger (*Hedychium gardnerianum*), strawberry guava (*Psidium cattleianum*), fountain grass (*Pennisetum setaceum*), and molasses grass (*Melinis minutiflora*);
- Threat of wildland fire, exacerbated by non-native grasses;
- Predation of nesting ʻuaʻu by feral cats (*Felis catus*), dogs (*Canis familiaris*), barn owls (*Tyto alba*), cattle egrets (*Bubulcus ibis*), and rodents (e.g., *Rattus* spp.);
- Rats, slugs, and other seed and herbivorous pests that kill or harm native plants, especially those species that are rare or at risk of extinction.
- Erosion and sedimentation from upland habitats that impacts coastal, wetland, and marine ecosystems downstream.
- Predation of endemic tree snails by alien carnivorous snails (e.g., *Euglandina rosea*) and rats;
- Localized excessive recreational use (e.g., Mānele Bay); and
- Human and boat interactions with marine mammals.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs), additional island-specific strategies for Lānaʻi include the following (bullet):

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Complete development and implement the Maui Landscape Conservation Plan to provide implementation-level guidance to enable managers to improve conservation outcomes for species and ecosystems at risk, to include:
        - Identification of species at risk
        - Spatial framework of recovery areas based on suitable habitat and recovery targets
        - Systematic guidance for cost effective recovery actions based on species groups and areas
        - Comprehensive guidance for management and restoration of ecosystems sufficient to stabilize and conserve biodiversity
        - Monitoring and adaptive management
    - Develop, revise, and update applicable planning documents, including endangered species recovery plans and reserve management plans.
    - Continue development and updates to inventory of lands in need of conservation protections and management to be used to prioritize acquisition of lands through purchase, donation, and set aside, to be designated as conservation reserves to support the goals of this SWAP.
    - Prevent extinctions of at risk plants, invertebrates, and birds through mitigation of priority threats;
    - Continue collection and propagation of imperiled plant and land snail species at risk of extinction;
    - Establish island-wide targets for the axis deer population and maintain numbers at those levels in collaboration with Pulama Lanai.

- Expand existing conservation management and implement future needs as identified below in the Management Needs section;
- Develop, revise, and/or implement recovery plans for threatened and endangered species on Lānaʻi;
- Increase active management in, or acquisition of, extremely rare habitats on Lānaʻi;
- Increase the total proportion of managed area that is free of ungulates and predatory mammals and that is separate from existing game management units;
- Assess potential reintroduction of native birds historically found on Lānaʻi;
- Institute landscape-level predator management (primarily rodent and feral cat) around known and suspected ʻuaʻu nesting colonies;
- Evaluate methods requirements necessary to maintain old plantation roads as functioning firebreaks;
- Support restoration efforts on the island, particularly of native habitats and areas with ecological connectivity to watersheds;
- Control erosion control and restore/reforest northeast portion of the island to preserve upland habitat and minimize sedimentation and runoff into coastal areas and ocean waters; and
- Develop management plans for coastal and marine areas.

2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Improve biosecurity, prevention, early detection, and rapid response capacity for high-risk species that may circumvent biosecurity networks and are not yet established in the Hawaiian Islands (e.g., brown tree snake, West Nile virus, Argentine fire ant), or that may be present in the Main Hawaiian Islands but are not yet established on Lānaʻi (mongooses, fire ants); explore the feasibility of increasing biosecurity requirements for passengers and materials arriving aboard the ferry from Maui; and
    - Inventory existing terrestrial and aquatic invasive species, develop sufficient biosecurity procedures, and prioritize control actions.
3) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Improve dissemination of research information and data regarding native species populations and habitat condition;
    - Conduct increasingly systematic surveys and inventories for invertebrates in currently managed and unmanaged areas; and
    - Conduct forest bird surveys according to established statewide or improved survey design strategies to update information on populations and detect emerging trends.
4) Strengthen existing collaboration and develop new opportunities with Pūlama Lānaʻi and others.
    - Support efforts to develop community-based resource co-management;
    - Support projects that address non-point source pollution;
    - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and

identify areas where ungulate populations can be managed to provide for continued hunting opportunities; and
    - Collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.
5) Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Explore opportunities for community-based wildlife surveys and monitoring;
    - Expand existing outreach and educational programs at managed conservation areas and incorporate new information into training programs; and
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive species and habitats.
6) Support policy changes aimed at improving and protecting native species and habitats.
    - Evaluate all current marine resource management areas for purpose and management effectiveness and consider the need for new or expanded management actions or new managed areas;
    - Provide support for boundary expansions and new ecosystem-based provisions contained in the Hawaiian Islands Humpback Whale National Marine Sanctuary revised management plan. Encourage research opportunities and expand public education and outreach; and
    - Improve coordination of policies and programs to meet the needs of native wildlife conservation but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section and include the following:

- Maui Nui Landscape Conservation Plan (in prep.)
- Long-range management plan for Natural Area Partnership Preserve: Kānepu‘u Preserve (2004, updated every six years);
- Species conservation and draft and final recovery plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), the *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for Hawaiian Forest Birds* (2003), and the *Draft Revised Recovery Plan for Hawaiian Waterbirds* (1999); *Maui Nui plants* (1997, 21 taxa), *Multi-island plants* (1999, 26 taxa) and *Addendum* (2002, + 10 spp.), *Lanai plants* (1995, 9 taxa, 138 pp.), *Hawaiian Ferns* (1998, 4 taxa), *Kokia cookei* (1998), *Gardenia brighamii* (1993), *Phyllostegia hispida* (2013), *Chamaesyce sp*. (draft), *Gouania hillebrandii* (1993);
- A summary of research and information on individual offshore islands was prepared by the Offshore Island Restoration Committee;
- The *Interim State Strategic Plan for Invasive Species Prevention, Control, Research, and Public Outreach*;
- Coastal Zone Management plans, including *Hawai‘i Implementation Plan for Polluted Runoff Control* and *Unified Watershed Assessment*;

- Hawaii's *Local Action Strategy to Address Land-based Pollution Threats to Coral Reefs* (first published in 2004);
- Bishop Museum's comprehensive species inventory database; and
- The Audubon Society and others maintain Sightings database of bird species observed in Hawai‘i.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats on Lāna‘i. The discussion of future management needs is highlighted within each current managed area. In comparison to other islands, Lāna‘i has few areas managed for the long-term conservation of native wildlife. There are no National Parks or Wildlife Refuges, State Forest Reserves, Natural Area Reserves, or Wildlife Sanctuaries, and there is no on-island invasive species committee. Pūlama Lāna‘i has a natural resources management program that oversees most of the resource conservation and management activities on Lāna‘i.

Management Areas

The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Lāna‘i.

***Kānepu‘u Preserve* (590 acres), The Nature Conservancy (TNC) and ‘Ike ‘Āina**

Species: ‘Apapane, pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), kōlea (*Pluvialis fulva* [Pacific golden plover]).
Habitats: Lowland dry communities, particularly olopua/lama dryland forest.
Current Management: Maintenance of fencing to exclude ungulates, deer control, invasive plant control, outplanting of native plants as part of Natural Area Partnership Program (NAPP).
Future Needs: Maintain existing fencing, install new fence sections as necessary, continue to implement weed control, and expand community involvement.

***State Seabird Sanctuary* (Four Offshore Islets), DOFAW**

Species: Nesting seabirds, primarily noio (*Anous minutus* [black noddy]), koa‘e ‘ula (*Phaethon rubricauda* [red-tailed tropicbird]).
Habitats: Coastal community.
Current Management: Surveys and monitoring of seabird populations, current threats, needed management actions.
Future Needs: Continue surveys and predator control.

***Mānele-Hulopo‘e Marine Life Conservation District (MLCD),* DAR)**

***Species*:** Species associated with shallow coral reef, sandy beach, and rocky habitats, ‘īlioholoikauaua (*Monachus schauinslandi* [Hawaiian monk seals]), honu (*Chelonia mydas* [green sea turtles]), nai‘a (*Stenella longirostris* [spinner dolphins]) and other marine cetaceans.

Habitats: Marine ecosystems, including shallow coral reef, sandy beach, and rocky habitats.
***Current Management*:** Allow fishing throughout MLCD, fish monitoring.
Future Needs: Evaluate the MLCD for purpose and management effectiveness and consider the need for new marine resource management areas.

***Mānele Harbor Fishery Management Area (FMA),* DAR**

***Species*:** Some or all regulated fish species.
Habitats: Marine and estuary ecosystems.
***Current Management*:** Limited take, gear, size, season, and/or area restrictions.
Future Needs: Evaluate the FMA for purpose and management effectiveness and consider need for new marine resource management areas.

***Hawaiian Islands Humpback Whale National Marine Sanctuary* (about 900,000 acres), Co-Managed by NOAA and DLNR**

***Species*:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Lanaʻi, which serves as critical habitat for humpback whales.
***Current Management*:** Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Species Conservation Management

***Lānaʻihale Watershed* (approximately 20,000 acres)**

Species: ʻApapane, ʻuaʻu, tree snails.
Habitats: Lowland mesic communities, lowland dry communities.
Current Management: Management strategy being implemented. Fencing of roughly1,450 hectares (3,600 acres) at Lānaʻihale summit, ungulate (primarily deer) exclusion, invasive plant removal, native species outplanting and reforestation, community involvement and outreach.
Future Needs: Work with land owner and stakeholders to leverage necessary funding to complete efforts at Lānaʻihale, ungulate control, species and habitat mapping, reforestation, and other critical management needs.

References:

Duvall, F. Wildlife Biologist, Division of Forestry and Wildlife. Personal communication. 2005.

Hawaiʻi Department of Business, Economic Development, and Tourism. 2003. State of Hawaiʻi data book. Available at: http://www3.Hawai'i.gov/DBEDT/index.cfm?section=READ_Databook1075. Accessed 28 March 2005.

Hawai‘i Department of Business, Economic Development, & Tourism. Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 13 May 2024.

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2005. Hawai‘i GAP Analysis. Personal communication.

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

National Oceanic and Atmospheric Administration. National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division. 2001. Sensitivity of coastal environments and wildlife to spilled oil: Hawai‘i atlas. Seattle (WA): National Oceanic and Atmospheric Administration.

Nature Conservancy of Hawai‘i. Hawaiian High Islands Ecoregional Plan.

Nature Conservancy. 2004. Kanepu‘u Natural Area Partnership Preserve long range management plan FY 2005-2010. Honolulu, (HI).

Offshore Island Restoration Committee. Available at: http://www.botany.hawaii.edu/gradstud/eijzenga/OIRC/ (last accessed 9 February 2005).

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai‘i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Census Bureau. 2021. Lanai CCD, Maui County, Hawaii. County Subdivision. Available at: https://data.census.gov/profile/Lanai_CCD,_Maui_County,_Hawaii?g=060XX00US1500992070. Accessed 13 May 2024.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 1999. Draft revised recovery plan for Hawaiian waterbirds, Second Revision. Portland, (OR): U.S. Fish and Wildlife Service. 107 pp.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation of Critical Habitat for three plant species from the island of Lanai, Hawai‘i.

U.S. Fish and Wildlife Service. 2003. Draft revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland, (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (Branta sandvicensis). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

MAUI

Maui is the second largest island in the State of Hawai‘i and is known as the Valley Isle. Thirty percent of the island is dominated by native vegetation with most of this habitat in east Maui. The upper elevation slopes and summits of both east and west Maui are typically native dominated, with coastal and lower elevation areas dominated by non-native vegetation. Three notable areas contain continuous native vegetation spanning a range of habitats, forming a landscape with a high diversity of total species: summit and leeward west Maui (wet forests and bogs transitioning to lowland mesic communities), windward east Maui (subalpine shrubland transitioning to wet forest), and leeward east Maui (subalpine community transitioning to remnant montane mesic then lowland and coastal dry communities). In addition, large tracts of intact native-dominated montane forests remain, with a canopy composed primarily of ‘ōhi‘a lehua (*Metrosideros polymorpha*) and koa (*Acacia koa*) and a well-developed sub-canopy layer of mixed native understory trees and shrubs. Habitat types are highly diverse, including coastal and wetland habitats, lava tube caves, aeolian habitats, and bogs. Maui also has ten offshore islets that are significant habitats for seabirds. Anchialine pools and ponds, which host a unique fauna of amphipods and shrimp, are found in young lava fields on the coast. As a result of the range of habitats, a diversity of species can be found including cave insects, endangered forest birds, marine mammals, and endemic freshwater fishes.

OVERVIEW

Geology and Hydrology

At 186,163 hectares (465,408 acres), Maui was formed between 750,000 and 1.3 million years ago, as first west Maui then east Maui emerged from two large shield volcanoes (West Maui and Haleakalā). Haleakalā is the tallest peak at 3,055 meters (10,023 feet), with Pu‘u Kukui in West Maui coming in second at 1,764 meters (5,788 feet). Maui, along with Hawai‘i Island) contain alpine and subalpine communities. Approximately 25 percent of the island is below 150 meters (500 feet) in elevation; just over 40 percent is above 610 meters (2,000 feet) in elevation. Major streams include Palikea (the second largest perennial stream in the state), Kalialinui-waialae gulch (the state’s second longest stream), Honokōhau stream (the longest stream channel in west Maui), and ‘Īao stream. Maui has 90 perennial streams, 56 of which are continuous. Waihe‘e and ‘Īao streams have the largest discharges - 60 and 43 million gallons per day (mgd) respectively. Many streams are diverted; Maui has the highest diversion of natural stream flows in the state. Kanahā Pond, historically a natural freshwater lake, is approximately 1 meter (3 feet) in depth and 16 hectares (41 acres) in size and is located wholly within the Kahului Airport boundary area.

Climate

Because of the size and elevation range of Haleakalā, climate and vegetation communities vary dramatically. Warm trade winds meet the windward side of the volcano and leave most of their moisture behind as rain or cloud drip on the windward side. At high elevations and on the leeward slopes of Haleakalā, dry conditions predominate. The geologically older West Maui mountains receive an average rainfall of 1,016 centimeters (400 inches) per year, making it the second wettest spot in the state.

Land and Water Use

Land use designations according to the State Land Use Commission are 53 percent Agricultural District, 42 percent Conservation District, five percent Urban District, and less than one percent Rural District. Major landowners in West Maui include the State of Hawai‘i, Maui Land and Pineapple, Inc., Makila Land Company, Kahoma Land Company, Kā‘anapali Land, LLC, Kamehameha Schools, and Maui County (Department of Water Supply). In East Maui, major landowners are the State of Hawai‘i (including the Department of Hawaiian Home Lands), the National Park Service (NPS), Alexander and Baldwin, Ulupalakua Ranch, and Haleakalā Ranch. Fifty-seven streams are diverted and seven have altered channels. Wailuku is the largest altered stream. Maui has ten impaired streams under Environmental Protection Agency (EPA) Clean Water Act standards. The East Maui canal system in Central Maui is the largest human-made stream system at 164 mgd.

Human Landscape

The estimated population on Maui is 154,100 (U.S. Census Bureau 2021)) with most of the island’s population located in central, south, and west Maui in areas such as Kahului and Wailuku, Kīhei, Lahaina, and Kā‘anapali. The average daily visitor census is approximately 54,693, with over 2.4 million people visiting annually (Department of Business, Economic Development, and Tourism 2024). Major industries are tourism, agriculture, technology, and agriculture value-added industries.

SPECIES AND HABITATS OF IMPORTANCE

Given the five elevation zones present on Maui, the island has a diversity of habitats for native wildlife. Particular habitats associated with native wildlife include alpine deserts, subalpine and montane forests and bogs, lowland forests, coastal communities, anchialine pools, and lava tube caves. Additionally, parts of East Maui have healthy freshwater aquatic systems on the slopes of ridges, in the streams of lower Hanawī, and the streams of the Kīpahulu and Kaupō area. These habitats support a diversity of native species including forest birds, invertebrates, ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), waterbirds, freshwater species, and seabirds. Plant endemism for Maui is estimated at 20 percent. Beaches provide habitat for nesting sea turtles. Offshore islets provide important habitats for seabirds, migratory birds, raptors, invertebrates, plants, and marine fauna. Approximately 9,509 hectares (23,496 acres) of critical habitat has been designated for Blackburn’s sphinx moth (*Manduca blackburni*), and 54 hectares (134 acres) for one species of Hawaiian picture-wing fly (*Drosophila neoclavisetae),* both of which have significant overlap with the 50,612 hectares (126,531 acres) of designated critical habitat for 60 endangered plants on Maui. In addition, critical habitat was approved in 2016 for 91 plant species (many of the species are also included in previously designated critical habitat), two forest bird species (‘ākohekohe or crested honeycreeper [*Palmeria dolei*] and kiwikiu or Maui parrotbill [*Pseudonestor xanthophrys*]), and three species of kāhuli (Lāna‘i tree snails [*Partulina semicarinata* and *P. variabilis]*, and Newcomb’s snail [*Newcombia cumingi*]), significantly increased the total area of critical habitat on Maui. Recovery habitats for the ‘ākohekohe and kiwikiu have also been identified by USFWS.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on Maui and its associated offshore islands. Maui is important habitat for several native forest birds, including the following Maui endemic species: ʻākohekohe, Maui ʻalauahio (*Paroreomyza montana newtoni* [Maui creeper]), and kiwikiu. Maui is also home to the third largest population of nēnē (*Branta sandvicensis* [Hawaiian goose]) in the state. Other federally listed species include the ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]), koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), ʻaʻo (*Puffinus newelli* [Newell's shearwater]), ʻōpeʻapeʻa, ʻīlioholoikauaua (*Monachus schauinslandi* [Hawaiian monk seal]), honu ʻea (*Eretmochelys imbricata* [hawksbill turtle]), and honu (*Chelonia mydas* [green sea turtle]). For invertebrates, in general, Maui is characterized by high levels of endemism and diversity representing many orders. For example, along with the federally endangered Blackburn's sphinx moth, Maui also hosts several endemic nalo meli maoli or yellow-faced bees (*Hylaeus* spp.), kāhuli or Hawaiian tree snails, and high levels of diversity within most families of beetles (Coleoptera). Other species on Maui include native freshwater fishes and invertebrates, endemic anchialine pool amphipods (Amphipoda), migratory birds, and raptors.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife and habitats are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats that are more acute or specific to Maui are listed below.

- The population of axis deer expanded rapidly across central Maui following the introduction of nine deer to the Puu o Kali area in 1959. The population is spreading into West Maui, causing habitat degradation and loss and economic impacts;
- Pigs, where present in unmanaged upper remote watersheds, can degrade sensitive bog communities and wet forest habitats (the state also manages the public hunting program to help control these animals and provide for subsistence and recreation in appropriate areas);
- Avian disease transmitted by mosquitoes restricts forest birds to high-elevation habitats and as temperatures warm because of climate change, mosquitos are moving upslope, enabling disease transmission to susceptible forest birds in previously disease-free high-elevation forests;
- Widespread presence of habitat-modifying invasive plants, including *Miconia calvescens*;
- Introduction of invasive species at airports, ports, and harbors;
- Invasive algae expansion in the coastal Lahaina and Kīhei areas;
- Predation by introduced animals such as mongooses (*Herpestes auropunctatus*), feral cats (*Felis catus*), feral dogs (*Canis familiaris*), barn owls (*Tyto alba*), cattle egrets (*Bubulcus ibis*), and rats (*Rattus* spp.), which prey on waterbirds, ground-nesting seabirds, forest birds, and nēnē;
- Introduced reptiles and amphibians, such as coqui frog (*Eleutherodactylus coqui*) and Jackson's chameleons (*Chamaeleo jacksonii*), which prey on native invertebrates and likely compete with native birds for food resources;
- Populations of feral cats and human-facilitated cat colonies kill waterbirds, seabirds, and native invertebrates and present an infectious disease risk for native wildlife across the island;

- Rats, slugs, and other seed and herbivorous pests that kill or harm native plants, especially those species that are rare or at risk of extinction. Erosion and sedimentation from upland habitats that impacts coastal, wetland, and marine ecosystems downstream.
- Development and other forms of degradation to wetlands, coastal flood plains, and coastal dunes in Hawai‘i pose significant threats to coastal water quality.
- Wildfire, particularly for low elevation dry habitats and exacerbated by non-native invasive plants that increase fuel loads;
- Hybridization between koloa maoli and introduced mallards;
- Development of formerly undeveloped areas and increased urbanization leading to loss and degradation of terrestrial, freshwater, and marine habitat (e.g., increased nutrients in coastal areas leads to non-native algal blooms which affect fish populations and coral habitats, sedimentation from development near stream corridors);
- Stream diversions, dams, and channelized flows;
- Insufficient in-stream flows to ensure the biological integrity of many stream systems;
- Localized point-source pollution originating from coastal developments, stormwater discharge, recreational boats, and cruise ships;
- Human disturbance of sensitive ecosystems such as lava tube caves or anchialine pools;
- Localized excessive recreational use at places like ‘Āhihi Kīna‘u Natural Area Reserve, Honolua Bay, and Molokini Shoal; and
- Human and boat interactions with marine mammals and sea turtles along the leeward coasts.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs), additional island-specific strategies for Maui include the following (sub-bullet):

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Complete development and implement the Maui Landscape Conservation Plan to provide implementation-level guidance to enable managers to improve conservation outcomes for species and ecosystems at risk, to include:
        - Identification of species at risk
        - Spatial framework of recovery areas based on suitable habitat and recovery targets
        - Systematic guidance for cost effective recovery actions based on species groups and areas
        - Comprehensive guidance for management and restoration of ecosystems sufficient to stabilize and conserve biodiversity
        - Monitoring and adaptive management
    - Develop, revise, and update applicable planning documents, including endangered species recovery plans and reserve management plans.
    - Continue and build on existing conservation management and implement future needs as identified below in the Management Needs section;
    - Implement conservation actions identified in the Potential Areas for Enhanced Conservation Management subsection;

- Continue development and updates to inventory of lands in need of conservation protections and management to be used to prioritize acquisition of lands through purchase, donation, and set aside, to be designated as conservation reserves to support the goals of this SWAP.
- Prevent extinctions of at-risk plants, invertebrates, and birds through mitigation of priority threats;
- Continue captive propagation of kiwikiu and imperiled land snails;
- Continue collection and nursery propagation of imperiled plant species at risk of extinction;
- Continue identification, development and implementation of mosquito control techniques for native bird conservation and apply mosquito control to native forest bird habitats;
- Protect remaining intact native forest, wetland habitat, and coastal areas from development through a combination of acquisition, conservation easements, or cooperative agreements with landowners;
- Develop community wildfire prevention plans, implement fire suppression measures, and ensure that adequate protocols are in place to guide post-fire restoration;
- Reduce ungulate populations and increase the total acreage of ungulate-free and predator-free areas inside existing fenced management areas;
- Implement the Maui Axis Deer Action plan to establish and achieve spatially explicit population targets for axis deer on Maui;
- Decrease the number of stream diversions and channelized streams;
- Work with Commission on Water Resource Management to ensure net increase in the number of streams that meet biological integrity and Instream Flow Standards sufficient to sustain viable native fish and invertebrate populations in accordance with EPA and Department of Health (DOH) water quality criteria;
- Protect remaining anchialine pools and ponds, lava tubes, and cave habitats, and developing partnerships to protect these resources on private lands;
- Collaborate in efforts to reduce point-source pollution threats from recreational boats and cruise ships;
- Continue to support ongoing projects and develop new partnerships that address non-point source pollution like water quality monitoring at Honolua Bay and elsewhere and encourage expansion of successful survey methodologies to other areas; and
- Develop management plans for all marine resource managed areas.
- Protect existing wetlands, and look to expand on these areas when possible, while identifying and restoring degraded wetlands and other natural coastal ecosystems.

2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Improve prevention capacity through increased biosecurity and screening programs that include advanced training and can be implemented at airport and ocean port facility inspection sites, and which include containment barriers at cargo receiving and unloading areas; regularly review procedures to enable insufficiencies to be identified and timely improvements to be implemented;

- Improve early detection and rapid response capacity for high-risk species that might circumvent biosecurity networks and are not yet established in Hawai‘i (e.g., brown tree snake, West Nile virus, Argentine fire ant) or that may be present in the Main Hawaiian Islands but are not yet established on Maui, yet pose a severe threat;
- Continue to support increased efforts to combat the spread and limit further establishment of high-priority invasive plants (e.g., *Miconia*) into pristine areas and to eradicate these species from areas with substantial native species recovery potential;
- Continue to facilitate and fund efforts of the Maui Axis Deer Committee and assist partnership organizations to address the need to manage populations of axis deer through fencing projects, managed hunting, and other control measures;
- Significantly expand control of mammalian predators (e.g., feral cats, rats) in and around waterbird and seabird habitat;
- Continue to implement actions that will reduce the number of streams negatively impacted by invasive species; and
- Support efforts to strengthen marine alien species prevention and control.

3) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
   - Continue to support improvements in the development of standardized methodologies and procedures for assessing populations, status and condition, threats, and conservations needs of native species;
   - Improve the dissemination of research and management information concerning Hawai‘i’s natural resources;
   - Conduct increasingly systematic surveys and inventories for invertebrates in currently managed and unmanaged areas;
   - Assess the impact of eco-tourism activities on native terrestrial, aquatic, and marine wildlife and habitats;
   - Expand surveys to monitor population status and trends of under-researched species groups such as montane seabirds, pueo, ‘ōpe‘ape‘a, and Blackburn’s sphinx moth, Maui *Partulinid* species, and other native invertebrates, and identify conservation needs;
   - Identify additional areas in which it is feasible to construct predator-proof fences to protect breeding seabirds such as ‘ua‘u and ‘a‘o, and where social attraction and nest site provisioning can be used to gradually establish new nesting colonies free from depredation by rats, mongooses, and feral cats;
   - Develop an island-wide programmatic habitat conservation plan (HCP) for nēnē to resolve conflicts with agricultural producers and property owners in developed rural and urban areas where nēnē may be increasing in numbers, to minimize and mitigate impacts on the species and speed its recovery;
   - Survey native wildlife community in koa-dominated forests in East Maui; and
   - Research the ecological role of alien bird (cattle egret and barn owl) predation and identify and implement practicable control strategies.

4) Strengthen existing and create new partnerships and cooperative efforts.
    - Encourage additional landowner participation and involvement in East Maui Watershed Partnership, West Maui Mountains Watershed Partnership, and Leeward Haleakalā Watershed Restoration Partnership;
    - Work with communities to address conservation threats and needs and develop appropriate actions;
    - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and identify areas where ungulate populations can be managed to provide for continued hunting opportunities;
    - Collaborate in efforts to reduce pollution and other threats from recreational and commercial boats and cruise ships; and
    - Continue to collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations.
    - Expand Ridge to Reef watershed management efforts and partnerships into the Olowalu/Ukumehame and the North Kihei watersheds to help reduce land-based sources of pollution into nearshore coastal waters.
5) Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i.
    - Maintain existing outreach and educational programs at managed conservation areas;
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive species and habitat areas; and
    - Expand and broaden public education and outreach to take advantage of the large science and management community on Maui.
6) Support policy changes aimed at improving and protecting native species and habitats.
    - Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
    - Assess ways to support increased enforcement capacities, including the use of new technologies and increased interagency enforcement capacity;
    - Support development of community-based marine managed areas and develop rules for community-based subsistence fishing areas as these partnerships develop;
    - Evaluate all current marine managed areas for purpose and management effectiveness and consider the need for new marine managed areas;
    - Improve integration of policies to address linkages between terrestrial and marine habitats and their shared conservation threats and needs;
    - Develop more marine managed areas to help promote coral reef resiliency; and
    - Improve coordination of policies and programs to meet the needs of native wildlife conservation but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section, and include the following:

- Maui Nui Landscape Conservation Plan (in prep.)
- Species conservation and draft and final recovery plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose* (2004), the *Revised Recovery Plan for Hawaiian Forest Birds* (2006), the *Draft Recovery Plan for the Blackburn's Sphinx Moth* (2003), the *Hawaiian Endangered Bird Partnership for Captive Propagation Five Year Workplan* (2002), the *Revised Recovery Plan for Hawaiian Waterbirds* (2011), and the *Recovery Plan for the Hawaiian Hoary Bat* (1998); *Maui Nui plants* (1997, 21 taxa), *Multi-island plants* (1999, 26 taxa) and *Addendum* (2002, + 10 spp.), *Hawaiian Ferns* (1998, 4 taxa), *Kokia cookei* (1998), *Gardenia brighamii* (1993), *Phyllostegia hispida* (2013), *Chamaesyce sp*. (draft), *Gouania hillebrandii* (1993); each of these management plans must be revised and updated or new, updated versions that address advancements and current knowledge need to be drafted to guide recovery initiatives;
- Management plans for state Natural Area Reserves (NARs): ʻAhihi-Kīnaʻu NAR (2012), Kanaio NAR (1993), West Maui NAR (1988), and Hanawī NAR (1989); Na Kula (2015).
- Management plans for state Forest Reserves (FR): Kamehamenui FR (in prep), Kipahulu FR (2023), Kahikinui FR (2021), Kula FR (2017), Waihou Spring FR (2010);
- Management plans for state Wildlife Sanctuaries.
- Management plans for partner reserves, including National Park Service, US Fish and Wildlife Service, and Hawaii Land Trust
- Maui Axis Deer Action Plan (in prep.) Critical habitat designations by USFWS for the Blackburn's sphinx moth and for ecosystems on Maui (2016);
- HCPs and Safe Harbor Agreements (SHAs): Renewable energy programs like Kaheawa Wind Power (Phase I and II, West Maui) and Auwahi Wind (East Maui) HCPs that contain provisions designed to promote a net conservation benefit for affected species listed under the Endangered Species Act (ESA) (e.g., ʻuaʻu , ʻaʻo , ʻōpeʻapeʻa , nēnē , and Blackburn's sphinx moth); SHAs have been used to incentivize and protect private landowners who are willing to engage in conservation actions that provide recovery benefits for ESA-listed species, providing needed opportunities that might not otherwise be available to facilitate recovery-related actions. Haleakalā Ranch and Piʻiholo Ranch work with the Department of Land and Natural Resources (DLNR) and other partners to provide suitable environmental conditions and habitat to facilitate nēnē population reintroduction on Maui.
- ʻUaʻu monitoring protocol for Hawaiʻi and Maui (2015);
- Long-range management plans for Natural Area Partnership Preserves (NAPPs): Kapunakea NAPP (Maui), Waiakamoi NAPP (Maui), Puʻu Kukui NAPP (Maui), Kānepuʻu NAPP (Lānaʻi), Pelekunu NAPP (Molokaʻi), Kamakou NAPP (Molokaʻi), Moʻomomi NAPP (Molokaʻi), and Kaʻū NAPP (Hawaiʻi);
- DOFAW's Draft Management Guidelines, which coarsely rate vegetation quality and provide guidelines for land use (public hunting, recreation, and forest products) for state lands managed by DOFAW;

- The *East Maui Watershed Partnership Management Plan, Mauna Kahalawai Watershed Partnership Management Plan,* and *Leeward Haleakala Watershed Restoration Partnership Management Plan*;
- The Aloha+ Challenge, a statewide initiative that includes a focus on watershed protection, aiming to reverse natural resource loss by increasing freshwater security, protecting watersheds, and managing invasive species, with a target to protect 30% of priority watershed forests by 2030;
- A summary of research and information on individual offshore islands, prepared by the Offshore Island Restoration Committee;
- The *Interim State Strategic Plan for Invasive Species Prevention, Control, Research, and Public Outreach*;
- Coastal Zone Management plans, including *Hawai'i Implementation Plan for Polluted Runoff Control* and *Unified Watershed Assessment*;
- Ongoing initiatives that support *Hawaii's Local Action Strategy to Address Land-based Pollution Threats to Coral Reefs* (first published in 2004);
- Bishop Museum's comprehensive species inventory database;
- The Audubon Society and others maintain Sightings database of bird species observed in Hawai'i;
- D.T. Fleming Arboretum at Pu'u Mahoe is in the process of compiling an electronic database reflecting native dryland forest species and facilitating research and propagation initiatives used to advance conservation of rare plant species in natural habitats; information on these programs can be found at ww.flemingarboretum.org; and
- The Holomua Marine Initiative community driven management plans, which are currently in the drafting process

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following sections address the current management actions and future needs of key habitats and species on Maui. The discussion of future management needs is highlighted within each currently managed area. Many areas on Maui are already under active management or protection through designation as a State NAR, NWR, State Wildlife Sanctuary, National Park, land trusts, and several public-private partnerships in the form of watershed partnerships and NAPPs. Each of these managed areas receives some level of agency or other support, including field teams composed of staff personnel or specific mission-oriented teams conducting species conservation management such as the Maui Invasive Species Committee, the Maui Forest Bird Recovery Project, and the Maui Nui Seabird Recovery Project. Management of most of these areas is guided by existing management plans. These plans strongly emphasize conservation and restoration with a focus on controlling ungulates, predatory small mammals, and invasive alien species (both flora and fauna). Together, these projects and ongoing initiatives have resulted in roughly 50 percent of the island being under some form of conservation management or protection.

Management Areas
The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Maui.

East Maui Watershed Partnership **(100,000 acres), Public-Private Partnership (NPS, DOFAW, The Nature Conservancy [TNC], Hāna Ranch Partners, LLC, East Maui Irrigation, Haleakalā Ranch, County of Maui Department of Water Supply)**

Species: ʻŌpeʻapeʻa, forest birds, pueo, kōlea (*Pluvialis fulva* [Pacific golden plover]), nēnē, ʻuaʻu , kāhuli, and hundreds of endemic terrestrial, aquatic, and semi-aquatic arthropods, and rare plants. Outstanding invertebrates include one of only nine species of flightless flies found worldwide, and several species of rare long-horned beetles.
Habitats: Montane and lowland wet native forest communities containing recovery habitat for more than 100 species at risk.
Current Management: Effective management of more than 50% of the partnership lands with fencing, ungulate control, invasive weed control, threat abatement for species at risk, and education and outreach.
Future Needs: Leverage additional funding opportunities to facilitate expanded management into other native-dominated forests within the partnership boundaries (e.g., Makawao Forest Reserve) and expand monitoring to include stream ecosystems and water quality, consistent with the guidance from the Maui Nui Landscape Conservation Plan. Incorporate new lands acquired from Hanawana to Keanae into the partnership to secure mauka to makai connectivity under effective management.

Haleakalā National Park **(33,465 acres), NPS**

Species: Highly significant for ʻuaʻu, nēnē, and invertebrates. Forest birds, ʻōpeʻapeʻa, rare plants.
Habitats: Alpine xeric communities, subalpine communities, montane communities, lowland communities, subterranean communities, coastal habitats.
Current Management: NPS staff implements surveys of threatened and endangered native and rare plants; predator, ungulate, and alien vegetation control and removal; fencing; vegetation sampling transects; surveys of threatened and endangered species; and nesting habitat protection and monitoring for nēnē and ʻuaʻu. Periodic surveys and inventories for ʻōpeʻapeʻa.
Future Needs: Continue to secure monitoring and management resources for seabirds, ʻōpeʻapeʻa, terrestrial invertebrates, vegetation, effects of land use changes in and adjacent to the park, invasive species, and water quality monitoring.

Hanawī NAR **(7,500 acres), DOFAW**

Species: Supports one of the highest number and densities of endangered forest birds in Hawaiʻi. Core populations of poʻouli, Maui ʻākepa, kiwikiu, ʻākohekohe, and Maui nuku puʻu. Other forest birds, pueo, native invertebrates, rare plants and land snails.
Habitats: Subalpine communities, montane wet communities, perennial streams.
Current Management:
Effective management of most of the reserve with fencing, ungulate control, invasive weed control, threat abatement for species at risk, and education and outreach.

Future Needs: Continue and, as necessary, intensify predator control. Continue existing management and develop new conservation strategies, as this area is critical for native forest birds.

Waiakamoi Preserve **(5,230 acres), TNC**

Species: ʻŌpeʻapeʻa, nēnē, forest birds, native invertebrates, rare plants.
Habitats: Montane wet communities.
Current Management: Ungulate control, invasive plant species control and eradication, research and monitoring, outreach.
Future Needs: Continue existing management and explore innovative management strategies; encourage research.

Leeward Haleakalā Watershed Restoration Partnership **(43,175 acres), Public-Private Partnership (DOFAW, Department of Hawaiian Home Lands [DHHL], NPS, James Campbell, Haleakalā Ranch, Kaʻonoʻulu Ranch, Kaupō Ranch, ʻUlupalakua Ranch, Nuʻu Mauka Ranch, Living Indigenous Forest Ecosystems (LIFE), individual private landowners, Hawaiʻi Community Foundation, Trust for Public Land [TPL], U.S. Forest Service, U.S. Geological Survey, USFWS, Natural Resources Conservation Service, County of Maui Department of Water Supply)**

Species: ʻŌpeʻapeʻa, forest birds, possibly ʻuaʻu, terrestrial invertebrates including Blackburn's sphinx moth, rare plants.
Habitats: Montane mesic communities, montane dry communities. Priority recovery habitat for endangered forest birds.
Current Management: Effective management of more than 30% of the partnership lands with fencing, ungulate control, invasive weed control, threat abatement for species at risk, and education and outreach. Management plan includes resource management from Makawao Forest Reserve to Kaupō above 1,067 meters (3,500 feet), including directed monitoring, extensive fencing, ungulate removal, testing of new methods, expanded use of geospatial database, koa reforestation. Related projects include successful fencing of Kahikinui Forest Reserve (DOFAW) and adjacent DHHL lands to facilitate large-scale restoration initiatives in the Kahikinui wilderness.
Future Needs: Develop and implement long-term partnership management plan for reforestation and restoration initiatives at Kahikinui. Continue long-range fencing projects. Expand management into other areas within the partnership boundaries (e.g., Kula Forest Reserve) and develop new and diverse funding opportunities consistent with the guidance from the Maui Nui Landscape Conservation Plan.

Kanaio NAR **(876 acres), DOFAW**

Species: ʻŌpeʻapeʻa, pueo, kōlea, nēnē, ʻuaʻu, terrestrial invertebrates including Blackburn's sphinx moth, nalo meli maoli, endemic *Odynerus* and *Ectemnius* wasps, potentially cave invertebrates, rare plants.
Habitats: Lowland dry communities. Significant remaining tract of dryland forest and shrubland.
Current Management: Fencing, invasive plant removal, ungulate control, native plant community enhancement.

Future Needs: Improve control of invasive species and restoration of biodiversity within the reserve. Continue to evaluate the addition of adjacent unencumbered land to the NAR, complete proposed boundary fencing of upper section.

West Maui Mountains Watershed Partnership **(52,940 acres), Public-Private Partnership (DOFAW, TNC, Maui Land and Pineapple, Inc., Amfac, Kahoma Land, Kamehameha Schools, Makila Land, County of Maui Department of Water Supply)**

Species: ʻŌpeʻapeʻa, forest birds, pueo, nēnē, koloa maoli, ʻuaʻu, ʻaʻo, terrestrial invertebrates including Blackburn's sphinx moth, pinapinao (*Megalagrion* spp. [damselflies]), and rare kāhuli (A*chatinellia* spp.), freshwater fishes, freshwater invertebrates, rare plants.

Habitats: Montane wet communities, lowland wet communities, lowland mesic communities, stream ecosystems.

Current Management: Long-range management plan exists. Fencing, ungulate and predator control, reduction of invasive alien weeds. The Hawaiʻi Unified Watershed Assessment proposed the West Maui Mountains as a Tier 1 Watershed complex in Need of Restoration under the Clean Water Act. Effective management of more than 50% of the partnership lands with fencing, ungulate control, invasive weed control, threat abatement for species at risk, and education and outreach. ***Future Needs***: Secure funding to continue implementing management plan, expand active management and fencing to protect additional high-quality native forests within the partnership boundaries (e.g., West Maui Forest Reserve), seek additional funding to continue non-point source water quality monitoring initiatives. Complete the full deer fence around the entire perimeter of partnership lands. Incorporate new lands acquired at lower elevations into the partnership to improve management opportunities for mauka to makai connectivity. Expand management of species at risk consistent with the Maui Nui Landscape Conservation Plan. Implement the Maui Axis Deer Action Plan for zero tolerance in all partnership lands.

West Maui NARS **(6,702 acres—Three Distinct Sections), DOFAW**

Species: Forest birds, ʻuaʻu, ʻaʻo, nēnē, migratory birds, terrestrial invertebrates including rare kāhuli, freshwater fishes, freshwater invertebrates, rare plants.

Habitats: Montane wet communities, perennial streams.

Current Management: Fencing, ungulate control, resource monitoring, non-native invasive plant control, public education, and volunteer recruitment.

Future Needs: Maintain and broaden existing management and encourage research.

Maui Forest Reserves**, DOFAW**

Species: Forest birds, ʻuaʻu, ʻaʻo, nēnē, migratory birds, terrestrial invertebrates including rare kāhuli, freshwater fishes, freshwater invertebrates, rare land snails and plants.

Habitats: Montane, lowland, wet, mesic, dry, subapline communities, perennial streams.

Current Management: Fencing, ungulate control, resource monitoring, non-native invasive plant control, public education, and volunteer recruitment.

Future Needs: Maintain and broaden existing management and encourage research.

Puʻu Kukui Preserve **(8,661 acres), Maui Land and Pineapple, Inc.**

Species: ʻŌpeʻapeʻa, forest birds, pueo, nēnē, migratory birds, seabirds, terrestrial invertebrates including rare kāhuli, freshwater fishes, freshwater invertebrates, rare plants.
Habitats: Montane wet communities, lowland wet communities, lowland mesic communities.
Current Management: Long-range management plan in place. Fencing, ungulate removal, small mammal and non-native invertebrate control, weed control and monitoring, rare species protection.
Future Needs: Maintain and broaden existing management activities as warranted.

Kapunakea Preserve **(13,000 acres), TNC**

Species: Forest birds, pueo, seabirds, terrestrial invertebrates including rare kāhuli.
Habitats: Montane wet communities, lowland mesic communities, lowland dry communities.
Current Management: Management plan exists. Ungulate control, invasive plant control, small mammal control, resource monitoring, community outreach, rare species protection, and research.
Future Needs: Continue existing management.

Kahikinui Forest Restoration Project, **DOFAW and DHHL**

Species: Native plants and forest resources, ʻōpeʻapeʻa, forest birds, pueo, nēnē, migratory birds, seabirds.
Habitats: Mid-elevation dry and semi-mesic forest.
Current Management: Fencing to exclude ungulates, ungulate removal, trapping to remove mammalian predators of ground-nesting birds and forest birds, monitoring to characterize baseline resource levels and occupancy, invasive plant removal and control, outplanting of native plant species and reforestation.
Future Needs: Leverage additional funding to fully implement restoration and continued monitoring initiatives, encourage research and test innovative conservation strategies, disseminate data and information to better inform the success of management actions.

Kanahā Wildlife Sanctuary **(235 acres), DOFAW**

Species: Seabirds, waterbirds, migratory birds, terrestrial invertebrates.
Habitats: Lowland wetland community including saline wetlands.
Current Management: Habitat restoration through invasive weed removal, predator control, surveys and monitoring, identification of new threats.
Future Needs: Continue existing management, maintain perimeter predator-proof fencing, and eradicate and control predators within the sanctuary.

Old Waiheʻe Dairy **(277 acres), Maui Coastal Land Trust**

Species: Migratory birds, terrestrial invertebrates.
Habitats: Coastal biological communities.
Current Management: Developing a site management plan.
Future Needs: Begin implementation of the management plan, review and revise as necessary.

Mūʻolea Point **(70 acres), Trust for Public Land**

Species: Seabirds, migratory birds, invertebrates, marine fauna, raptors.
Habitats: Coastal biological communities.
Current Management: Recent acquisition for permanent protection of natural and cultural resources.
Future Needs: Develop and implement a management plan.

Keālia National Wildlife Refuge **(700 acres), USFWS**
Species: Waterbirds, migratory birds, hawksbill sea turtles.
Habitats: Coastal biological communities, including saline and managed wetland habitat.
Current Management: Dune restoration, environmental education, fence maintenance as a barrier to turtle movement beyond beach berm in the direction of North Kīhei Road, turtle nest monitoring, protection from predators and human disturbance, facilitated hatchling emergence.
Future Needs: Continue existing management, expand community outreach, and engage beach users concerning dune restoration measures and sensitive wildlife resources.

Maluaka and Paniaka Wetlands**, State Parks**
Species**:** Endangered waterbirds, migratory birds.
Habitats: Coastal biological communities.
Current Management: Continue fence installation and maintenance at Maluaka; wetland is being fenced to control and manage predators and enhance native revegetation and invasive alien plant removal.
Future Needs: Develop and implement a management plan that includes fencing the Paniaka wetland and ponds to protect and enhance waterbird productivity and native vegetation communities; continue collaboration with State Parks Division on species management and support of DOFAW's annual waterbird counts and breeding season monitoring of waterbirds.

ʻĀhihi Kīnaʻu NAR **(2,045 acres, including marine), DOFAW**
Species: Migratory birds, waterbirds, terrestrial invertebrates, anchialine pool and pond fauna, marine mammals, marine fishes, marine invertebrates.
Habitats: Coastal biological communities, marine and terrestrial systems; includes unusual communities associated with recent lava flows, including anchialine pools, subterranean lava tubes, and aeolian systems on the surface of the flows.
Current Management: Resource monitoring (particularly for any illegal activities), public outreach and education, and natural, historical, and cultural resource interpretation; post signs; ensure adequate protection of restricted areas; and manage public visitation to minimize overuse. The makai section is fenced and ungulate free, which contains all the anchialine pools. No take of terrestrial or marine resources.
Future Needs: Continue management of human activity, monitoring, education, and outreach. Develop partnerships to manage stormwater impacts on surface features and coastal resources.
State Wildlife Sanctuaries **(Eight Offshore Islands), DOFAW**
Species: Seabirds, migratory birds, native plants.
Habitats: Coastal biological communities.
Current Management: Removal of small mammalian predators, restoration of native vegetation and habitat.

Future Needs: Increase surveys and monitoring, disseminate findings and benefits of restorative actions to the public, encourage research opportunities.

Two Marine Life Conservation Districts (MLCDs), **Division of Aquatic Resources (DAR): Honolua-Mokulēʻia, Molokini Shoal**

Species: Species associated with shallow and offshore coral reef ecosystems, sandy beach, and rocky habitats. ʻĪlioholoikauaua, honu, naiʻa (*Stenella longirostris* [spinner dolphins]) and other cetaceans.
***Habitats*:** Marine ecosystems.
***Current Management*:** Limited access in most MLCDs, education and outreach, monitoring, information dissemination.
***Future Needs*:** Evaluate MLCDs for purpose and management effectiveness and consider the need for new or expanded marine managed areas.

Three Fishery Management Areas (FMA), **DAR: Kahului Harbor, Kīpahulu Community-Based Subsistence Fishing Area, and Kahekili Herbivore Fisheries Management Area**

Species: Some or all regulated fish species.
***Habitats*:** Marine and estuary ecosystems.
***Current Management*:** Limited take, gear, size, season, and/or area restrictions.
***Future Needs*:** Evaluate purpose and management effectiveness and consider need for new marine managed areas.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), Co-Managed by NOAA and DLNR**

***Species*:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Maui, which serves as critical habitat for humpback whales.
***Current Management*:** Humpback whale 91-meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Species Conservation Management

The following projects and programs include state, federal, university, and private cooperative management efforts to address specific conservation needs of SGCN on Maui and often involve island-wide research and management that extend across boundaries and jurisdictions.

DOFAW Maui Branch, **DOFAW and Conservation Partners Maui Nui wide**

Species: All species at risk, including birds, plants, and invertebrates.
Habitats: All habitats and ecosystems.
Current Management: Twenty focal management units that support the largest numbers of the most vulnerable species, including more than 100 species of birds, plants, and

invertebrates. Inventory and monitoring, threat abatement for feral ungulates, weeds, predators, and pests, construction of predator-proof exclosures.
Future Needs: Expand to the full MNLCP network of sites for recovery of all 416 species at risk.

***Plant Extinction Prevention Program*, USFWS, DOFAW, University of Hawai‘i**
Species/Habitats: Plant species at risk of extinction.
Current Management: Inventory and monitoring, collection and propagation, research, threat abatement for feral ungulates, weeds, predators, and pests, construction of predator-proof exclosures.
Future Needs: Expand to the implement the full MNLCP network of sites for recovery of all 197 plant species at risk.

***Snail Extinction Prevention Program*, USFWS, DOFAW, University of Hawai‘i**
Species/Habitats: Snail species at risk of extinction.
Current Management: Inventory and monitoring, collection and propagation, research, construction of 20 predator-proof exclosures, threat abatement for feral ungulates, weeds, predators, and pests.
Future Needs: Expand to the implement the full MNLCP network of exclosures for recovery of all snail species at risk.

***Maui Invasive Species Committee*, Public-Private Partnership**
Species/Habitats: All species and habitats affected by invasive species.
Current Management: Invasive species prevention, response, and control.
Future Needs: Continue to increase invasive plant and animal prevention capacity, develop and improve detection and rapid response capacity, garner additional resources to address established and future threats to native habitats.

***Maui Forest Bird Recovery Project*, USFWS, DOFAW, University of Hawai‘i**
Species/Habitats: Endemic forest birds, particularly endangered and critically endangered species and their habitats.
Current Management: Research and conservation management, implementation of the *Draft Revised Recovery Plan for Hawaiian Forest Birds*, development and implementation of five-year implementation and management plans.
Future Needs: Leverage adequate funding to revise and implement recovery and management plans.

***Maui Nui Seabird Recovery Project,* DOFAW and University of Hawai‘i**
Species: Seabirds.
Habitats: Montane and coastal nesting habitats.
Current Management: Monitoring of colonies, identification of threats, control of predators, and facilitation of research.
Future Needs: Leverage adequate funding, develop new partnerships with public and private stakeholder groups to advance conservation initiatives.

Makamakaʻole Seabird Mitigation Preserve, West Maui, **SunEdison (Kaheawa Wind Energy Habitat Conservation Plan)**

Species: Seabirds (ʻuaʻu and ʻaʻo)

Basis for Priority Designation: Project feasibility and ability to conduct monitoring, remnant and declining populations of both seabird species and direct link to heavy predation pressure, research and population modeling suggest significant conservation value can be achieved.

Existing Conservation Actions: Two predator exclusion fences, artificial nesting burrows, social attraction, predator abatement, monitoring; implemented in 2014 and first ʻuaʻu and ʻaʻo arrive within the management site in 2015.

Potential Areas for Enhanced Conservation Management

In addition to maintaining and enhancing existing conservation and management actions, additional efforts are needed for the long-term conservation of Maui's native wildlife. The following section identifies areas where enhanced conservation management would significantly benefit native species or their habitats (previously identified areas of the Makawao Forest Reserve and Kanaio can be found under the future needs discussion in the management needs section). Areas are discussed in habitat order from the mountains to the sea.

Kīpahulu Forest Reserve (upper portion above 3,500 feet between Kaupō Gap and Kīpahulu Valley)**, DOFAW**

Species: Forest birds, nēnē, invertebrates, rare plants.

Basis for Priority Designation**:** Remnant native forests still intact, but high densities of feral goats are rapidly destroying the understory, clearing their way into wet forests. Habitats include, from west to east, drier koa-dominated into wet ʻōhiʻa-dominated. Mesic koa forest is increasingly rare on Maui.

Potential Conservation Actions: Fence the most intact areas, remove feral goats, and develop Game Management Areas or public hunting access (currently no public hunting access allowed) through adjacent landowners (e.g., the national park Kaupō trail).

Dryland habitats **(leeward Haleakalā down to coast of southern Maui)**

Species: Wiliwili (*Erythrina sandwichensis)* forests, koa forests, diverse dryland forests, terrestrial invertebrates, rare plants.

Basis for Priority Designation: Low-elevation dryland forest is highly imperiled and significantly reduced from historical range. Tracts of native wiliwili groves remain primarily in undeveloped private parcels in the coastal areas of Mākena and the ahupuaʻa of Maluaka, Kaʻeo, Papaʻanui, Waipao, and Keauhou. Remnant diverse dryland forest remains in the Auwahi area. Threatened by the potential for development. *Erythrina* gall wasp is identified as a significant threat. Wiliwili is a keystone species in native dryland forest and is host to several species of native terrestrial invertebrates, while in general, the dryland forest hosts many rare plant species.

Potential Conservation Actions: Fence intact tracts of dryland forest, remove deer and goats and invasive plants, suppress fires, outplant native species, conduct community outreach and public education, and preserve cultural and historical artifacts.

***Wetland habitats (*Kīhei Coast, Ukumehame, North Shore, Cape Hanamanioa, Nu‘u, Pauwalu Point, Ke‘anae Peninsula, East Maui stream, lo‘i)**

***Species*:** Waterbirds, migratory birds, native plants.

***Basis for Priority Designation*:** These areas have been identified by USFWS and the Pacific Coast Joint Venture as areas particularly suitable for waterbird conservation and recovery.

Potential Conservation Actions: Control small mammal predators and invasive species; where private lands occur, support voluntary and incentive-based programs for increased conservation.

Coastal Areas on State Lands in the north and northwest portions of West Maui; other intact coastal areas (South, East Maui)

***Species*:** Wetland birds, migratory shorebirds and waterfowl, seabirds, native invertebrates, native plants.

***Basis for Priority Designation*:** Hawai‘i has few remaining intact native coastal vegetation areas; these areas generally comprise diverse coastal vegetation communities. However, these communities are threatened by destructive ungulates (mostly cattle and axis deer).

Potential Conservation Actions: Identify the most intact areas and assess suitability for appropriate conservation measures, including fencing, removal and control of ungulates, and designation as special coastal conservation areas.

***Kanahā Beach,* Maui County**

***Species*:** Native invertebrates, seabirds, native plants.

***Basis for Priority Designation*:** An area that is rich with native plants and native invertebrates, but is faced with immediate threats by human activities such as off-road vehicles. Existing actions that have benefited ecological function include removal of invasive plants, restoration and replanting of native plants, public education, and construction of a vehicle barrier to protect sensitive habitat. This area has the potential to serve as a public education and stewardship model where measures to protect and restore coastal areas can be demonstrated and incorporated into broader programmatic community outreach strategies.

Potential Conservation Actions: Continue existing management activities and significantly increase outreach and public opportunities for hands-on volunteer stewardship experiences.

Anchialine Pond Habitat

***Species*:** Anchialine shrimp, endemic anchialine amphipods (*Grandidierella palama, Paramoera rua, Rotomelita ana*).

***Basis for Priority Designation*:** Anchialine pool habitats are experiencing degradation as a result of invasive species and human disturbance, leading to decreasing populations of anchialine species and significant, possibly irreversible ecological alteration.

Potential Conservation Actions: Prevent introduction of non-native fish (tilapia), manage human disturbance, and develop and implement effective and ongoing education and outreach.

References:

Duvall, F. Wildlife Biologist, Division of Forestry and Wildlife. Personal communication. 2005.

East Maui Watershed Partnership. 2004. Draft environmental assessment: East Maui Watershed Partnership fence extensions in the East Maui Watershed.

Groombrigde JJ, Massey JG, Bruch JC, Malcolm T, Brosius CN, Okada MM, Sparklin B, Fretz JS, and VanderWerf, EA. 2004. An attempt to recover the Po‘ouli by translocation and an appraisal of recovery strategy for bird species of extreme rarity. Biological Conservation 118(3):365-375.

Haleakalā National Park. Annual performance plan fiscal year 2004. National Park Service, 2004. Available at: http://www.nps.gov/hale/pphtml/documents.html (accessed 24 March 2005).

Hawaii's Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Business, Economic Development, & Tourism, Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed 13 May 2024.

Hawai‘i Department of Health, Hawai'i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai'i.gov/DBEDT/index.cfm?section=READ_Databook1075. (accessed 28 March 2005).

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2005. Hawai‘i GAP Analysis. Personal communication.

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Howarth FG. 2002. An assessment of the conservation status of the terrestrial cave fauna occurring on the Islands of Maui and Moloka‘i, Hawai‘i. Honolulu, (HI): U.S. Fish and Wildlife Service, Pacific Islands Office.

Hu, D, GE Ackerman, CSN Bailey, DC Duffy, and DC Schneider. 2015. Hawaiian Petrel Monitoring Protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR–2015/993. National Park Service, Fort Collins, Colorado.

Kealia Pond National Wildlife Refuge. Available at: http://www.fws.gov/pacific/pacificislands/wnwr/mkealianwr.html (accessed 24 March 2005).

Leeward Haleakalā Watershed Restoration Partnership. 2004. Restoration of hardwood watershed koa (*Acacia koa* gray) forests for enhancement of economic, cultural, and biological resources on leeward Haleakalā Volcano, Hawai‘i.

Loomis I. 2005. Saving Maui: Maui taxpayers are fighting off development by buying land for conservation. Honolulu Magazine, January 24.

Loope LL. Status and trends of the nation’s biological resources: Hawai‘i and the Pacific Ocean. U.S. Geological Survey. Available at: http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed 7 December 2004).

Maui Land and Pineapple Company, Ltd. 1999. Pu‘u Kukui Watershed Management Area: Fiscal year 1999 Progress Report. Department of Land and Natural Resources: Natural Area Partnership Program.

Medeiros AC, Loope LL, Chimera CG. Kanaio Natural Area Reserve biological inventory and management recommendations. Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources, March 1993. http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife. 1992. ‘Ahihi -Kinau Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. 1989. Hanawī Natural Area Reserve management plan. Hawai’i Department of Land and Natural Resources.

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. 2003. Final environmental assessment: natural resources conservation project, Kanaio Natural Reserve. Hawai‘i Department of Land and Natural Resources.

Natural Area Reserves System Program, Division of Forestry and Wildlife. West Maui Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources, December 1988. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Nature Conservancy of Hawai‘i. Hawaiian High Islands Ecoregional Plan.

Nature Conservancy of Hawai‘i. 2003. Kapunakea Preserve: long range management plan fiscal years 2004-2009. Honolulu, Hawai‘i: Department of Land and Natural Resources, 2nd revision. Available at: http://www.state.hi.us/dlnr/dofaw/pubs/LRPKapunakea_rev2.pdf (accessed 24 March 2005).

Nature Conservancy of Hawai‘i. 1999. Waikamoi Preserve: long range management plan fiscal years 2001-2006. Honolulu, (HI): Department of Land and Natural Resources.

Paine JR. 1991. IUCN directory of protected areas in Oceania. Gland: International Union for Conservation of Nature and Natural Resources.

Price JP. 2004. Floristic biogeography of the Hawaiian Islands: influences of area, environment and paleogeography. Journal of Biogeography 31(3):487-500.

Price JP, Wagner WL. 2004. Speciation in Hawaiian angiosperm lineages: cause, consequence, and mode. Evolution 58(10):2185-2200.

Stone CP, Pratt LW. 1994. Hawaii’s plants and animals: biological sketches of Hawai‘i Volcanoes National Park. Honolulu: Hawai‘i Natural History Association.

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai‘i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Census Bureau. 2021. QuickFacts, Maui County, Hawai‘i. Available at: https://www.census.gov/quickfacts/fact/table/mauicountyhawaii/PST045223. Accessed 13 May 2024.

U.S. Fish and Wildlife Service. 2003. Draft recovery plan for the Blackburn’s Sphinx Moth (*Manduca blackburni*). Portland, (OR): U.S. Fish and Wildlife Service. Ix+113 pp.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland, (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn’s Sphinx Moth: final rule. 68 FR 34710. Honolulu, (HI).

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

West Maui Mountains Watershed Partnership. 2001. Final environmental assessment for the West Maui Mountains watershed protection project.

KAHOʻOLAWE

Kahoʻolawe is the smallest of the eight Main Hawaiian Islands. The island was historically inhabited by several hundred Native Hawaiians who farmed and fished for subsistence. Kahoʻolawe also was important as a religious center where the navigators and *kahuna* (priests) responsible for guiding the ocean voyages of early Hawaiians were trained. Consequently, Kahoʻolawe is listed on the National Register for Historical Places, containing 544 archaeological and historical sites with over 2,000 features including some of the largest and oldest heiau (Hawaiian shrines) in Hawaiʻi. After the arrival of Europeans, the island was used as a penal colony, for ranching, and for military training, including extensive bombing practice. These activities resulted in severe ecological degradation, and much of the soil (particularly on the eastern side and along the ridge crests) is exposed and lost to strong, easterly trade winds. Alien-dominated vegetation covers most of the island and includes kiawe (*Prosopis pallida*) forest and buffel grass (*Cenchrus ciliaris*) grasslands. Remaining native habitats include coastal dry shrubland dominated by maʻo (*Gossypium tomentosum* [Hawaiian cotton]), ʻilima (*Sida fallax*), and ʻakiʻaki (*Sporobolus virginicus*), lowland dry grassland, mixed shrub coastal dry cliff, a high salinity anchialine pool, intermittent streams, and ephemeral pools. Nearshore marine resources include substantial coral reefs and intertidal communities. Native wildlife species on the island include the endangered Blackburn's sphinx moth *(Manduca blackburni*), seabirds, and ʻīlioholoikauaua (*Monachus schauinslandi* [Hawaiian monk seal]).

OVERVIEW

Geology and Hydrology

Kahoʻolawe is 11,520 hectares (28,800 acres) in total area, 17.6 kilometers (11 miles) long and 11.2 kilometers (7 miles) wide at its broadest point. The island is gently sloped with a diagonal ridge running across it. Steep sea cliffs mark the southern and eastern coastlines while sloping ridges with bays and beaches characterize the northern and western coasts. The highest point of the island is on the northeast end, at 450 meters (1,477 feet). Approximately 39 percent of the island is below 150 meters (500 feet) in elevation. Kahoʻolawe has two offshore islands. There are no perennial streams.

Climate

Located in Maui's rain shadow, Kahoʻolawe is very dry and arid, receiving no more than 65 centimeters (25 inches) of rain annually with most occurring on the eastern side of the ridge.

Land and Water Use

The U.S. Navy had used Kahoʻolawe for several decades of military bombing exercises which ceased in 1990. The following ten-year Navy clean-up resulted in approximately ten percent subsurface clearance of the island and 69 percent surface clearance of unexploded ordnance from the island. In 2003, management and ownership of the island was officially transferred from the U.S. Navy to the Kahoʻolawe Island Reserve Commission (KIRC), a state agency administratively attached to the Department of Land and Natural Resources (DLNR), for management. The entire island is designated State is under the State Land Use Code.

The island of Kahoʻolawe and the waters two miles from the shoreline are designated as the Kahoʻolawe Island Reserve, owned by the State of Hawaiʻi. KIRC manages Kahoʻolawe in trust for a future Native Hawaiian sovereign entity. Access to the island is restricted due to unexploded ordnance, and commercial use is strictly prohibited. The island is managed and maintained in perpetuity for the following purposes: 1) preservation and practice of all rights customarily and traditionally exercised by the Native Hawaiians for cultural, spiritual, and subsistence purposes; 2) preservation and protection of its archaeological, historical, and environmental resources; 3) rehabilitation, revegetation, habitat restoration, and preservation; and 4) education. Overall activities on the island are guided by the following principles: traditional ecological knowledge, ecosystem succession, strategic restoration, keeping practices in line with the island's geography and natural systems, and integrated research and action.

Human Landscape

Although the island has no permanent residents, barracks provide accommodations for about 50 workers who arrive by boat or are flown in by helicopter for conservation and management activities, and for visitors coming to volunteer for conservation activities or participate in cultural practices.

SPECIES AND HABITATS OF IMPORTANCE

Historically, Kahoʻolawe was home to a range of vegetation communities that included dry forest and shrublands, grasslands, coastal vegetation, and possibly a mesic forest. The 200 years of goat and sheep ranching, unmanaged grazing, and mostly unsustainable historical land and resource use practices followed by decades of military training exercises and bombings, has contributed to over 80 percent of Kahoʻolawe being now represented by barren or hardpan soil and/or alien-dominated vegetation. In addition to the two islets, the western coastal area is the only area where native vegetation remains. Despite this, Kahoʻolawe is still home to 14 rare plants as well as a new species, *Kanaloa kahoolawensi*s, in a new genus. Under the island's management plan, five native terrestrial communities have been identified: ʻAkiʻaki Coastal Dry Grassland, the Hawaiian Mixed Shrub Coastal Dry Cliff, the ʻIlima Coastal Dry Shrubland, the Maʻo Coastal Dry Shrubland, and the Pili Lowland Dry Grassland. Most of the rare plant populations that are known can be found on the southern and eastern sea cliffs.

For wildlife in particular, important areas on the island include coastal areas such as Honokanaiʻa, Kūheia, Lae ʻO Kuikui, Hakioawa, and the uplands. In addition, the U.S. Fish and Wildlife Service (USFWS) has designated 1,701 hectares (4,252 acres) of critical habitat for Blackburn's sphinx moth (*Manduca blackburni*) and 1,180 hectares (2,915 acres) for one native plant, *Kanaloa kahoolawensis*. These critical habitat designations are separate from each other with no spatial overlap. Vegetation within this area consists of mixed-species, mesic and dry grass and shrubland communities with a high percentage of non-native vegetation interspersed with native vegetation. There are also several wetland areas on the island (e.g., Lua Keālialalo, Lua Keālialuna, Lua Makika) that can provide habitat for migratory shorebirds and waterbirds. Kahoʻolawe is also home to two islets, Puʻu koae and ʻAleʻale, both of which provide significant habitats for some nesting seabirds and potential habitat for more rare species such as the ʻuaʻu

(*Pterodroma sandwichensis* [Hawaiian petrel]), ʻakēʻakē (*Oceanodroma castro* [band-rumped storm petrel]), and migratory birds (e.g., kioea (*Numenius tahitiensis* [bristle-thighed curlew]) and contain native shrub coastal dry cliff communities.

Appendix A provides information on the wildlife Species of Greatest Conservation Need present on Kahoʻolawe and its associated offshore islands. KIRC has plans to also reintroduce species such as birds, invertebrates, and potentially reestablish favorable habitat conditions for ʻōpeʻapeʻa (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), andmarine turtles.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats more acute or specific to Kahoʻolawe are listed below. Because Kahoʻolawe has no perennial streams, there are no identified threats specific to freshwater species on Kahoʻolawe.

- Feral cats (*Felis catus*), barn owls (*Tyto alba*), and rodents that prey on ground nesting seabirds;
- Established populations of alien ants, wasps, and parasites that negatively affect native invertebrates and birds;
- Widespread non-native vegetation and soil erosion threaten habitat restoration efforts and may impact nearshore reefs during periods of excessive stormwater discharge (an estimated 1.9 million tons of soil is lost each year);
- Unexploded ordnance that limits the scope of conservation activities;
- Fire that can exacerbate the distribution of alien vegetation and disrupt current native vegetation restoration efforts;
- Marine debris accumulation;
- Sedimentation due to historic grazing and land degradation; and
- Lack of compliance with fishing regulations.

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) , additional island-specific strategies for Kahoʻolawe include the following (bullets):

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in the Management Needs section;
    - Develop, revise, and/or implement recovery plans for threatened and endangered species on Kahoʻolawe;
    - Leverage and secure permanent, long-term funding for KIRC;
    - Eradication of mammalian predators, particularly feral cats and rats, and develop effective control of avian predators (e.g., barn owls, cattle egrets) that can be implemented efficiently on the island;
    - Enhance existing wetlands and anchialine pool ecosystems (e.g., control of alien vegetation and replanting of native species);

    - Reintroduce appropriate native species (e.g., waterbirds, Laysan duck [*Anas laysanensis*], native passerines, seabirds, native invertebrates, ʻōpeʻapeʻa, native plants) and test ecosystem-based approaches to long-term conservation measures;
    - Implement fire suppression measures and protocols for fire management and post-fire restoration; and
    - Increase marine debris removal capacity and collaborate with experts on managing marine debris issues.
2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Improve prevention measures by developing and implementing efficient biosecurity procedures that include screening materials, early detection, and rapid response capacity for high-risk species not yet established in the Hawaiian Islands (e.g., brown tree snake, West Nile virus, Argentine fire ant) or that may be present in the Main Hawaiian Islands but are not yet established on Kahoʻolawe; and
    - Support efforts to strengthen marine alien species prevention and control.
3) Strengthen existing and create new partnerships and cooperative efforts.
    - Support ongoing projects to address non-point source pollution; and
    - Continue to work collaboratively with the Natural Resources Conservation Service (NRCS) and native plant propagation facilities to produce quantities of native plant materials sufficient to support restoration efforts.
4) Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawaiʻi.
    - Maintain existing outreach and educational programs directed at managed conservation areas.
5) Support policy changes aimed at improving and protecting native species and habitats.
    - Evaluate relevant policies and conservation strategies for purpose and management effectiveness and consider modifications or new approaches that will facilitate the success of conservation needs; and
    - Increase enforcement capacity and education and outreach related to KIRC strategic conservation initiatives in the reserve.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section and include the following:

- Specific management plans developed by KIRC, including the *Kahoʻolawe Use Plan* (1995), the *Kahoʻolawe Ocean Management Plan* (1997), the *Kahoʻolawe Environmental Restoration Plan* (1998), and the *Draft Access and Risk Management Plan* (2001);
- Species conservation and draft and final recovery plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Recovery Plan for Blackburn's Sphinx Moth* (2003); and the *Newell's Shearwater and Hawaiian Petrel 5-Year Action Plan* (2011).
- Critical habitat designations by USFWS for the Blackburn's sphinx moth and *Kanaloa kahoolawensis*;

- A summary of research and information on individual offshore islands, prepared by the Offshore Island Restoration Committee;
- Bishop Museum's comprehensive species inventory database; and
- The Audubon Society and others maintain a Sightings database of bird species observed in Hawai‘i.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats on Kaho‘olawe. The discussion of future management needs is highlighted within each current managed area. Unlike other islands (except Ni‘ihau), Kaho‘olawe is managed by one entity, KIRC.

Management Areas

The following state, federal, and private lands are being managed to meet the current and future species and habitat conservation needs of Species of Greatest Conservation Need (SGCNs) on Kaho'olawe.

***Kaho‘olawe Island Reserve* (28,800 terrestrial acres—entire island), KIRC**

Species: Native invertebrates including Blackburn's sphinx moth and koa butterfly (*Udara blackburni*), seabirds, migratory birds.
Habitats: Coastal dry grasslands, dry cliff, dry shrublands, anchialine pool, wetlands.
Current Management: Erosion control, revegetation and habitat restoration with an emphasis on the use of native species such a pili grass (*Heteropogon contortus*), which is used to reduce stormwater flow and revegetate bare areas and swales as a soil conservation and erosion remediation measure, ongoing predator control including the field testing of self-resetting trap technologies.
Future Needs: Continue implementing existing management and develop and test new strategies. Leverage support for adequate funding to implement all aspects of conservation and management and revise future management approaches consistent with the long-term restoration vision for Kaho‘olawe. Continue efforts to develop effective island-wide feral cat and rat eradication including the eventual use of large-scale aerial dispersal of toxicants that will not harm native species.

***Kaho‘olawe Island Reserve* (marine waters out 2 miles from shore), KIRC**

Species: ‘īlioholoikauaua, coral reef organisms, pelagic and bottomfishes, green sea turtles, hawksbill turtles, various sharks (manō) including hammerhead and oceanic white tips along with regular coastal shark species, manta rays, and variuos marine mammals including dolphins (nai‘a) of various species and other whale speices.
***Habitats*:** Marine ecosystems including shallow coral reef, deeper reefs, sandy beach, and rocky habitats.
***Current Management*:** Limited access and take, no commercial activity, monitoring, water quality improvements.
***Future needs*:** Conduct additional monitoring, increase enforcement, and continue support for research.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), Co-Managed by NOAA and DLNR**

Species**:** Humpback whale (*Megaptera novaeangliae*).

Habitats: Marine ecosystems surrounding Kahoʻolawe, which serves as critical habitat for humpback whales.

Current Management**:** Humpback whale 91-meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.

Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

References:

Dames and Moore. July 1997. Kahoʻolawe ocean management plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

Kahoʻolawe Island Reserve Commission. Available at: http://www.state.hi.us/kirc/ (accessed 9 March 2005).

Lindsey GD, et al. 1997. Technical options and recommendations for faunal restoration of Kahoʻolawe. Kahoʻolawe Island Reserve Commission.

PBR Hawaiʻi. December 1995. Kahoʻolawe use plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

Social Science Research Institute at the University of Hawaiʻi at Manoa. 1998. Kahoʻolawe environmental restoration plan. Available at: http://kahoolawe.Hawai'i.gov/restoration/restoration_plan/restoration_plan.htm (accessed 9 March 2005).

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawaiʻi Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn's Sphinx Moth: final rule. 68 FR 34710. Honolulu, (HI)

HAWAIʻI

The island of Hawaiʻi is the largest, highest, and youngest in the Hawaiian Archipelago. It has two mountains over 4,000 meters (13,000 feet), three active volcanoes, and twice the area of all the other islands combined. Hawaiʻi is also climatically diverse: Kawaihae, on the leeward Kohala coast, averages less than 26 centimeters (10 inches) of rain each year, while mid-elevation forests on the windward side of the island receive over 700 centimeters (270 inches) of rain. The highest mountains are usually snow-capped through the winter and are host to a suite of endemic arthropods in an aeolian ecosystem. Lava flows from the active volcanoes isolate patches of forest called kīpuka, leading to genetic divergence between isolated populations, and ultimately, speciation. Young lava flows are colonized quickly and become habitat for specialized arthropod fauna. Lava tubes in older flows host a diverse and unique cave fauna. Wet forests are home to a spectacular radiation of endemic birds as well as many unique invertebrates such as happy-face spiders and carnivorous caterpillars. Most of the original lowland habitat on the island has been transformed by human habitation, and whole suites of bird and snail species have been extirpated and are known only from fossils. In addition, honeycreeper and honeyeater species that were adapted to low-elevation forests have disappeared, both from the loss of forests and the introduction of alien pests and diseases such as avian pox, malaria, and mammalian predators. The extent of the missing native arthropod fauna can only be guessed, but one assumes it is extensive, and that the loss of arthropod pollinators and seed dispersers likely affects forest health in the remaining habitats

Aquatic systems on the windward side are supported by the rain. As one starts at Wailoa in Hilo Town the moves north up the coastline the abundance of stream systems is greater than may other places in Hawaiʻi. These systems support culturally significant species such as ʻoʻopu, hīhīwai, and ʻōpae kuahiwi. Further down stream in the estuaries highly esteemed silver fish such as āholehole, ʻamaʻama, and moi. In the marine environment submerged boulder fields form prime habitat for many targeted species of fish. At the foot of the sea cliffs of this area in the rocky intertidal region locals gather delicacies like ʻopihi, ʻaʻama, and limu.

Aquifer systems on the west side of Hawaiʻi Island, particularly in the Kona region, are primarily supported by rainfall, fog drip, and groundwater recharge through the island's porous volcanic rock. Rainwater infiltrates the ground, replenishing basal aquifers where freshwater floats above denser saltwater. In higher elevations, water is also stored in dike-impounded aquifers, where volcanic dikes trap water. The region's volcanic geology, with its permeable lava flows, allows for efficient groundwater movement and storage, but these aquifers are vulnerable to over-extraction and development pressures

OVERVIEW

Geology and Hydrology

The island of Hawaiʻi comprises five shield volcanoes, all of which are less than a million years old. The youngest three of these (Hualālai, Maunaloa, and Kīlauea) are active; therefore, the landscape includes extensive areas of seemingly barren lava flows. Continuously changing forest boundaries and interesting succession patterns are the result. The two older volcanoes (Maunakea and Kohala) are marked by the cinder cones characteristic of late-stage eruptions,

and by deep, stream-eroded valleys on the windward side. Only 12 percent of the island is below 150 meters (500 feet) in elevation; nearly 70 percent of the island is above 610 meters (2,000 feet) in elevation. The island of Hawai‘i has 132 perennial streams, 70 of which are continuous. Wailuku River has the largest discharge at 250 million gallons per day (mgd). Anchialine ponds, which host a unique fauna of amphipods and shrimp, are found in young, coastal lava fields. Waiākea Pond is a natural freshwater lake that is over 2.3 meters (7 feet) deep and 11 hectares (27 acres) in area, and Lake Waiau, at 4,300 meters (13,020 feet), is the only alpine lake in the state. Hawai‘i has three offshore islets.

In Hawaii County, the distinct hydrology of Maunakea and Maunaloa significantly influences the area's ecology. On Maunakea, the geological structure leads to more surface water flow due to the steeper slopes and presence of clay-rich layers, which act as barriers to water infiltration. This results in surface runoff and thin perched aquifers at higher elevations. Studies in the Humu‘ula Saddle region reveal that water is found closer to the surface on Maunakea, with perched water tables as shallow as 500 feet deep. This creates intermittent streams and contributes to the unique ecosystems at higher elevations

On Maunaloa, the volcanic structure supports greater groundwater flow. The porous lava flows allow water to percolate deeper into the earth, where it collects in extensive basal aquifers. These aquifers feed springs along the shoreline, contributing to freshwater ecosystems near the coast. The groundwater flow from Maunaloa is slower and more diffuse, but it plays a critical role in sustaining coastal springs and wetlands that are important for native species

Climate

Because of its size and elevation range, Hawaii's climate and vegetation communities vary dramatically. Warm trade winds meet the island and leave most of their moisture behind as rain or cloud drip on the windward side. At high elevations and on the Kona side, dry or even arid conditions predominate. Convection-driven onshore breezes on the leeward side create upslope showers most afternoons, resulting in a broad band of mesic forest. The peaks of Maunaloa and Maunakea have permanent frost.

Land and Water Use

Hawai‘i’s 1,042,000 hectares (2,573,400 acres) include 80 percent of the state’s remaining native habitat. About 51 percent of the land is in the State Conservation District, and 47 percent is in the Agricultural District. About 251,000 hectares (678,612,000 acres) are managed by the Division of Forestry and Wildlife (DOFAW), part of the State Department of Land and Natural Resources (DLNR). Over 188,000 hectares (465,000 acres) are managed by federal agencies (three-fourths of this is managed by the National Park Service (NPS) or U.S. Fish and Wildlife Service (USFWS), and about one-fourth by the U.S. Army). Thus, approximately 40 percent of the total land area of the island is under state or federal management. Approximately 42,000 hectares (105,000 acres) of conservation-zoned forest land is under private ownership or management. The largest private landowners on the island are Kamehameha Schools (KS), Parker Ranch Trust, and Yee Hop Ranch. An additional 13 of the state’s 40 largest landowners manage at least some areas that are in the conservation zone and that likely support some native wildlife populations. Seventy-four streams are diverted and four have altered channels. The largest altered stream is Wailoa. The island of Hawai‘i has 17 impaired streams under the U.S.

Environmental Protection Agency's Clean Water Act standards. The Lower Hāmākua Ditch system in Kohala is the largest man-made stream system at 32 mgd.

Human Landscape

In 2020 there were 200,629 residents on the island of Hawai‘i (U.S. Census Bureau 2021). The island's population is centered in Hilo on the windward side and Kailua-Kona on the leeward side, with additional concentrations in Waimea and the Puna region.

Tourism, agriculture, and government services are the main economic drivers. Primary agricultural products on the island include beef, coffee, macadamia nuts, papaya, and tropical flowers. Sugarcane production on Hawai‘i ended in 1996 and many former sugar lands have since been converted to lands for forestry products or for large-lot residential development. Ranching, sugar, and forestry shaped the landscape.

The resident population is supplemented by an average daily visitor population of about 37,701 (by air alone HTA 2022) with more than 80 percent of visitors arriving in Kona. A total of 1.76 million people visited Hawai‘i in 2023 (BEDT 2024). Over 1.6 million people visited the Hawai‘i Volcanoes National Park in 2023 (Ferracane, 2024). About 50,000 visitors each year purchase tours to areas where they encounter at least some native habitat and might see terrestrial wildlife.

SPECIES AND HABITATS OF IMPORTANCE

Major native terrestrial habitat types on the island include wet montane forest, mesic montane forest, subalpine mesic forest and shrubland. Additional but smaller areas support alpine shrubland and alpine desert, dry montane and dry lowland forests, wet lowland forest, coastal forest and coastal shrub and grasslands. Despite this diversity of habitat types, 42 percent of the island is considered "converted" to human use. The U.S. Fish and Wildlife Service (USFWS) has designated critical habitat for palila (*Loxioides bailleui*), ‘i‘iwi (*Drepanis coccinea*), and Blackburn's sphinx moth (*Manduca blackburni*) (about 59,000 hectares or 146,000 acres) with much of it overlapping with critical habitat for 41 endangered plant species (84,000 hectares or 208,000 acres) and for two endangered and one threatened

Marine and freshwater habitats include coral reefs, submerged boulder fields, wetlands, streams, tidepools, estuaries, rocky intertidal, and anchialine pools. The designated critical habitat for marine and freshwater species on Hawaii Island includes areas essential for species like the Hawaiian monk seal, anchialine pool shrimp, and certain freshwater fish. These habitats are vital for breeding, feeding, and shelter, and aim to protect coral reefs, shorelines, and wetlands essential for species recovery. The critical habitat areas cover various coastal and nearshore environments, as well as inland anchialine pools, which are unique brackish water ecosystems. Eighty percent of the known worldwide anchialine pools are on Hawai‘i.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on the island of Hawai‘i. The island of Hawai‘i supports a great number of endemic species, including forest birds (palila, ‘akiapōlā‘au (*Hemignathus munroi*), ‘ōma‘o (*Myadestes obscurus* [Hawai‘i thrush], and Hawai‘i ‘ākepa (*Loxops coccineus*) and terrestrial invertebrates, including several species of land snails (*Partulina physa* and *Auricullela armata*), the wekiu bug

(*Nysius wekiuicola*), and bees (*Hylaeus spp*). Because of its size and the loss of habitat on other islands, Hawai‘i also provides abundant habitat for species such as the ‘io (*Buteo solitarius* [Hawaiian hawk]), ‘i‘iwi , nēnē (*Branta sandvicensis* [Hawaiian goose]), and anchialine pond fauna, such as anchialine pool shrimp *(Halocaridina rubra)*. Other federally listed species include the ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), ‘alae ke‘oke‘o (*Fulica alai* [Hawaiian coot]), ae‘o (*Himantopus mexicanus knudseni* [Hawaiian stilt]), and koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]), Blackburn’s sphinx moth, and sea turtles. For terrestrial invertebrates, in general, Hawai‘i is characterized by high levels of endemism and diversity within many orders. Hawai‘i supports rare species of stink bugs, damsel bugs, plant hoppers, and kissing bugs (Heteroptera), lacewings (Neuroptera), beetles (Coleoptera), moths (Lepidoptera), flies (Diptera), yellow-faced bees (Hymenoptera), and damselflies (Odonata).

Many other species, including migratory birds, seabirds, freshwater fishes, freshwater invertebrates, marine reptiles, marine fishes, and marine invertebrates are found on the island or in the near-shore waters. Hawai‘i’s most threatened marine and freshwater species include the endangered Hawaiian monk seal (*Neomonachus schauinslandi*) and Hawaiian green sea turtle (*Chelonia mydas*), both facing habitat loss, pollution, and entanglement in fishing gear. Important native fish like ‘ōpelu and endemic ‘o‘opu (stream gobies), such as *Sicyopterus stimpsoni*, are at risk due to , stream diversions, and habitat degradation. Native damselflies and anchialine pool shrimp (*Halocaridina rubra*) are also critically endangered, primarily due to habitat destruction and invasive species. Conservation efforts focus on habitat restoration, legal protections, and community-based initiatives to safeguard these unique species. Additionally, the endangered hawksbill sea turtle is known to nest and forage along the Eastern side of Hawaii Island.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife and habitats are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats that are more acute or specific to the island of Hawai‘i are listed below.

- Alien grass domination in former dry forest and coastal habitats. These grasses (e.g., fountain grass [*Pennisetum setaceum*]) are fire-adapted and fire-prone which makes them particularly threatening to conservation of the remaining rare dry habitats in Kona. In addition, alien grasses in montane mesic and wet forests inhibit seedling recruitment among native forest plants, so that mechanical or chemical removal is required for native reforestation. Increasing drought conditions associated with climate change further compound the fire threat, and prolonged drought and increased risk of fire is a major threat for palila and its critical habitat on Maunakea;
- Uncontrolled populations of feral ungulates such as sheep-mouflon hybrids (*Ovis aries–Ovis musimon) threaten* native vegetation and regeneration, thereby indirectly affecting forest species. They may also be directly affecting nesting resources and predating seabirds such as ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]) and ‘akē‘akē (*Oceanodroma castro* [band-rumped storm petrel]). Recent fencing and ungulate control conducted by DLNR have reduced this threat on Maunakea;

- Additional introduction of axis deer (*Axis axis*) to Hawai‘i island. Axis deer are a huge threat to Hawaii’s agriculture and native forests. Previously introduced populations were successfully eradicated from the island
- Wide-ranging populations of pigs (*Sus scrofa*), sheep (*Ovis aries*), cattle *(Bos taurus*), and goats (*Capra hircus*) continue to pose significant management challenges for habitat and species management, contributing to losses of forest cover that adversely affect groundwater retention and stream quality, ultimately increasing marine sedimentation and decreasing coral reef viability. DLNR also manages the public hunting program to help control these animals and provide for subsistence and recreation in appropriate areas;
- Invasions of wet forests by alien plants, notably fire tree (*Morella faya*), guava (*Psidium guajava*), blackberry (*Rubus* spp.), and banana poka (*Passiflora tarminiana*) change forest composition and likely affect arthropod and snail communities. Over 44,500 hectares (110,000 acres) are infested with miconia (*Miconia calvescens*). Currently, the Big Island Invasive Species Committee’s (BIISC’s) work is limited to monitoring and removing plants found in the buffer zone of established populations. Other invasive plants that are a growing threat on Hawai‘i island and being actively controlled include Barbados gooseberry (*Pereskia aculeate*), rubbervine (*Cryptostegia grandiflora*), pampas grass (*Cortaderai jubata* and *C. selloana*), myrtle (*Morella cerifera*), and smoke bush (*Buddleja madagascariensis*);
- *Vespula* and other predatory and parasitoid wasps are known to affect invertebrate communities in Hawai‘i Volcanoes National Park and in palila habitat at Pu‘u Lā‘au. In addition to negative impacts on native arthropods, food availability for this and other bird species may be affected as a result. Other invasive animal species of concern are ants, including little fire ant (*Wasmania auropunctata*), yellow crazy ant (*Anoplolepis gracilipes*), and red imported fire ant (*Solenopsis invicta*); carnivorous snails (*Euglandina rosea*); coqui frogs (*Eleutherodactylus coqui*); and Jackson’s chameleon (*Chamelaeleo jacksonii*);
- Since the discovery of little fire ants on Hawai‘i island in 1999, the threat and damage caused by the species has been growing. These ants threaten biodiversity, alter tropical ecosystems, impede agricultural productivity, mar horticultural sales, and impede tourism. BIISC is collaborating with the Hawai‘i Department of Agriculture to control and monitor efforts on Hawai‘i island;
- ‘Alalā (*Corvus hawaiiensis*) recovery has been hampered by habitat degradation and fragmentation and hostile habitat, i.e., the presence of disease and both native and introduced predators in release areas. The extant population is in captivity and has reached the target captive population size that will allow birds to be released. Releases occurred from 2016 – 2018, however these were not successful. Efforts are now underway to release the birds on the island of Maui starting in 2024;
- Mongoose, feral cats, and feral dogs continue to threaten establishment of new populations of nēnē on Hawai‘i. Continuing the relocation program of nēnē from Kaua‘i will require large predator-proof pens, as well as additional labor to maintain the pens and monitor the success of the introduction of new birds and any problems that may arise.
- The small size and isolation of forest bird populations have likely contributed to the decline and disappearance of some of these populations. The degree to which this is also true for arthropods and snails is unknown;

- Anchialine pond fauna are threatened by saltwater intrusion from sea level rise and human activities, especially land development and the intentional release of alien fish and shrimp into these ponds and;
- Introduced freshwater fish and invertebrates have adverse effects on native stream species;
- Stream alterations and inadequate instream flows have negative effects on native freshwater species;
- Increased stream sediment load resulting from fire, forestry, urban development, and pasture agriculture contributes to sedimentation impacts on near-shore marine habitats;
- Lack of staff and facilities to prevent the introduction of invasive non-native species into the state and between islands contributes to delays and reduces the effectiveness of rapid response and control actions to eradicate invasive pests once detected;
- The arrival and spread of new avian diseases, such as the mange detected on ʻamakihi, threatens native bird populations;
- Spread of Rapid ʻŌhiʻa Death (ROD [*Ceratocystis fimbriata]*), a fungal disease, can kill up to 50 percent of ʻōhiʻa in a stand, referred to as ʻōhiʻa wilt. ʻŌhiʻa wilt is currently found across Hawai'i Island, in pockets on Kaua'i, and in a small number of trees on O'ahu, putting ecosystems at risk;
- Overharvesting for marine aquarium trade;
- Overfishing of marine herbivores are detrimental to coral reef health;
- Un sustainable take can diminish fisheries;
- Climate change induced coral bleaching and ocean acidification;
- Ship groundings;
- Degraded Water Quality (LBSP) and Quantity;
- Coastal Development;
- Invasive Species;
- Habitat Loss;
- Marine Debris;
- Localized Depletion of Fisheries; and
- Disinformation

ISLAND STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs), additional island-specific strategies for the island of Hawaiʻi include the following (bullets)

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Support existing conservation management and implement future needs as identified below in ‘Management Needs’ section;
    - Implement conservation actions identified below in the ‘Potential Areas for Enhanced Conservation Management’ subsection;
    - Develop and/or implement recovery plans for threatened and endangered species on Hawaiʻi;
    - Continue to relocate nēnē away from Kauaʻi to safe locations and within predator-proof pens, maintain the pens and predator-control efforts, and monitor success of

the relocation project and evidence of the birds moving into areas where they create problems;
- Explore and implement conservation translocations of critically imperiled plants and animals from lower elevation islands to Hawai‘i;
- Increase active management in, or acquisition of, extremely rare habitats such as the dry forest patches, caves, anchialine ponds, and summits of the high mountains;
- Increase the total acreage of ungulate-free and predator-free areas;
- Protect remaining intact native forest, wetland habitat, and coastal areas from development through a combination of acquisition, conservation easements, or cooperative agreements with landowners;
- Develop management plans for all marine managed areas;
- Implement fire suppression measures and protocols for post-fire restoration;
- Protect remaining anchialine ponds and lava tube and cave habitats;
- Collaborate in efforts to reduce pollution threats from recreational boats and cruise ships; and
- Support projects to deal with light and non-point source pollution and support expansion of successful methods to other areas.
- Restore habitat and water quality for aquatic species
- Conduct studies to better understand the influence of surface water and groundwater management on aquatic species
- Restock select fishery species
- Collect data and engage stakeholders to determine appropriate rule making actions
- Work with stakeholders to assure access for sustainable take of aquatic resources
- Conduct studies and perform actions to improve fisheries and the status of aquatic resources
- Support community efforts to restore habitat and improve the status of aquatic resources
- Support additional legislation regarding feeding feral cats, chickens, and pigs combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
- Improve early detection and rapid response capacity for species not yet established in the islands (e.g., brown tree snake, West Nile virus, Argentine fire ant) or present in the Main Hawaiian Islands but not yet established on the island of Hawai‘i, including the coconut rhinoceros beetle and long horned beetle;
- Increase efforts to prevent establishment of or eradicate priority invasive plants in pristine areas (e.g., miconia), to control spread of bleeding heart (*Homolanthus populinafolia),* fountain grass (*P. setaceum*) and other dry grasses, and to eradicate priority invasive species from areas with recovery potential;
- Expand control of mammalian predators (e.g., feral cats, rats) in waterbird (including nēnē), seabird, and forest bird habitat;
- Decrease the overall number of streams negatively impacted by invasive species; and
- Support efforts to strengthen marine alien species prevention and control.

2) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Improve dissemination of research and data regarding native species populations and habitat condition;
    - Conduct surveys and inventories for invertebrates in currently managed areas;
    - Assess impact of eco-tourism activities on terrestrial and aquatic native wildlife and associated habitats;
    - Survey status and distribution of invasive *Ichnuemonidae* wasps in the Kohala, Kona, and Kaʻū areas; and
    - Assess interaction of nēnē with farmers, utilities, municipal infrastructure, public transportation sectors, and airports, and develop a habitat conservation plan (HCP) as needed to address any conflicts.
3) Strengthen existing and create new partnerships and cooperative efforts.
    - Develop and strengthen partnerships with the Native Hawaiian community to ensure access and sustainable use for cultural practice and traditions.
    - Formalize partnerships with military agencies to manage areas (including state land) for habitat conservation;
    - Continue partnership with the Office of Hawaiian Affairs (OHA) to manage the Wao Kele O Puna forest legacy reserve for wildlife and endangered species habitat, watershed and forest conservation, and cultural resources use and protection;
    - Expand existing collaboration with the Department of Hawaiian Homelands (DHHL) to foster sustainable agroforestry to expand high elevation native ecosystems on Maunakea and add value to beneficiaries;
    - Encourage additional landowner participation and involvement in island wide Watershed Partnerships;
    - Expand partnerships with the hunting community to control and reduce ungulate populations where sensitive native species and habitats are being managed, and identify areas where ungulate populations can be managed to provide for continued hunting opportunities;
    - Expand partnerships with conservation NGOs to aide in restoring important habitats and species across Hawaiʻi;
    - Expand current firefighting capacity through greater interagency cooperation (e.g., sharing equipment, training, and fighting capacity);
    - Collaborate with the National Oceanic and Atmospheric Administration (NOAA) to ensure the protection of marine mammal populations; and
    - Work with project developers, landowners, and stakeholders to develop and implement HCPs to address wildlife-human conflicts, to minimize and fully mitigate impacts on native wildlife and habitats, and to provide net environmental benefits to wildlife populations.
    - Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawaiʻi.
    - Maintain existing outreach and educational programs at managed conservation areas;
    - Improve conservation education of visitors and the tourism industry on the appropriate use of natural areas, particularly sensitive habitats and areas; and

- Expand and broaden public education and outreach to take advantage of the large science and management community on the island.

4) Support policy changes aimed at improving and protecting native species and habitats.
    - Organize an interagency working group to develop vision and policy analysis for stream conservation actions;
    - Assess ways to support increased enforcement capacities, including cross-deputation between federal (including military) and state agencies, development of a Community Fisheries Enforcement Unit for Hawai‘i, and development of community-based Makai Watch program;
    - Support development of community-based marine managed areas on Hawai‘i and develop rules for community-based subsistence fishing areas as these partnerships develop;
    - Evaluate all current marine managed areas for purpose and management effectiveness and consider need for new marine managed areas;
    - Improve integration of policies to address linkages between terrestrial and marine habitats and their shared conservation threats and needs; and
    - Improve coordination of policies and programs to meet the needs of native wildlife conservation, but also provide for other uses of state lands, including public hunting, outdoor recreation, and forest products development where appropriate, and thereby retain support of the broader community for natural resource and wildlife conservation.

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section and include the following:

- Species Conservation Plans prepared by USFWS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose* (2004), the *Revised Recovery Plan for Hawaiian Forest Birds* (2006), the *Draft Recovery Plan for the Blackburn's Sphinx Moth* (2003), the *Revised Recovery Plan for the ʻAlalā (Corvus hawaiiensis)* (2009), the *Revised Recovery Plan for Hawaiian Waterbirds* (2011), and the *Recovery Plan for the Hawaiian Hoary Bat* (1998);
- Critical habitat designations by USFWS for the palila, the Blackburn's sphinx moth, and for threatened and endangered plants on the island of Hawai‘i;
- A Decision Support Framework for Conservation Introductions USFWS Pacific Region (2024);
- Hawaiian petrel monitoring protocol for Hawai‘i and Maui;
- The U.S. Army has developed an Integrated Natural Resources Management Plan and Implementation Plan for the Pōhakuloa Training Area (2005);
- Management Plans for the State Natural Area Reserves (NAR): Kahauale‘a NAR (1992), Kīpāhoehoe NAR (2002), Laupāhoehoe NAR (1989), Manukā NAR (1992), Pu‘o o Umi (1989), and Pu‘u Maka‘ala (2013);
- DOFAW and State Parks jointly developed a management plan for the ahupua‘a of Pu‘u Wa‘awa‘a and the makai lands of Pu‘u Anahulu;

- The Division of Forestry and Wildlife's (DOFAW) Management Guidelines, which coarsely rate vegetation quality and provide guidelines for land use (public hunting, recreation, and forest products) for state lands managed by DOFAW;
- Management Plans for the Kohala Mountain Watershed Partnership (2007), Three Mountain Alliance Management Plan (2007), and Maunakea Alliance Management Plan (2010);
- USFWS Hakalau Forest National Wildlife Refuge Comprehensive Conservation Plan (2010);
- The Cave Conservancy of Hawai‘i has developed a management plan for the Kīpuka Kanohina Cave Preserve (2003);
- Center for Maunakea Stewardship Master Plan For The University Of Hawai‘i Maunakea Lands E Ō I Nā Leo (Listen To The Voices) Volume 1 (2022)
- A summary of research and information on offshore islands management developed by the O‘ahu Offshore Islet Seabird Sanctuaries project, described at <http://hbmpweb.pbrc.hawaii.edu/dlnr/projects/offshore>;
- The Hawai‘i Invasive Species Council Strategic Plan 2015-2020 (2015) for invasive species prevention, control, research, and public outreach;
- DOFAW's *Snail Extinction Prevention Program Strategic Plan* (2014);
- Coastal Zone Management plans, including *Section 309 Coastal Zone Assessment and Strategy* (2010) and the *Hawai‘i Ocean Resources Management Plan* (2013);
- Bishop Museum has a comprehensive database of invertebrates; and
- The Audubon Society maintains a Sightings database of bird species observed in the state.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats on the island of Hawai‘i. The island of Hawai‘i has numerous areas managed in part for long-term conservation of native wildlife. These include five National Park/National Historic Park units (NP/NHP), two units composing a National Wildlife Refuge (NWR) complex, nine NARs, State Forest Reserve lands, and OHA forest legacy Forest Reserve. Three Watershed Partnerships, the Big Island Invasive Species Commission (BIISC), and a number of additional private and public efforts promote habitat and species-specific conservation management needs.

Hawai‘i island is home to five out of the 11 state Marine Protected Areas (MPAs), with state-managed areas, known as Marine Life Conservation Districts, overseen by the Hawai‘i Division of Aquatic Resources. While MPAs are recognized as one of the most effective methods for preserving marine biodiversity, their effect on local recreational fisheries has been uncertain until now. This study offers important global insights for management agencies, conservationists, and recreational fishers on the long-term outcomes of establishing MPAs. The MPAs for Hawai‘i island are listed below:

- Kealakekua Bay Marine Life Conservation District, Hawai‘i
- Lapakahi Marine Life Conservation District, Hawai‘i
- Old Kona Airport Marine Life Conservation District, Hawai‘i

- Waialea Bay Marine Life Conservation District, Hawai‘i
- Wai‘ōpae Tidepools Marine Life Conservation District, Hawai‘i

MANAGEMENT AREAS

Maunakea Forest Reserve and Palila Critical Habitat **(73,442 acres), DOFAW**

Species: Forest birds, palila (including palila critical habitat), ‘io, nēnē, ‘ōpe‘ape‘a, terrestrial invertebrates, rare plants.
Habitats: Subalpine and alpine communities.
Current Management: Habitat restoration, reforestation, fencing and ungulate control, alien plant species control, reforestation of māmane (*Sophora chrysophylla*), outplanting of native and endangered plant species, annual bird surveys, and fire control.
Future Needs: Maintain fences and conduct ungulate removal, conduct palila surveys, monitor avian disease, control predators in palila nesting area, continue restoration of the māmane forest, outplant native and endangered plants, and conduct wildland fire control.

Maunakea Ice Age NAR **(3,886 acres), DOFAW**

Species: Possibly ‘ua‘u, terrestrial invertebrates, including rare insects, rare plants.
Habitats: Alpine communities.
Current Management: Wekiu bug surveys and research. Education and on-site management of recreational and cultural users is provided by the Office of Maunakea Management ranger staff. Public hunting for ungulate (mouflon sheep) control in surrounding Maunakea Forest Reserve.
Future Needs: Complete management plan. Continue collaboration with Office of Maunakea Management. Monitor climate change impacts on Lake Waiau.

Pōhakuloa Training Area **(109,811 acres), U.S. Army**

Species: ‘Ōpe‘ape‘a, forest birds (including palila critical habitat), ‘io, nēnē, terrestrial invertebrates, rare plants.
Habitats: Subalpine communities.
Current Management: Management plan exists. Primary purpose of the area is military training; management of natural resources and endangered species is limited to exclosures and “intensive management areas.” Monitoring, fire prevention and control.
Future Needs: Review impact of live fire training on current natural resource management activities. Review fire risk posed by military training activities to critical habitat on Maunakea.

Wao Kele O Puna Forest Legacy Reserve (25,856 acres), **OHA**

Species: Native and endangered forest birds, terrestrial invertebrates, ‘ōpe‘ape‘a, rare plants.
Habitats**:** Lowland wet communities.
Current Management: Invasive weed control.
Future Needs**:** Continue management, including ungulate and predator control, weed control, and outplanting of native plants.

***Big Island NWR Complex*, USFWS Hakalau Forest NWR (32,733 acres).**

Speciess: Forest birds, ʻio, koloa maoli, nēnē, ʻōpeʻapeʻa, terrestrial invertebrates including rare snails, rare plants.

Habitats: Montane wet communities.

Current Management: Habitat restoration via koa (*Acacia koa*) reforestation, fencing and ungulate control, alien plant species control, and propagation and outplanting of understory and endangered plant species. Annual forest bird surveys. Vegetation monitoring.

Future Needs: Continue existing management, avian disease monitoring, control of pest animals; survey and control wasps (*Vespula pensylvanica*), accelerate planting of bird food resources such as ʻōhiʻa (*Metrosideros polymorpha*) and koa, conduct wildland fire control, build predator-proof fence for nēnē, and acquire land to expand the refuge.

Kona Forest Unit of Hakalau Forest NWR (15,448 acres)

Species: Forest birds, ʻio, historically ʻalalā (tract was acquired as ʻalalā habitat), nēnē.

Habitats: Montane mesic communities.

Current Management: Habitat restoration via koa reforestation, fencing and ungulate control, alien plant species control, and propagation and outplanting threatened and endangered plant species. Annual forest bird surveys, invasive plant survey, and pest animal survey. Vegetation monitoring.

Future Needs: Continue existing management. Acquire land to expand the refuge, build fencing, and conduct ungulate removal and habitat restoration.

***Three Mountain Alliance* (1,116,000 acres), Public-Private Partnership (NPS, USFWS, DLNR, Biological Resources Division of the U.S. Geological Survey (USGS), U.S. Forest Service, Hawaiʻi Department of Public Safety, The Nature Conservancy, KS, Natural Resources Conservation Service)**

Species: Forest birds, ʻio, highly diverse terrestrial invertebrates including rare snails and insects, rare plants.

Habitats: Subalpine communities, montane wet communities, montane mesic communities.

Current Management: Management plan exists. Habitat restoration via fencing and ungulate removal, propagation and outplanting of native endangered species, control of incipient alien weed invasions. Management programs have been developed to support the watershed's overall goals and include habitat protection and restoration; watershed protection; support of compatible economic use and compatible recreation and ecotourism; education, awareness, and public outreach; cultural resource protection and research; and monitoring and management program indicators.

Future Needs: Continue existing management. Secure funding to implement priority projects identified in the management plan (e.g., develop a multi-agency fencing strategy to address additional ungulates and protect a core conservation area) for the priority areas of ʻŌlaʻa-Kīlauea, Kaʻū, Kapapala, South Kona, and North Kona.

***Kohala Mountains Watershed Partnership* (~20,000 acres), Public-Private Partnership (Parker Ranch, Inc., Kahua Ranch, Ltd., Ponoholo Ranch, Ltd., The Queen Emma Foundation, KS, Laupāhoehoe Nui, LLC, DLNR, State Department of Hawaiian Home Lands (Hawai‘i County Department of Water Supply, The Nature Conservancy)**

***Species**:* Forest birds, koloa maoli, migratory shorebirds and waterfowl, kōlea (*Pluvialis fulva* [Pacific golden plover]), terrestrial invertebrates, including rare snails and insects, rare plants.

Habitats: Montane wet communities.

***Current Management*:** Management plan developed in 2008.

Future Needs: Secure funding to implement management plan. Complete fencing, ungulate removal, and weed control.

The Maunakea Watershed Alliance (500,000 acres) Public-Private Partnership (Department of Land and Natural Resources, Department of Hawaiian Homelands, Kamehameha Schools, Hakalau Forest National Wildlife Refuge, Kuka'iau Ranch, Queen Liliuokalani Trust, Parker Ranch, The Nature Conservancy, Pacific Islands Fish and Wildlife Office, Institute of Pacific Islands Forestry)

Species: Native flora, Forest birds, and rare invertebrates, while conserving diverse habitats

Habitats: montane dry forests and alpine tundra

Current Management: Efforts to prioritize habitat restoration through ungulate control and fencing, the propagation of native species, and invasive species management. Educational outreach and cultural resource preservation are also key components.

Future Needs: developing a long-term funding strategy and expanding habitat restoration efforts across the watershed.

***Hawai‘i Volcanoes National Park* (333,086 acres), NPS**

Species: ‘Ōpe‘ape‘a, forest birds, ‘io, nēnē, seabirds (including ‘ua‘u and ‘akē‘akē), diverse terrestrial invertebrates, rare plants, marine species associated with shallow coral reef and rocky habitat, hawksbill and green sea turtles.

Habitats: Alpine communities, subalpine shrubland, montane communities, lowland communities, coastal communities, cave habitat, marine ecosystems.

Current Management: Management plan exists. Fencing and ungulate control, use of Forward Looking Infrared (FLIR) technology for detection and control of ungulates, habitat restoration, eradication of priority non-native plants, propagation and outplanting of native plant species (particularly rare plants); 600-acre predator-proof fence designed to protect ‘ua‘u on Maunaloa, ongoing predator control for the protection of endangered species, monitoring and management of endangered species, and public education and outreach.

Future Needs: Continue existing management. Expand partnerships that provide opportunities for complementary monitoring and management of adjacent habitat for native wildlife, especially for rare species, including forest birds, seabirds, and invertebrates. Collaborate with DOFAW to ensure that the nēnē translocation project includes long-term monitoring and associated management and outreach as relocated birds disperse across Hawai‘i Island. Use habitat suitability models to inform

conservation of rare plants and develop and apply habitat vulnerability assessments for the management of special ecological areas.

***Pu‘u Maka‘ala NAR* (18,730 acres), DOFAW**

Species: Forest birds, ‘alalā, ‘io, pueo (Hawaiian owl [*Asio flammeus sandwichensis*]), nēnē, terrestrial invertebrates including rare snails and insects, rare plants.
Habitats: Montane wet communities.
Current Management: Management plan exists and was updated in 2013. Ungulate management, weed management, habitat protection and rare species restoration, wildlife and plant monitoring, outreach and education, fire prevention and response, predator control.
Future Needs: Continue existing management. Fence remainder of NAR boundary and build new fence to subdivide management units. Implement ungulate and weed control and small mammal predator control, develop support facilities and use as a site at which to reintroduce ‘alalā back into the wild and to release other endangered birds.

***Kīpuka ‘Āinahou Nēnē Sanctuary* (11,157 acres), DOFAW**

Species: Nēnē, forest birds, terrestrial invertebrates, rare plants.
Habitats: Montane wet communities. Montane mesic communities.
Current Management: Public hunting.
Future Needs: Enhance site for nēnē habitat and transient use, identify high-quality native habitat needing protection.

***Waiākea 1942 Lava Flow NAR* (644 acres), DOFAW**

Species: Forest birds, terrestrial invertebrates, including rare insects, rare plants.
Habitats: Montane wet communities, subterranean communities.
Current Management: Recent insect survey by Bishop Museum.
Future Needs: Complete management plan.

***Kahauale‘a NAR* (22,521 acres), DOFAW**

Species: Forest birds, ‘io, terrestrial invertebrates, including rare insects, rare plants.
Habitats: Montane wet communities, lowland wet communities.
Current Management: Management plan exists. Trail management only. Limited invasive species control.
Future Needs: Continue existing management and expand management to include fencing and ungulate removal focusing on most intact areas, control of alien weed invasions, and other non-native species control to reduce impacts of alien invertebrates.

***Manukā NAR* (25,550 acres), DOFAW**

Species: ‘Ōpe‘ape‘a, forest birds, seabirds, ‘alalā (known historically), ‘io, terrestrial invertebrates including rare insects, rare plants, anchialine pond fauna.
Habitats: Subalpine communities, montane mesic communities, lowland dry communities, coastal communities, anchialine ponds.
Current Management: Management plan exists. Removal of feral pigs and goats, invasive non-native plant (e.g., fountain grass) control, wildlife monitoring, fencing

around rare communities, coqui frog control, monitoring, *Vespula* eradication, predator control.
Future Needs: Continue existing management. Fence entire boundaries, removal ungulates, biocontrol for fountain grass, Christmas berry, strawberry guava, eradication of *Clidemia hirta*, coqui frog.

***Kīpāhoehoe NAR* (5,583 acres), DOFAW**
Species: Forest birds, seabirds, ʻio, terrestrial invertebrates including rare snails and insects, rare plants.
Habitats: Montane wet communities, montane mesic communities, lowland mesic communities, lowland dry communities.
Current Management: Management plan exists. Fencing and ungulate removal in most pristine habitats, weed control in intact native communities (upper elevation forests and pili grasslands).
Future Needs: Continue existing management. Expand fencing to include entire NAR, biocontrol for Christmas berry, strawberry guava, *Clidemia hirta*.

***Waiea NAR* (1,259 acres), DOFAW**
Species: Forest birds, ʻio, terrestrial invertebrates including rare snails and insects, rare plants.
Habitats: Montane wet communities, montane mesic communities, lowland mesic communities.
Current Management: Fencing and ungulate removal in most pristine habitats, weed control in intact native communities (upper elevation forests and pili grasslands).
Future Needs: Continue existing management and develop management plan. Expand fencing to include entire NAR, biocontrol for Christmas berry, strawberry guava, *Clidemia hirta*.

***Kaʻū Preserve* (3,491 acres), TNC**
Species: Forest birds, ʻio, terrestrial invertebrates, rare plants. Possibly ʻōpeʻapeʻa. The region also provides potential habitat for the reintroduction of endangered species such as the ʻalalā.
Habitats: Lowland wet communities, lowland mesic communities.
Current Management: Management plan exists. Fencing, ungulate control, invasive non-native plant control, community outreach.
Future Needs: Continue participation in the Natural Area Partnership Program. Implement management plan for fencing, reducing feral ungulate damage, removing habitat-modifying weeds, preventing wildfire, and facilitating public access to the forest.

***Kaʻū Forest Reserve* (61,641 acres) DOFAW**
Species: Forest birds ʻakiapōlāʻau (*Hemignathus munroi*), ʻalawī (*Oreomystis mana* [Hawaiʻi creeper]), and Hawaiʻi ʻakepa (*Loxops coccineus*); ʻio; terrestrial invertebrates; rare plants. Possibly ʻōpeʻapeʻa. The region also provides potential habitat for the reintroduction of endangered species such as the ʻalalā.
Habitats: Lowland wet communities, lowland mesic communities.

Current Management: Management plan exists. Fencing, ungulate control, invasive non-native plant control, predator control, forest bird surveys, public access, fire control, monitoring for insects and disease, community outreach.
Future Needs: Implement management plan to fence 12,000 acres, remove feral ungulates, remove high-priority weeds, control non-native predators, reintroduce the ʻalalā, continue forest bird surveys, survey and inventory rare native plants and animals including snails and invertebrates, prevent wildfire, and provide public access to the forest.

Kona Hema Preserve **(8,061 acres), TNC**

Species: Forest birds, ʻio (Hawaiian hawk), terrestrial invertebrates, rare plants. The preserve also provides potential habitat for the reintroduction of endangered species such as the ʻalalā.
Habitats: Montane mesic communities, lowland mesic communities.
Current Management: Management plan exists. Restoration via fencing and ungulate control. Research on koa reforestation.
Future Needs: Continue existing management, fencing, and ungulate eradication from fenced units.

Puʻu Waʻawaʻa Wildlife Sanctuary **(3,806 acres), DOFAW**

Species: ʻŌpeʻapeʻa, forest birds, ʻio, pueo, nēnē, recovery habitat for ʻalalā, terrestrial invertebrates, including rare moths and insects, rare plants. Part of the U.S. Forest Service's Hawaiʻi Experimental Tropical Forest.
Habitats: Montane mesic communities, montane dry communities, lowland dry communities.
Current Management: Management plan exists. Removal of livestock, fire control, prevention of illegal logging. Limited fencing, ungulate and invasive species control.
Future Needs: Implement Puʻu Waʻawaʻa management plan and DOFAW Management guidelines; manage site consistent with wildlife sanctuary rules to reflect conservation status, complete fence repairs and remove all ungulates, implement fire threat mitigation, and implement outplanting program. Implement research and management component of Hawaiʻi Experimental Tropical Forest management plan.

Puʻu O ʻUmi NAR **(10,142 acres), DOFAW**

Species: Forest birds, ʻio, koloa maoli, ʻaʻo (*Puffinus newelli* **[**Newell's shearwater]) ʻUaʻu (Pterodroma sandwichensis [Hawaiian petrel]), terrestrial invertebrates including rare snails and insects, rare plants.
Habitats: Montane wet communities.
Current Management: Management plan exists. Fencing, ungulate removal, weed control, predator control, monitoring.
Future Needs: Continue existing management. Extend fencing to protect most intact bogs and forests from ungulates. Increase control of priority weed species such as kahili ginger (*Hedychium gardnerianum*), yellow ginger (*Hedychium flavescens*), *Melastoma candidum*, banana poka (*Passiflora tarminiana*), and blackberry (*Rubus argutus*).

Laupāhoehoe NAR **(7,894 acres), DOFAW**

Species: Forest birds, ʻio, koloa maoli, terrestrial invertebrates, rare plants.
Habitats: Montane wet communities, lowland wet communities.
Current Management: Management plan exists. Part of the U.S. Forest Service's Hawaiʻi Experimental Tropical Forest.
Future Needs: Increase active management. Implement fencing, feral pig control, weed control, and monitoring to assess management effectiveness.

***Cooperative Nēnē Sanctuaries*, Public-Private Partnership**
Species: Nēnē.
Habitats: Forested areas and shrublands.
Current Management: There are two cooperative nēnē sanctuaries: KS's Keauhou (Kaʻū) and Keauhou II (Hualālai). Predator control (small mammals) during breeding seasons. Release of captive-bred birds. Supplemental food and water. Exclosures for nesting birds and goslings.
Future Needs: Continue existing management.

***Kaloko-Honokohau NHP* (1,161 acres), NPS**
Species: ʻŌpeʻapeʻa, aeʻo, ʻalae keʻokeʻo, migratory birds, anchialine pond fauna, species associated with shallow coral reef and rocky habitat, honu (*Chelonia mydas* [green sea turtle]).
Habitats: Coastal communities, anchialine ponds, marine ecosystem (including shallow coral reef and rocky habitats and sandy beach).
Current Management: Management plan exists. One-time inventories for bats, herpetofauna, native plants, shoreline birds. Habitat restoration at ʻAimakapā (alien weed removal), protection of wetland and anchialine habitats, reef monitoring, and research. Marine and terrestrial monitoring protocols are under development (covering fishes, fisheries, marine benthos, freshwater animals, selected birds, bat, terrestrial invertebrates, vegetation, land use changes in and adjacent to park, invasive species, and water quality).
Future Needs: Continue existing management, predator control. Expand partnerships for complementary monitoring and management of adjacent habitat for native terrestrial and marine species.

***Puʻuhonua O Honaunau NHP* (182 acres), NPS**
Species: Migratory birds, honu.
Habitats: Coastal communities, marine ecosystems.
Current Management: Management plan exists. One-time inventories for bats, herpetofauna, native plants, shoreline birds. Turtle protection via public education. Marine and terrestrial monitoring protocols are under development (covering fishes, fisheries, marine benthos, freshwater animals, selected birds, bat, terrestrial invertebrates, vegetation, land use changes in and adjacent to park, invasive species, and water quality).
Future Needs: Continue existing management. Expand partnership for complementary monitoring and management of adjacent habitat for native wildlife.

***Puʻukoholā Heiau NHP* (83 acres), NPS**
Species: Migratory birds.
Habitats: Coastal communities, nearshore marine ecosystems.

Current Management: Management plan exists. One-time inventories for bats, herpetofauna, native plants, shoreline birds. Marine and terrestrial monitoring protocols are under development (covering fishes, fisheries, marine benthos, freshwater animals, selected birds, bats, terrestrial invertebrates, vegetation, land use changes in and adjacent to park, invasive species, and water quality). Research on grassland habitat restoration.
Future Needs: Continue existing management.

State Seabird Sanctuary **(three offshore islands), DOFAW**

Species: Seabirds, migratory birds.
Habitats: Coastal communities.
Current Management: Surveys and monitoring.
Future Needs: Continue surveys and monitoring. Evaluate implementation of offshore islands management program developed by the O‘ahu Offshore Islet Seabird Sanctuaries project, described at <http://hbmpweb.pbrc.hawaii.edu/dlnr/projects/offshore>.

Four Marine Life Conservation Districts (MLCDs), **Division of Aquatic Resources (DAR): Kealakekua Bay, Lapakahi, Old Kona Airport, Wailea Bay**

Species**:** Species associated with shallow coral reef, sandy beach, and rocky habitats, Hawaiian monk seals (*Monachus schauinslandi*), honu, spinner dolphins (*Stenella longirostris*), and other marine mammals.
Habitats: Marine ecosystems including shallow coral reef, sandy beach, rocky habitats.
Current Management**:** Limited access in most MLCDs; eight MLCD across the islands include at least some No Take areas; Old Kona Airport allows fishing throughout the MLCD; fish monitoring.
Future Needs**:** Evaluate all MLCDs for purpose and management effectiveness and consider need for new marine managed areas.

Nine Fishery Management Areas (FMAs), **DAR: Miloli‘i Community-Based Subsistence Fishing Area Hilo Bay, Wailiku River and Waikola River, Kailua Bay, Kawaihae Harbor, Keauhou Bay, Kīholo Bay, Kona Coast, Puako Bay and Reef, and West Hawai‘i Regional Fishery Management Area**

Species**:** Some or all regulated fish species.
Habitats: Marine and freshwater ecosystems.
Current Management**:** Limited take, gear, size, season, and/or area restrictions.
Future Needs**:** Evaluate all FMAs for purpose and management effectiveness and consider need for new marine managed areas.

South Kona ‘Ōpelu Fishing Area, **DAR**

Species: ‘Ōpelu.
Habitats: Marine ecosystems.
Current Management**:** Gear and fishing area restrictions.
Future Needs: Evaluate purpose and management effectiveness and consider need for new marine protected areas.

Hawaiian Islands Humpback Whale National Marine Sanctuary **(about 900,000 acres), NOAA and DLNR**

***Species*:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystems surrounding Hawai‘i island, which serves as critical habitat for humpback whales.
***Current Management*:** Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the ESA, MHI component of the Structure of Populations, volunteer whale counts and other community events, and educational activities, research, and enforcement.
Future Needs: Review other marine species, including seabirds and marine turtles, and habitats for inclusion in the Sanctuary management plan and increase and enhance research, education, and enforcement actions.

Species Conservation Management
The following projects and programs include state, federal, university, and private cooperative management efforts to address specific conservation needs of SGCNs on Hawai‘i, and often involve island-wide research and management that extend across boundaries and jurisdictions.

***Big Island Invasive Species Committee* (BIISC), Public-Private Partnership**
Species/Habitats: All species and habitats affected by invasive species.
Current Management: Prevention of incipient invasions, invasive species control, public education.
Future Needs: Adequate funding to support priority BIISC actions.

***Wetlands Restoration*, Public-Private Partnership**
Species: Koloa maoli, nēnē, other waterbirds and migratory birds.
Habitats: Wetland areas island wide.
Current Management: Restoration or creation of 28 montane ponds on private lands, including fencing to exclude ungulates and feral dogs and predator control. Development of programmatic Safe Harbor Agreement to cover future participating landowners (Safe Harbor Agreement completed with one landowner).
Future Needs: Obtain approval of new Safe Harbor Agreements, provide technical assistance for private landowners.

***Nēnē Relocation Project from Kaua‘i to Hawai‘i: 2012-2015,* DOFAW**
***Species*:** Nēnē.
Habitats: Subalpine communities.
***Current Management*:** Because they were a risk to aviation safety, over 316 nēnē were captured on Kaua‘i adjacent to the airport and relocated to a 44-acre predator-proof pen in the Saddle Road Pu‘u O‘o area of Hawai‘i. Current management involves constructing predator-proof fencing, controlling predators in the pen, monitoring movement patterns of birds once they are released and leave the pen, and monitoring site fidelity the following year. Birds attempting to return to Kaua‘i are captured and held.
***Future Needs*:** Monitor the success of the relocation project, and the site fidelity of birds once they are released on the Big Island. Over four years of releases, no birds relocated to another island returned to Kaua‘i. One pair from the Big Island relocated to Kaua‘i.

Potential Areas for Enhanced Conservation Management

In addition to maintaining and enhancing existing conservation actions, additional efforts are needed to balance long-term conservation of native wildlife with recreational opportunities on the island of Hawai‘i. The following section identifies areas where enhanced conservation management could significantly benefit native species or their habitats. The State’s watershed initiative has fostered watershed and other public-private partnerships that have greatly expanded and enhanced conservation management of lands through control and management of game animals, reforestation, and wetland restoration.

Waipi‘o and Waimanu Valley, Kīholo Springs Pond and Marsh, Opae‘ula Pond, Kealakekua Bay Pond, Lokoaka Pond, Waiākea Pond, and Ke‘anae Pond

Species: Ae‘o, ‘alae ke‘oke‘o, koloa maoli, migratory waterfowl and shorebirds, associated native invertebrates.

Basis for Priority Designation: These wetland systems are considered core or supporting wetland areas in the USFWS *Recovery Plan for Hawaiian Waterbirds, Second Revision*. Waipi‘o and Waimanu have extensive wetlands and taro lo‘i, which require long-term protection. Habitat for wetland bird species. They are currently unmanaged.

Potential Conservation Actions: Where private lands occur, support voluntary and incentive-based programs for potential conservation, in all areas, enhance waterbird habitat by removing invasive vegetation and excluding predators. Provide technical assistance to private landowners to guide this process. Control predators (rats, cats, mongooses) during nesting season, especially where endangered ae‘o and ‘alae ke‘oke‘o occur. Coordinate pesticide use with DAR. Implement efforts to remove feral mallards, if present, to avoid hybridization with koloa maoli.

***Anchialine areas*, DLNR, KS, NPS, NARS, private**

Species: Anchialine amphipods and shrimp, ae‘o, migratory shorebirds.

Basis for Priority Designation: There are only about 700 anchialine pools worldwide, 80 percent of which are on Hawai‘i. Anchialine ponds support a unique fauna which is threatened by human activities ranging from coastal development and subsequent changes in hydrology to “biological pollution” by those who intentionally dump alien fish (mosquito fish and tilapia) and shrimp into ponds. Also, *Holocaridina rubra* is potentially threatened by commercial harvesting.

Potential Conservation Actions: Where private lands occur, support voluntary and incentive-based programs for potential conservation, improved public education regarding fragility of anchialine ecosystems. Develop and implement ichthyocide methods to control alien fish in salt water. Divert human use away from these features.

Streams originating in more protected areas*: *below Hakalau, Wailuku River, Honoli'i, Pāhoehoe, Kapue, Kolekole, Kīlau, Ha‘akoa, Kaiwilahilahi, and Pāhale, and additional protection below Kohala watershed and others

Species: ‘O‘opu (*Awaous stamineus*), *Megalagrion* damselflies, koloa maoli.

Basis for Priority Designation: Protect native freshwater fish species. Alien fish in these streams may prey on native *Megalagrion* species.

Potential Conservation Actions: Implement additional fencing and removal of ungulates to improve stream water quality and reduce erosion, benefiting stream and ocean fish.

Caves: Kipuka Kanohina (near Ocean View, 800-1,400 feet), ʻUmi Manu and Henahena systems (Puʻu Waʻawaʻa), Kaʻū and Kapāpala (tubes are unsurveyed), Emesine Cave (Upper Waiākea FR), Wao Kele O Puna, Kīholo Bay, and Kaʻūpūlehu and Puʻu Waʻawaʻa ahupuaʻa between Mamalahoa and Queen Kaahumanu Highways

Species: Endemic cave-adapted fauna. A unique species is known from coastal tubes at Kīholo (*Oliarus lorettaei*). In Emesine Cave, species include *Nesidiolestes ana* (blind, cave-adapted thread-legged bug), ten other cave-adapters including planthopper *Oliarus polyphemus*, moth *Schrankia* sp., rock crickets *Caconemobius varius* and related species, tree cricket *Thaumatogryllus cavicola,* millipede *Nannolene* sp.*,* rock centipede *Lithobius* sp., and springtails *Collembola* spp. At higher elevations in Kaʻūpūlehu and Puʻu Waʻawaʻa, there are planthoppers, moths, centipedes, spiders, and crickets.

Basis for Priority Designation: Hawaiʻi's cave fauna is globally unique. To protect the cave systems, land above them must be managed for conservation. Some of the caves already listed are included in other sections of this document.

Potential Conservation Actions: Protect habitat above caves as cave-adapted ecosystems depend on tree roots and moisture. Construct gates to manage human access.

References:

Brock RE, Richard E. 2004. Anchialine resources in two Hawaiʻi State Natural Area reserves: ʻAhihi –Kinaʻu, Maui Island and Manuka, Hawaiʻi Island with recommendations for their management. Honolulu, (HI): Pacific Islands Coastal Program, US Fish and Wildlife Service

Brown S, et al. 2001. United States shorebird conservation plan. Manomet, (MA): Manomet Center for Conservation Sciences.

Cabin RJ, Weller SG, Lorence DH, Flynn TW, Sakai AK, Sandquist D, Hadway LJ. 2000. Effects of long-term ungulate exclusion and recent alien species control on the preservation and restoration of a Hawaiian tropical dry forest. Conservation Biology 14(2):439-453.

Cave Conservancy of Hawaiʻi. 2003. Kipuka Kanohina Cave Preserve management plan. Cave Conservancy of Hawaiʻi.

Chai DL, Cuddihy C, Stone C. 1989. An inventory and assessment of anchialine pools in Hawaiʻi Volcanoes National Park from Wahaʻula to Kaʻaha, Puna and Kaʻu, Hawaii. Technical Report #69. Cooperative National Park Resources Studies Unit. National Park Service Contract No. CA 8015-2-0001. 37 pp.

Ferracane, J., 27 February 2024. 325.5 million visits to national parks in 2023; 1,620,294 visits at Hawaiʻi Volcanoes National Park. National Park Service. Available at: https://www.nps.gov/havo/learn/news/20240227-nr-2023-visitation-stats.htm#:~:text=At%20Hawai%CA%BBi%20Volcanoes%20National%20Park, Halema%CA%BBuma%CA%BBu%20crater%20at%20K%C4%ABlauea%20summit. Accessed 15 May 2024.

Friends of Hakalau Forest National Wildlife Refuge. n.d. Available at: https://friendsofhakalauforest.org/. Accessed 15 May 2024.

Giffin, J. Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communication.

Giffin J. 2003. Puʻu Waʻawaʻa biological assessment. State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife.

Hadway LJ, Hadfield MG. 1998. Assessment of the current status of *Partulina* tree-snail species on the island of Hawai‘i with comments on additional land snail species. Honolulu: Department of Zoology, University of Hawai‘i.

Hart, PJ. USGS. Personal communication.

Hawai‘i Audubon Society. 1993. Hawaii’s birds. Honolulu: Hawai‘i Audubon Society.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. Accessed 28 March 2005.

Department of Business, Economic Development, & Tourism. Visitor Statistics, Tourism Dashboard. Available at: https://dbedt.hawaii.gov/visitor/tourism-dashboard/. Accessed May 13, 2024.

Hawai‘i Department of Health, Hawai’i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Forest legacy: amended assessment of needs, State of Hawai’i. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Kahaualea Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Manuka Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1993. Kipahoehoe Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Laupahoehoe Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Pu‘u Maka‘ala Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Pu‘u ‘O Umi Natural Area Reserve management plan. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife and Division of State Parks. 2003. Management plan for the Ahupua‘a of Pu‘u Wa‘awa‘a and the Makai lands of Pu‘u Anahulu. State of Hawai‘i.

Hawai‘i Department of Land and Natural Resources. Undated. Interim State of Hawai‘i strategic plan for invasive species prevention, control, research and public outreach. Honolulu, (HI).

Hawai‘i Department of Land and Natural Resources. 2014. Division of Forestry and Wildlife Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Honolulu.

Hawai‘i Department of Land and Natural Resources. 2013. Division of Forestry and Wildlife Snail Extinction Pu‘u Maka‘ala Natural Area Reserve (NAR) Management Plan. Honolulu.

Hawai‘i Tourism Authority. 2023. Table 8: Average Daily Census by Island. 2022 Annual Visitor Research Report Tables, Available at: https://www.hawaiitourismauthority.org/research/annual-visitor-research-reports/. Accessed 15 May 2024.

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu, (HI): Pacific Coast Joint Venture.

Hu, D, GE Ackerman, CSN Bailey, DC Duffy, and DC Schneider. 2015. Hawaiian Petrel Monitoring Protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR–2015/993. National Park Service, Fort Collins, Colorado.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kohala Mountain Watershed Partnership. 2007. Kohala Mountain Watershed Management Plan. Available at: http://kohalawatershed.org/wp-content/uploads/janKWPmanagement_plan.pdf (Accessed June 30, 2015)

Mauna Kea Watershed Alliance. 2010. Mauna Kea Watershed Management Plan. Prepared by M.C. Steward. Hawaii Division of Forestry & Wildlife. Honolulu.

Medville, D. Personal communication.

Miller, E. (2014, February 18). Mauna Kea aquifers shallower than expected. West Hawaii Today. Retrieved November 15, 2024, from https://dlnr.hawaii.gov/mk/files/2016/11/B-17aa-WHT-Mauna-Kea-Aquifers-Shallower-than-Expected.pdf

Office of Mauna Kea Management. 2009. Natural Resources Management Plan for the University of Hawaii Managed Areas on Mauna Kea. Available at http://www.malamamaunakea.org/uploads/management/plans/CMP_NRMP_2009.pdf (Accessed 30 June 2015)

Pacheco C. Hawai‘i Forest and Trail. Personal communication.

Parker, D. M., Balazs, G. H., King, C. S., Katahira, L., & Gilmartin, W. (2009). Short-range movements of hawksbill turtles (Eretmochelys imbricata) from nesting to foraging areas within the Hawaiian Islands. *Pacific Science*, 63(3), 371–382. https://doi.org/10.2984/049.063.0307

Pejchar L. Stanford University postdoctoral researcher. Personal communication.

Preston DK, McShane MK, Evenhuis NL, Samuelson GA, Arakaki KT, Polhemus DA. 2004. Arthropod Survey of the Waiakea 1942 Lava Flow Natural Area Reserve and Selected Kipuka Within the Mauna Loa Kipuka Mosaic, Hawai‘i. Contribution No. 2004-009 to the Hawai‘i Biological Survey, Honolulu (HI): Bishop Museum.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society

Stone F. Personal communication.

Takasaki, K. J. (1993). Ground water in Kilauea Volcano and adjacent areas of Mauna Loa Volcano, Island of Hawaii (Open-File Report No. 93-82). U.S. Geological Survey. https://pubs.usgs.gov/publication/ofr9382

Three Mountain Alliance. 2007. Three Mountain Alliance Management Plan. Available at: http://hawp.org/_library/documents/three-mountain-alliance/tma%20mgmt%20plan.final.2.pdf (Accessed

June30, 2015).Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai‘i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Tweed, E. USGS. Personal communication.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

University of Hawai‘i at Hilo. (n.d.). Hydrologic structures within Mauna Kea volcano. Center for Maunakea Stewardship. Retrieved November 15, 2024, from https://hilo.hawaii.edu/maunakea/library/reference.php?view=3253

U.S. Census Bureau. 2021. QuickFacts, Hawai‘i County, Hawai‘i. Available at: https://www.census.gov/quickfacts/fact/table/hawaiicountyhawaii/PST045223. Accessed on 13 May 2024.

U.S. Army Garrison, Hawai‘i and U.S. Army Corps of Engineers. 2005. Integrated natural resources management plan and implementation plan for the U.S. Fish and Wildlife Service Biological Opinion, 2005-2010. Prepared by the Center for Ecological Management of Military Lands, Fort Collins: Colorado State University, and the Natural Resources Office, Pohakuloa Training Area, U.S. Army, Hawaii.

U.S. Fish and Wildlife Service. 2003. Draft revised recovery plan for the ‘Alala (*Corvus hawaiiensis*). Portland, (OR): U.S. Fish and Wildlife Service. Xi+78 pp.

U.S. Fish and Wildlife Service. 2003. Draft revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (*Branta sandvicensis*). Portland, (OR): U.S. Fish and Wildlife Service. 148 + xi pp.

U.S. Fish and Wildlife Service. Hawaiian Islands Animals: Listed and Candidate Species, as Designated under the U.S. Endangered Species Act. Updated May 10, 2004.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2009. Revised Recovery Plan for the ‘Alalā (*Corvus hawaiiensis*). Portland, Oregon. xiv + 104 pages.

U.S. Fish and Wildlife Service. 2010. Hakalau Forest National Wildlife Refuge Comprehensive Conservation Plan. Portland Oregon.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish & Wildlife Service. (n.d.). *Blackburn's sphinx moth (Manduca blackburni)*. Retrieved November 15, 2024, from https://www.fws.gov/species/blackburns-sphinx-moth-manduca-blackburni

U.S. Fish & Wildlife Service. (n.d.). *Critical habitat for 12 Hawai‘i Island species*. Retrieved November 15, 2024, from https://www.fws.gov/story/critical-habitat-12-hawaii-island-species

Warshauer R. USGS. Personal communication.

Wood KR, Polhemus J. Unpublished data.

NORTHWESTERN HAWAIIAN ISLANDS

The Northwestern Hawaiian Islands (NWHI), also known as Papahānaumokuākea, extend approximately 1,600 kilometers (1,000 miles) to the northwest of Kauaʻi. The area includes the ten main islands and atoll systems of Nihoa, Mokumanamana, Lalo (French Frigate Shoals), Kamole (Laysan Island), Kamokuokamohoaliʻi (Maro Reef), ʻŌnūnui and ʻŌnūiki (Gardner Pinnacles), Kapou (Lisianski Island), Manawai, Kuaihelani (Midway Atoll – not part of the State of Hawaiʻi), and Hōlanikū (Kure Atoll). The total number of islands varies per atoll system. The presence of some of the smaller. sandy islands are also affected by storms and climate change. These islands and atolls are remnants of earlier volcanic high islands in the Hawaiian chain that pre-date the Main Hawaiian Islands (MHI) in the southeast. Most of the NWHI, except those in the extreme southeast, have little vertical relief and only sandy soils with little forest development. This reduced habitat variability means there are far fewer natural terrestrial habitats and lower terrestrial species diversity than found in the MHI. However, there is a high abundance of extant endemic species and other significant animal populations in the region because of the less intensive historical human impact and high marine species diversity. Six species of plants in the NWHI are federally protected under the Endangered Species Act (ESA). The rocky islands in the southeast make excellent nesting areas for some cliff-nesting and other seabirds. Kamole has a large euryhaline lake that helps support the endemic and endangered Laysan ducks (*Anas laysanensis*) as well as some unique aquatic fauna. Kamole and Nihoa also have extant populations of three other endemic and endangered birds, the Laysan finch (*Telespiza cantans*), Nihoa finch (*Telespiza ultima*), and Nihoa millerbird (*Acrocephalus familiaris kingi*).

All of the NWHI support large nesting populations of various seabird species. In total, approximately 14 million individuals, belonging to 18 seabird species, nest in the NWHI:

- pākalakala (*Sterna lunata*) gray-backed tern
- noio (*Anous minutus)* black noddy
- kaʻupu (*Phoebastria nigripes*) black-footed albatross
- blue-gray noddy (*Procelsterna cerulean)*
- Bonin petrel (*Pterodroma hypoleuca*)
- ʻā (*Sula leucogaster*) brown booby
- noio-kōhā (*Anous stolidus*) brown noddy
- ʻou (*Bulweria bulwerii*) Bulwer's petrel
- Christmas shearwater (*Puffinus nativitatis*)
- ʻiwa (*Fregata minor*) great frigatebird
- mōlī (*Phoebastria immutabilis*) Laysan albatross
- ʻā (*Sula dactylatra*) masked booby
- ʻā (*Sula sula*) red-footed booby
- koaʻe ʻula (*Phaethon rubricauda*) red-tailed tropicbird
- ʻewaʻewa (*Sterna fuscata*) sooty tern
- ʻuaʻu kani (*Puffinus pacificus*) wedge-tailed shearwater
- manu-o-Kū (*Gygis alba*) white tern
- koaʻe kea (*Phaethon lepturus*) white-tailed tropicbird

The area is significant for having the majority of the worldwide breeding population of mōlī (93%), kaʻupu (95%), ʻou and Bonin petrels, and 25 percent of the worldwide population of ʻuaʻu kani. Many endemic terrestrial arthropods and land snails also occur in the NWHI. Lalo serves as the most important nesting grounds for the honu, or green sea turtle (*Chelonia mydas*), in the state. All of the islands and atolls of the NWHI provide essential breeding and pupping habitat for ʻīlioholoikauaua, or Hawaiian monk seal (*Monachus schauinslandi*). Both honu and ʻīlioholoikauaua are protected by the ESA. ESA protected species can also be found in the open ocean marine environment of the NWHI such as the endangered false killer whale, threatened oceanic manta ray, and threatened oceanic white tip shark.

Marine habitat of the NWHI is dominated by atoll reef systems and thus differs from the MHI, which mostly have fringing coral reefs. The NWHI have extensive atoll formations with large lagoons and patch reef complexes separated from the open ocean in many areas. Many endemic marine species occur only in the NWHI. The communities here are also less impacted by anthropogenic influence and invasive species, and are dominated by large numbers of predatory sharks, jacks, and snappers and a higher diversity of stony corals than in the MHI. Significant cultural places in the form of Native Hawaiian archaeological sites and historical ship and airplane wrecks are also present in the region.

OVERVIEW

Geology

The total coastline of all islands in the NWHI measures approximately 50 kilometers (30 miles) and total land area, excluding Kuaihelani (Midway Atoll), is about 8 square kilometers (3.1 square miles). The age of the various islands and atolls ranges from 7.2 million-year-old Nihoa to 27.7 million-year-old Kuaihelani. Because of the age of the islands, they have undergone extensive erosion and subsidence of their basaltic rock foundations. Only Mokumanamana (Necker Island), Nihoa, La Perouse Pinnacle, and ʻŌnūnui and ʻŌnūiki (Gardner Pinnacles) have substantial exposed basaltic rock substrate. Further to the northwest, the islands consist of sandy substrates derived from reef formations overlaying the original basalt.

Climate

Rainfall and temperature are consistent across and within these islands because of their small size. Precipitation averages about 50 to 75 centimeters (20 to 30 inches) per year. Much of the rainfall occurs during winter and is delivered by cold fronts associated with large north Pacific low-pressure systems and storms, which generate large ocean swells, powerful surf, and strong winds. Precipitation declines during summer.

Land and Ocean Use

All of the emergent land in the NWHI falls within state or federal jurisdiction. Papahānaumokuākea Marine National Monument (PMNM) encompasses approximately 140,000 square miles of water and emergent land from Nihoa to Hōlanikū (Kure Atoll) and 200 miles out from shore. Within the boundary of PMNM are several other management areas including the NWHI Coral Reef Ecosystem Reserve under National

Oceanic and Atmospheric Administration (NOAA) management, the Hawaiian Islands National Wildlife Refuge (HINWR), Midway Atoll National Wildlife Refuge (Midway Atoll), and Battle of Midway National Memorial under U.S. Fish and Wildlife Service (USFWS) management, the Kure Atoll Wildlife Sanctuary and Kure Atoll Field Station managed by the State of Hawai‘i Department of Land and Natural Resources (DLNR) as a seabird sanctuary, and the NWHI Marine Refuge also managed by DLNR. All the islands are part of the County of Honolulu with the exception of Kuaihelani (Midway Atoll), which is technically under federal jurisdiction.

Overlapping jurisdictions and shared stewardship responsibilities among state and federal agencies have resulted in the multi-agency co-management of PMNM. PMNM is administered jointly by four co-trustees – the Department of Commerce, the Department of the Interior, the State of Hawai‘i, and the Office of Hawaiian Affairs according to Proclamation 8031. On December 8, 2006, a Memorandum of Agreement (MOA) was signed by Secretary of Commerce Carlos M. Gutierrez, Secretary of the Interior Dirk Kempthorne, and Hawai‘i Governor Linda Lingle, which provides for coordinated administration of all the Federal and State lands and waters within the boundaries of the Monument. The MOA established the institutional arrangements for managing the Monument, including representation of Native Hawaiian interests by the Office of Hawaiian Affairs on the Monument Management Board (MMB). Day-to-day management is overseen by the seven-member MMB comprised of NOAA Office of National Marine Sanctuaries, NOAA National Marine Fisheries Service (NMFS), USFWS - Ecological Services, USFWS – Refuges, DLNR - Division of Aquatic Resources, DLNR - Division of Forestry and Wildlife, and the Office of Hawaiian Affairs.

There are about 2,220 square kilometers (860 square miles) of coral reefs in state waters around the NWHI, and about 6,300 square kilometers (2430 square miles) of reef in Federal Exclusive Economic Zone waters around the atolls and reefs that are part of Hawai‘i (i.e., not including Kuaihelani [Midway Atoll] and the submerged banks). Thus, approximately 26 percent of the coral reefs of these areas are under state jurisdiction and management.

Human Landscape

There is no real resident population besides a few NWR staff and volunteers at Kuaihelani (Midway Atoll), seasonal field camp staff and volunteers at Kamole (Laysan) and Tern Island in Lalo (French Frigate Shoals), and a few DLNR staff and volunteers at Hōlanikū (Kure Atoll). The U.S. Coast Guard (USCG) operated active long-range navigation (LORAN) installations at Tern Island and Green Island in Hōlanikū (Kure Atoll) until 1979 and 1992, respectively. Kuaihelani (Midway Atoll) was occupied by the U.S. Navy until 1996, when management authority was then transferred to USFWS.

Archaeological sites point to prehistorical occupation of Mokumanamana and Nihoa. Numerous incidents of feather poaching, unregulated harvest, marketing of wildlife resources, and guano mining took place from 1850 to 1909, at which time President Theodore Roosevelt issued an Executive Order that created the Hawaiian Islands Bird

Reservation. Despite the availability of historical records and the known loss of three endemic bird species from Kamole (Laysan), the true extent of impacts resulting from early human activities is unknown. The principal economic driving forces in the NWHI today are resource protection, management initiatives, and scientific research.

ISLAND AND ATOLL SUMMARIES

The following are brief summaries of the various island and atoll systems, from north to south.

Hōlanikū (Kure Atoll), at the northwestern end of the archipelago, is the world's northernmost coral atoll. About 10 kilometers (6 miles) in diameter and 1 square kilometer (0.4 square miles) in land area, Hōlanikū is a typical atoll comprised of one major island, Green Island, and one or more smaller, intermittent sand spits. Maximum elevation is 6 meters (20 feet). It has about 32,375 hectares (80,000 acres) of reef habitat. Hōlanikū is approximately 2,100 kilometers (1,300 miles) northwest of Honolulu. The USCG closed the LORAN station on Green Island and left the site in 1992. Since then, the atoll has been occupied intermittently during NMFS and DLNR summer field camps, and year-round since 2010 by DLNR staff and volunteers at the field station. Hōlanikū is managed as a State Seabird Wildlife Sanctuary. Conservation initiatives at Hōlanikū are implemented in close coordination with the Kure Atoll Conservancy, a 501(c)(3) non-profit foundation. Bird and dolphin surveys, marine debris removal, and invasive vegetation control and native plant species replanting are the main management actions. Rats were eradicated from Green Island in 1993-1994. Introduced big-headed ants (*Pheidole megacephala*) and scale insects are a potential threat, as are introduced invasive plants, especially *Verbesina encelioides*. Toxic chemicals have been detected that are likely from the prior USCG occupation. Hawaiian grouper, or hapu‘upu‘u (*Epinephelus quernus*) appear more abundant in shallow water at Hōlanikū than in other parts of the NWHI. A large group of spinner dolphins (*Stenella longirostris*) is regularly observed at Kure Atoll, suggesting these dolphins may be resident.

Kuaihelani (Midway Atoll), located approximately 2,040 kilometers (1,270 miles) northwest of Honolulu, consists of two major islands (Sand and Eastern), small sand islets, and a fringing coral reef. It is about 10 kilometers (6 miles) in diameter and 6.5 square kilometers (2.5 square miles) in land area. Maximum elevation is 4 meters (12 feet). It has about 36,000 hectares (89,000 acres) of reef habitat. Kuaihelani was claimed by the United States in 1859. Since that time, there have been considerable activities that have resulted in significant alteration of the physical environment. Projects have included blasting and dredging a ship channel through the coral reef, the installation of a cable station (which led to the introduction of various species of plants and animals and the importation of an estimated 9,000 tons of topsoil for use in gardening) in 1902, and the construction of an airport in 1935 by Pan American Airways. Kuaihelani also played a critical strategic role in World War II. USFWS established the Midway Atoll NWR as an overlay refuge in 1988 through a cooperative agreement with the U.S. Navy, and the atoll was transferred from the Navy to USFWS in 1996. Kuaihelani is now managed by USFWS as the Midway Atoll NWR and is not technically part of the State of Hawai‘i. The world's largest breeding colony of mōlī nests there, as does the second largest colony

of kaʻupu. The NWR also contains important habitat for the ʻīlioholoikauaua, the honu, large numbers of migratory seabirds, and a variety of coastal strand plants. The atoll waters support numerous species of nearshore, coral reef, and pelagic fish species, as well as odontocete cetaceans (e.g., toothed whales).

Manawai (Pearl and Hermes Atoll), is a low coral atoll made up of as many as eight islets, five of which are permanent. The reef encloses an elliptical lagoon, approximately 32 kilometers by 18 kilometers (20 miles by 11 miles) in size and has 0.3 square kilometers (0.1 square miles) of land area. Maximum elevation is 3 meters (10 feet). It has about 121,400 hectares (300,000 acres) of reef habitat. In 1822, two British whaling ships, the *Pearl* and the *Hermes*, ran aground there on the same day. From 1926 to 1930, fishing operations for pearl oysters led to the construction of several buildings on the atoll's Southeast Island. This base was abandoned in October 1931 and U.S. military forces destroyed the buildings during World War II. The atoll is unoccupied except for NMFS and USFWS summer field camps. Significant seabird, honu, and ʻīlioholoikauaua nesting and pupping occur here. About 160,000 seabirds from 17 species nest at Manawai including about 20 percent of the world population of kaʻupu. The atoll is also an important nesting site for Tristram's storm-petrels (*Oceanodroma tristrami*). NMFS removed over 300 tons of marine debris from the beaches and reefs of Manawai in the years prior to 2005. Marine debris documentation and removal has continued to be a major management endeavor at Pearl and Hermes Reef and elsewhere in the NWHI, complicated by the presence of the cryptogenic nuisance alga Chondria tumulosa. Laysan finch were introduced to Pearl and Hermes Reef (Southeast Island) in 1967 to establish another population and reduce the risk of extinction resulting from unexpected stochastic events. USFWS is currently trying to resolve the challenge of managing invasive *Verbesina encelioides*; the management effort appears to have benefited the Laysan finch population at Southeast Island.

Kapou (Lisianski Island), is a low, sandy island measuring approximately 1.6 kilometers (1 mile) long and 1 kilometer (0.6 mile) wide, with a land area of 1.5 square kilometers (0.6 square miles). Maximum elevation is 12 meters (40 feet). It lies near the north edge of Neva Shoal, a large coral reef area varying in depth to 18 meters (60 feet). It has about 125,400 hectares (310,000 acres) of reef habitat. In 1805, the ship Neva ran aground on the shoal and Captain Urey Lisianski, a Russian explorer, jettisoned cargo to free the ship. During the same period, Kapou was visited by expeditions harvesting fish, turtles, guano, bêche-de-mer (sea cucumbers), and sharks, as well as ʻīlioholoikauaua. More concentrated exploitation of the island took place from 1904 to 1910 by Japanese feather poachers, but this activity was halted in 1910 through aggressive enforcement. Introduced mice and rabbits denuded the island of vegetation. Subsequent visits to Lisianski Island appear to have been limited. The island is unoccupied except for NMFS and USFWS summer field camps. Kapou is an important breeding and pupping island for ʻīlioholoikaua and provides significant nesting habitat for seabirds, including the largest Bonin petrel colony in the world.

Kamole (Laysan Island), the largest land area in the NWHI at 4 square kilometers (1.6 square miles), is a coral-sand island enclosing a hyper-saline lake of about 0.5 square

kilometers (0.2 square miles) in area. The island is about 3 kilometers (2 miles) long and 1.6 kilometers (1 mile) wide and is partially surrounded by a fringing reef. Maximum elevation is 12 meters (40 feet). It has about 40,500 hectares (100,000 acres) of reef habitat. The first well-documented visit was by the Russian ship *Moller* in 1828. The biota of the island remained relatively undisturbed until the late 19th century. By the turn of the century, the activities of sealers and guano miners had seriously affected the ʻīlioholoikauaua population, nearly eliminating it. These activities were followed in 1909 to 1910 by intensive harvesting of bird skins and feathers by Japanese poachers, who carried out an additional poaching raid in 1915. Since that time, visits to Kamole have primarily been those of survey parties and scientific expeditions. The island has been occupied nearly continuously since 1991 by USFWS staff and volunteers attempting to eradicate invasive weeds and during the summer months by a NMFS field camp. The whole island is designated as critical habitat for endangered plants. Endangered and endemic Laysan ducks and Laysan finches occur naturally only on Kamole (though a group of Laysan ducks was successfully introduced outside its native range to Kuaihelani, and Laysan finches were introduced to Manawai). About 2 million individuals from 17 seabird species nest on the island. Kamole has the state's largest nesting colonies of mōlī and kaʻupu. Kamole also has the largest colonies of ʻuaʻu kani and Christmas shearwaters, and a significant colony of koaʻe ʻula. Revegetation with native plants is currently occurring as well as efforts to remove invasive *Verbesina* and *Cenchrus* weeds. After several years of concerted effort, *Cenchrus* is now believed to have been eradicated from the island. Kamole is the northernmost area where *Acropora* corals occur in the NWHI.

Kamokuokamohoaliʻi (Maro Reef), is an irregular reef network with no distinct atoll or fringing reef. It is approximately 19 kilometers by 10 kilometers (12 miles by 6 miles) in size. It has about 202,300 hectares (500,000 acres) of reef habitat. There is only a small awash rock outcrop and no terrestrial wildlife. Maro Reef does not contain a consistent fringing reef, only intertwined reef spurs radiating out and encompassing several relatively isolated lagoons. High vertical relief and algal cover on the reefs are also atypical for the NWHI. ʻĪlioholoikauaua and honu occur here but do not give birth or nest here because of the lack of haul-out and nesting habitat. There are large populations of Galapagos (*Carcharhinus galapagensis*) and other sharks that appear to occupy some of the predatory niche otherwise occupied by ulua (*Carangidae*) at other NWHI atolls.

Lalo (French Frigate Shoals), a crescent-shaped coral atoll about 19 kilometers by 28 kilometers (12 miles by 18 miles) in size, is open to the west and partially enclosed by a crescent-shaped reef to the east. The largest land area in the atoll is Tern Island; a number of smaller islets are scattered along the westerly reef of the crescent. There are two exposed emergent volcanic rocks called La Perouse Pinnacles. Total land area is about 0.3 square kilometers (0.1 square miles); maximum elevation is 36 meters (120 feet) at La Perouse Pinnacle. French Frigate Shoals has about 93,000 hectares (230,000 acres) of reef habitat. In 1786, Compte de La Pérouse, a French naval officer and explorer, nearly lost two frigates at the atoll, the event giving the atoll its name. La Perouse Pinnacles was often mistaken as another sailing vessel causing ships to run aground at the atoll. In 1859, the Hawaiian vessel, Gambia, stopped at the atoll. In 1882, a vessel chartered by a U.S.

company visited the atoll and departed with a cargo of shark (flesh, fins, and oil), turtles (shells and oil), bêche-de-mer (sea cucumber), and bird down. In 1895, the atoll was officially annexed by the Republic of Hawai‘i. During the 1930s, the U.S. Navy used the area extensively for training exercises. Following the Battle of Midway during World War II, an airbase was established on Tern Island, and construction of a LORAN station was begun in 1944 on East Island. When the airbase was closed in 1946, fishermen from Hawai‘i began to use the facilities. The East Island LORAN station was in operation until 1952. At that time a new LORAN station at Tern Island was activated and was operated by the USCG until mid-1979. A small staff from USFWS occupied the facility from that date until 2013, augmented by representatives of other agencies and private projects. A powerful storm devastated the Tern Island field station in 2013, and there has been no permanent USFWS presence since. French Frigate Shoals has the largest breeding populations of ‘īlioholoikauaua and honu and the highest coral diversity in the NWHI. There is a landfill on Tern Island that is contaminated with PCBs and lead; it has been proposed for removal from Tern Island in 2024. The dilapidated seawall supporting the runway foundation along the northern margin of the island is a priority management issue as the wall can trap and harm seals, turtles, and other wildlife. This is the only location in the NWHI where all 18 seabird species known to nest in the NWHI are present.

‘Ōnūnui and ‘Ōnūiki* (*Gardner Pinnacles) has a total land area of 0.03 square kilometers (0.01 square miles) and a maximum elevation of 57 meters (190 feet). It has about 242,800 hectares (600,000 acres) of reef habitat. In 1820, Captain Joseph Allen of the Nantucket whaler, Maro, reported seeing the island and naming it Gardner’s Island. The two volcanic rocks serve as roosting and breeding sites for smaller populations of 12 species of seabirds, including blue-gray noddies. A few ‘īlioholoikauaua haul out there. Coral diversity is high but abundance is low because of the lack of shallow-water habitat and the predominance of high wave energy from the exposure to the open sea on all sides. Gardner Pinnacles has one species of plant, the succulent sea purslane. Despite its small size and isolation, the island has a wide array of insects. Spiders, mites, moths, centipedes, flies, beetles, isopods and earwigs, among others, are found on Gardner Pinnacles.

Mokumanamana (Necker Island), about 1.4 kilometers (0.7 miles) long by 0.2 kilometers (0.2 miles) wide, is a rocky, J-shaped island consisting of two parts connected by a low isthmus. Total land area is 0.6 square kilometers (0.07 square miles) and maximum elevation is 82 meters (276 feet). It has about 153,800 hectares (380,000 acres) of reef habitat. Its European discovery is credited to Compte de La Pérouse in 1786 who named the island Necker after Jacques Necker, the finance minister under Louis XVI but prehistoric habitation of the island was noted in about 1879 by one of the early landing parties. Mokumanamana is known for its numerous wahi pana (religious places) and mea makamae (cultural objects). Fifty-five cultural places are known, of which 33 are religious, 17 are shelter caves, and 2 sites are of unknown function. These cultural sites are thought to date primarily before the habitation sites on Nihoa Island were abandoned in the eighteenth century. Ships periodically visited the island during the mid- and late-1800s, but heavy seas often thwarted landings. In 1857, Kamehameha IV sent Captain John Paty to claim Mokumanamana for the Kingdom of Hawai‘i. This claim was

contested until 1894 when the island was annexed by the Republic of Hawai‘i. During the period of feather poaching by the Japanese early in the 20th century, patrol vessels visited Mokumanamana, but no evidence of harassment of the birdlife was seen. The whole island is designated as critical habitat for three endemic endangered plants. Nine insects are endemic to the island as are one trap-door spider and one land snail. About 60,000 seabirds from 16 species nest or roost on the island. There is a large colony of blue-gray noddies. Observations of ‘īlioholoikauaua at the island suggest that the species has occurred there regularly for at least a century, although likely for much longer. Mokumanamana Island is uninhabited and only rarely visited by humans. Both Mokumanamana and Nihoa have low coral diversity (less than 20 species) because of high wave action and scour.

Nihoa Island, the easternmost point of the NWHI, is a precipitous remnant of a volcanic peak, about 450 meters (1,500 feet) long and ranging in width from roughly 90 to 320 meters (300 to 1,000 feet). Total land area is 0.6 square kilometers (0.3 square miles); maximum elevation is 269 meters (903 feet). It has about 57,500 hectares (142,000 acres) of reef habitat. This remote land of rugged cliffs and steep valleys provided a home for Native Hawaiians between A.D. 1000 and A.D. 1700. More than 80 cultural sites are known, including habitation terraces and bluff shelters, religious places, agricultural terraces, and burial caves. Many of the mea makamae (cultural objects) and structures associated with these wahi pana (cultural places) are similar to many found throughout the Main Hawaiian Islands. It is believed that the abundance of natural resources and at least three freshwater seeps may have supported as many as 175 people between A.D. 1000 and A.D. 1700. Over the years, difficulties in landing on the steep slopes of Nihoa have restricted visits and may explain why feather poachers did not attempt to exploit the island. European discovery is credited to Captain Douglas of the ship Iphegenia who visited the island in 1789 and noted it was uninhabited. Queen Ka‘ahumanu visited Nihoa in 1822 and annexed it as part of the Kingdom of Hawai‘i. In 1857, King Kamehameha IV officially annexed the island. In 1885, Queen Lili‘uokalani and her 200-person entourage visited Nihoa and documented their trip. During the 1960s, military personnel occupied Nihoa briefly. The island is rarely visited but mainly visited only by USFWS staff, other researchers, and Native Hawaiians on cultural expeditions. The whole island is designated as critical habitat for endangered plants including three species endemic to the island. Endemic Nihoa millerbird and endemic Nihoa finch are both ESA-listed. Over 500,000 seabirds nest on the island. Fifty Nihoa millerbirds were translocated to Laysan in 2011–2012 and the population has grown steadily on Laysan to roughly 160 individuals now. The island supports the largest known colony of ‘ou in the world. It also supports the largest colonies of ‘iwa, ‘ā (brown boobies and red-footed boobies), noio (black noddies), blue-gray noddies, noio-kōhā (brown boobies) and manu-o-Kū (white terns). There are at least 17 insects-- six ticks and mites, a trap-door spider, and six endemic land snails. Recent outbreaks of the non-native grasshopper, *Schistocerca,* are a concern for endangered plants and the birds and invertebrates that rely on this habitat.

SPECIES AND HABITATS OF IMPORTANCE

Laysan, Lisianski, Nihoa, and Mokumanamana Islands are the most important islands for arthropods, seabirds, the endangered passerines (Laysan finch, Nihoa finch, and Nihoa

millerbird) and Laysan duck. Data on seabird numbers is available through the federal Pacific Seabird Monitoring Database. Honu and ʻīlioholoikauaua have their largest reproductive groups at French Frigate Shoals. Data on ʻīlioholoikauaua and honu are maintained by NMFS Pacific Islands Fisheries Science Center. Critical habitat for the Hawaiian monk seal was designated by NMFS in 1988 out from shore to 20 fathoms around the named islands (from Nihoa to Kure Atoll). Laysan ducks were translocated in 2004 to Midway Atoll and to Kure Atoll in 2014. Survival is high among translocated birds, which produced at least 19 young in 2015.

For marine species there is a peak in species diversity in the middle of the NWHI, near French Frigate Shoals. The extreme north has cooler water temperatures that may limit some coral species and geographic isolation that may limit dispersal and recruitment of some species. The middle islands are also closer to Johnston Atoll and other Central Pacific islands that may serve as stepping stones for recruitment of species from the south. In particular, some fishes and acroporid corals appear to exist in the NWHI for this reason. Abundance of species is good in most places, and historical damage from recent human occupation on Kure, Midway, and French Frigate Shoals is now reduced with the removal of military and USCG facilities. A few endemic marine species only occur in the NWHI. They are: *Synchiropus kinmeiensis* (a dragonet fish) which has been collected from Maro Reef through Kure Atoll; *Scorpaenopsis pluralis* (a scorpionfish), known only from the holotype (original described specimen) collected off Laysan; *Epigonius devaneyi* (a deep water cardinalfish) which has been found from Mokumanamana to Maro Reef; and *Nerita plicata*, a shallow water snail that is found only in the NWHI. Biological data are gathered by USFWS, NMFS, National Ocean Service, and Division of Aquatic Resources (DAR) research programs as well as collaborative research cruises among these agencies.

SUMMARY OF KEY THREATS TO SPECIES AND HABITATS

Many general threats to native wildlife are discussed in Chapter 4 (Statewide Conservation Needs) and Chapter 5 (Marine Conservation Needs). Threats more acute or specific to the NWHI are listed below.

- Habitat degradation from non-native vegetation (*Cenchrus*, *Verbesina*);
- Unknown factors leading to decline in ʻīlioholoikaua, especially at French Frigate Shoals, possibly related to changes in ocean productivity;
- Pollution (PCBs and lead contamination on Tern Island; PCBs, pesticides, and copper at Kure);
- Marine debris (since 1996, 1,167 metric tons (more than 2 million pounds) of primarily derelict fishing gear and plastics have been removed by NOAA and partner non-profit organizations Papahānaumokuākea Marine Debris Project and National Fish and Wildlife Foundation);
- Introduced species on land or in water (historically, rabbits on Laysan and rats on Kure; currently, *Schistocerca* grasshoppers on Nihoa, *Acanthophora spicifera* on Kuaihelani, *Chondria tumulosa* on Manawai, Hōlanikū, and Kuaihelani, taʻape and roi through the NWHI, along with at least 80 other introduced insect species);

- Seabirds and marine mammals are threatened by longline fishery interactions outside state jurisdiction;
- Climate change leading to loss of island habitat from storms and sea-level change, alteration to food webs, and exacerbation of other stressors; and
- Natural disasters.

NWHI STRATEGIES

In addition to the statewide strategies identified in association with the seven conservation objectives in Chapter 4 (Statewide Conservation Needs) (main bullet), additional NWHI specific strategies include the following (sub-bullet):

- Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive.
    - Implement Recovery Plans for honu and ʻīlioholoikauaua;
    - Collaborate between state and federal agencies and encourage Hawaiʻi residents to take steps that would reduce factors leading to climate change impacts;
    - Develop, revise, and/or implement formal recovery plans for threatened and endangered species in the NWHI;
    - Continue to ensure the success of Laysan duck and Nihoa millerbird translocations;
    - Maintain a year-round presence on Kure Atoll to facilitate expanded research, management, and education activities;
    - Continue implementing access and management plan initiatives in the PMNM and all management areas in the NWHI; and
    - Mitigate pollution and implement contaminant remediation measures at Kure Atoll and Tern Island.
- Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
    - Decrease the acreage dominated by invasive, non-native vegetation and insects; and
    - Monitor for non-native marine algae and implement management response if detected.
    - Improve on and follow Best Management Practices (BMPs) to minimize the spread of nuisance algae.
- Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs.
    - Improve dissemination of research information and data regarding native species populations and habitat condition;
    - Conduct surveys and inventories for invertebrates in currently managed and unmanaged areas;
    - Better understand the population dynamics and important ecological factors explaining declines in ʻīlioholoikaua, especially at Lalo; and
    - Continue research that addresses the feeding ecology, distribution, life history, pathology, and threats affecting Hawaiian monk seal recovery.

- Strengthen existing and create new partnerships and cooperative efforts.
    - Continue to coordinate with PMNM Co-Trustee agencies to enhance and implement protections and management actions for marine species in the NWHI, and continue implementing measures that reduce and mitigate fishery interaction and bycatch; and
    - Enhance partnerships with federal enforcement agencies including the USCG and NOAA Office of Law Enforcement.
- Support policy changes aimed at improving and protecting native species and habitats.
    - Continue to develop and advance secure and adequate funding for long-term and enduring management of marine and other trust resources; and
    - Assess ways to support increased enforcement and surveillance capacities, including the use of new technologies and increased interagency enforcement capacity.
    - Translocation of seabird species to Main Hawaiian Islands and other high islands or coastal areas

PLANS AND TOOLS TO AID MANAGEMENT

Management plans and tools exist to address some of the threats listed in the Summary of Key Threats to Species and Habitats section. Many apply to the entire marine ecosystem and thus are placed here.

- The HINWR maintains up-to-date information to educate the public and management community on issues and activities associated with management of NWHI refuge areas and resources. Information available at: http://www.fws.gov/refuges/profiles/index.cfm?id=12526;
- PNMN provides information on management activities and initiatives being implemented by Co-Trustee agencies. Available at: http://www.papahanaumokuakea.gov/;
- The Western Pacific Regional Fisheries Management Council has Fisheries Management Plans that guide fishing for Bottomfish and Seamount Fisheries, Precious Corals, Crustaceans, Coral Reef Ecosystems, and Pelagic species. Available at: www.wpcouncil.org;
- Species Conservation Plans prepared by USFWS and NMFS, including the *Regional Seabird Conservation Plan* (2005), *U.S. Pacific Islands Regional Shorebird Conservation Plan* (2004), the *Draft Revised Recovery Plan for the Laysan Duck* (2004); the *Northwestern Hawaiian Islands Passerines Recovery Plan* (1984); *Recovery Plan for the Hawaiian Monk Seal* (2004); and recovery plans for the U.S. Pacific populations of the green sea turtle, hawksbill sea turtle, leatherback turtle, loggerhead turtle, and olive ridley turtle (1998);
- The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve has an operations plan that is incorporated into the PMNM strategic management plan. Available at: http://www.papahanaumokuakea.gov/;
- NOAA CoastWatch uses a variety of satellite remote sensing datasets in an effort to better monitor and analyze the central Pacific Ocean. Information and data available at: http://www.nsof.class.noaa.gov/glossary/CWHAW.htm; and

- NOAA's Coral Reef Information System (CoRIS) is designed to be a single point of access to NOAA coral reef information and data products, especially those derived from NOAA's Coral Reef Conservation Program. Information and data available at: http://www.coris.noaa.gov/.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key species and habitats of the NWHI. Future needs are being considered by all agencies with management authority over NWHI wildlife. Currently managed areas consist of a State Wildlife Sanctuary, a State Marine Refuge, National Wildlife Refuges, a National Memorial, a Coral Reef Ecosystem Reserve, and a Marine National Monument. Hawai'i's State Wildlife Action Plan recognizes the importance of the ongoing actions in these managed areas and considers these actions a priority.

In addition to currently managed areas, other conservation actions for the NWHI are being considered. Revisions to catch limits, open and closed fishing areas, and fishing methods are always under review and consideration by DAR. The HINWR in the NWHI is developing an updated management plan for terrestrial and marine areas. The NWHI has benefited enormously by the creation of PMNM, which has greatly enhanced the comprehensive agency co-management of trust resources in the NWHI ecosystem. A discussion of future management needs is highlighted within each currently managed area below.

***Kure Atoll State Wildlife Sanctuary* (260 acres), Division of Forestry and Wildlife**

Species: Seabirds,ʻīlioholoikaua, Laysan duck, spinner dolphin.
***Habitats*:** Atoll ecosystem consisting of shallow coral reefs, sandy beach, lagoon and rocky habitats, low-lying emergent lands with unique vegetation communities.
***Current Management*:** Limited access, invasive species control and active biosecurity precautions, native vegetation replanting, monitoring of seabirds, ʻīlioholoikaua, Laysan duck, and small cetaceans, and marine debris documentation and removal.
***Future Needs*:** Additional monitoring; ten-year uninterrupted presence needed to achieve invasive *Verbesina* eradication and restoration objectives.

***Hawaiian Islands National Wildlife Refuge* (620,000 acres), USFWS**

***Species*:** Laysan finch, Laysan duck, Nihoa millerbird, Nihoa finch, 18 seabirds, migratory shorebirds, ʻīlioholoikaua, honu, endemic coral reef organisms, pelagic fishes, bottomfishes, sandy habitat organisms, spinner dolphins, and other cetaceans.
Habitats: Atoll and low oceanic island ecosystem, coral reefs, pelagic ecosystem, hypersaline lake, unique vegetation communities.
***Current Management*:** Limited access, limited take, active biosecurity procedures to limit unwanted introductions of species and pathogen agents, invasive species

control and removal, endangered species monitoring, translocation, and range expansion. Native species reintroduction, seabird monitoring and research, and coral reef monitoring and research. NMFS conducts research and monitoring on honu and ʻīlioholoikaua, leads a multi-partner effort to remove marine debris from beaches and reefs of the NWHI, collaborates with marine researchers, and conducts public education and cultural outreach.
***Future Needs*:** Revise management plan as necessary; coordinate actions with the State of Hawaiʻi and federal agency partners; secure necessary funding and support to implement needed environmental remediation measures, reconstruct new field station and support facilities at Tern Island and French Frigate Shoals, and ensure that long-term monitoring can be implemented and maintained at Laysan and other critical locations in the refuge.

***Papahānaumokuākea Marine National Monument, Hawai'i,* Agency Co-Trustees: DLNR, NOAA, USFWS, and OHA**

Species: ʻīlioholoikaua, honu, endemic coral reef organisms, pelagic fishes, bottomfishes, sandy habitat organisms, spinner dolphins and other cetaceans.
Habitats: Marine ecosystems, atolls, low-elevation oceanic islands.
***Current Management*:** Limited access and take, no anchoring or any other activities that can damage coral, no discharge of pollutants, agency co-management, cultural outreach and practices.
***Future Needs*:** Continue to leverage the necessary funding to ensure long-term support for needed management initiatives and agency co-management capacity.

***NWHI Coral Reef Ecosystem Reserve*, NOAA**

Species: ʻīlioholoikaua, honu, endemic coral reef organisms, pelagic fishes, bottomfishes, sandy habitat organisms, spinner dolphins and other cetaceans.
Habitats: Large coral reef ecosystems, submerged oceanic banks, pelagic communities.
***Current Management*:** Limited access and take, no anchoring or any other activities that can damage coral, and no discharge of pollutants; research activities and educational opportunities.
***Future Needs*:** Continue to leverage the necessary funding to ensure long-term support for needed management initiatives, implement research, and refine management plan.

The Northwestern Hawaiian Islands Marine Refuge, DAR

Species: Some or all regulated fish species.
Habitats: Marine ecosystems.
Current Management: Limited take, gear, size, season, and/or area restrictions.
Future needs: Evaluate purpose and management effectiveness and consider need for additional management.

References:

Evenhuis NL, Eldredge LG, editors. 2004. Natural history of Nihoa and Necker Islands. Honolulu, (HI): Bishop Museum Press. 222 pp.

Harrison, C.S. 1990. Seabirds of Hawai‘i: Natural History and Conservation. Cornell University Press.

Hawai‘i Department of Business, Economic Development, and Tourism. 2003. State of Hawai‘i data book. Available at: http://www3.Hawai’i.gov/DBEDT/index.cfm?section=READ_Databook1075. (Accessed 28 March 2005).

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

King R. D., surveyor. 1931. Index to the Islands of the Territory of Hawaii Including Other Islands Under the Sovereignty of the United States Scattered in the North Pacific Ocean.

Maragos J, Gulko D, editors. 2002. Coral reef ecosystems of the Northwestern Hawaiian Islands: interim results emphasizing the 2000 surveys. Honolulu, (HI): U. S. Fish and Wildlife Service and Hawai’i Department of Land and Natural Resources. 46 pp.

National Oceanic and Atmospheric Administration (US) [NOAA]. 1988. Critical habitat, Hawaiian monk seal, Endangered Species Act. Federal Register 53(102):18988-18998.

National Oceanic and Atmospheric Administration. (US) [NOAA]. 2005. NWHI Coral Reef Ecosystem Reserve. Final Reserve Operations Plan. Honolulu, (HI).

National Oceanic and Atmospheric Administration (US) [NOAA]. 2013. Papahānaumokuākea Marine National Monument Permitted Activities 2013 Annual Report.

National Oceanic and Atmospheric Administration, Office of Response and Restoration, Marine Debris Program. 2024. Papahānaumokuākea Marine National Monument Map. Available at: https://marinedebris.noaa.gov/images/papah-naumoku-kea-marine-national-monument#:~:text=Holoikauaua%2D%20contemporary%20Hawaiin%20name%2FPearl,name%2FH%C5%8Dlanik%C5%AB%20%2D%20ancient%20Hawaiin%20name. Accessed 28 June 2024.

Rauzon M. 2001. Isles of refuge: wildlife and history of the Northwestern Hawaiian Islands. Honolulu: University of Hawai’i Press.

Ulukau. n.d. Hawaiian Dictionaries. Available at https://wehewehe.org/. Accessed 24 June 2024.

U.S. Fish and Wildlife Service. Hawaiian Islands National Wildlife Refuge. Available at: http://refuges.fws.gov/profiles/index.cfm?id=12526.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Northwestern Hawaiian Islands passerines. Portland, (OR): U.S. Fish and Wildlife Service. 66 pp.

U.S. Fish and Wildlife Service. 1986. Hawaiian Islands National Wildlife Refuge master plan, Environmental Impact Statement. Honolulu, (HI): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1998. Laysan Island ecosystem restoration plan. Honolulu, (HI): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2002. Final economic analysis of designations of critical habitat for plant species from the NWHI. Honolulu, (HI): Research Solutions, LLC.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

CHAPTER 7: SPECIES OF GREATEST CONSERVATION NEED

In order to address required elements 1-5, Hawai‘i’s State Wildlife Action Plan (SWAP) presents information on the Species of Greatest Conservation Need (SGCNs) as taxon-specific fact sheets. Each fact sheet provides information related to the conservation status of the taxon, general information, distribution, abundance, the locations and condition of key habitats, threats, conservation actions, monitoring actions, and research priorities.

The fact sheets are grouped into the following taxonomic categories: terrestrial mammal, forest birds, raptors, waterbirds, seabirds, migratory birds (waterfowl and shorebirds), Northwestern Hawaiian Islands passerines and waterfowl, terrestrial invertebrates, freshwater fishes, freshwater invertebrates, anchialine pond fauna, marine mammals, marine reptiles, marine fishes, and marine invertebrates. Appendix A provides a comprehensive list of Hawai‘i’s Wildlife (Fauna) SGCNs, identifies the fact sheet in which information on each taxon may be found, and notes the habitat type, island distribution, and federal and state listing status.

Appendix B provides a comprehensive list of Hawai‘i’s (Flora) SGCNs and identifies each taxon’s federal and state listing status, the species in the Plant Extinction Prevention (PEP) Program (i.e., species with fewer than 50 individuals remaining in the wild), and species identified as important elements of native habitats.

Photo: USFWS

Terrestrial Mammal

ʻŌpeʻapeʻa or Hawaiian hoary bat

Lasiurus cinereus semotus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Indigenous NatureServe Heritage Rank G5/T2 – Species Secure/Subspecies Imperiled
Recovery Plan for the Hawaiian Hoary Bat – USFWS 1998

SPECIES INFORMATION: The ʻōpe ʻape ʻa, or Hawaiian hoary bat (Family: Vespertilionidae), is Hawaiʻi ʻs only native terrestrial mammal, although sub-fossil evidence indicates that at least one other bat species was native to the islands. Following genetic markers, the hoary bat may have dispersed to the Hawaiian Islands from the mainland one to two times (Baird et al. 2015; Pinzari et al. 2020). The first emigrant may have arrived approximately ten thousand years ago, and the more recent emigrant arrived an estimated 600 years ago (Russell et al. 2015). Alternatively, one migration event occurred to the island of Maui and, from Maui, hoary bats dispersed to the other islands. This document recognizes ʻōpeʻapeʻa as a single species (*Lasiurus semotus*) with geographic separation on each island (Pinzari, et al. 2023).

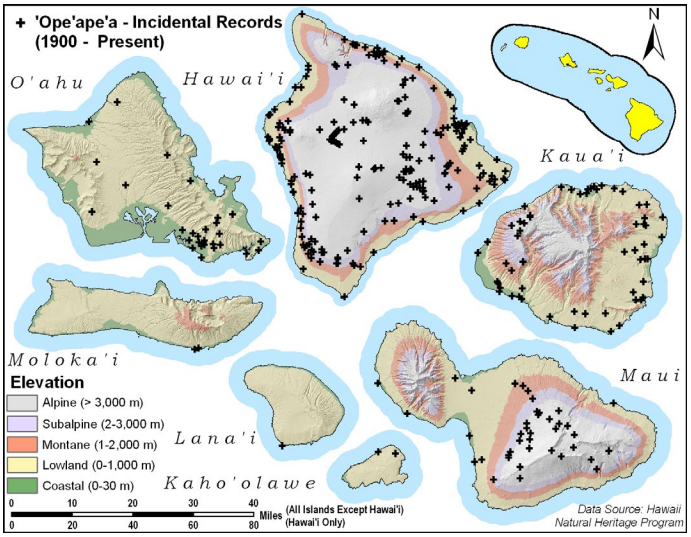
Both sexes have a coat of brown and gray fur. Individual hairs of the coat are tipped or frosted with white; hence the name "hoary" which means frosted. The older population of hoary bats on the Hawaiian Islands is typically chestnut brown in color with less white "frosting" of the fur tips—it has largely lost the "frosted" appearance. The more recent population comprises individuals that are more hoary ("frosted"), similar to mainland hoary bats. Males and females have a wingspan of approximately one-third of a meter (1 foot), and females are typically larger than males. The Hawaiian name refers to a half taro leaf or canoe sail shape; these being somewhat similar to the shape of the bat.

Data pertaining to ʻōpeʻapeʻa ecology, life history, and population estimates are limited owing largely to its cryptic and solitary nature. ʻŌpeʻapeʻa breeding has been documented on all of the main islands except for Niʻihau and Kahoʻolawe. and these studies indicate that ʻōpeʻapeʻa roost in native and non-native vegetation exceeding 15 feet in height above ground level (Montoya-Aiona, et al. 2020). The species is not observed using cracks in rocks, or human-made structures for roosting. While roosting during the day, ʻōpeʻapeʻa are solitary, although mothers and pups roost together. They begin foraging either just before or after sunset depending on the time of year. Elevation and rainfall may affect distribution and activity patterns and have been found foraging over a large range of elevation from sea level to the summit of Mauna Loa at 13,678 feet in lava tubes (Bonaccorso et al., 2016). ʻŌpe ʻape ʻa feed on a variety of native and non-

native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites; and similar to other insectivorous bats, prey is located using echolocation. ʻŌpeʻapeʻa spend about half of their time in what is called a "core use area." Generally, ʻōpeʻapeʻa tend to not overlap their core use areas with other ʻōpeʻapeʻa. Core use areas vary in size probably due to the quality of habitat each ʻōpeʻapeʻa inhabits. Water courses, gullies, and edges (e.g., coastlines and forest/pasture boundaries) appear to be important foraging areas, use lava tubes on Mauna Loa and the species is also attracted to insects that congregate near lights. Mating most likely occurs between September and December. Pregnancy occurs between April to early June and females usually give birth to twins during June. Mother bats lactate from late June through August and likely stay with their pups until they are six to seven weeks old. Females exhibit philopatry to their roost sites. Little is known regarding dispersal, but inter-island dispersal is possible.

DISTRIBUTION: In Hawai'i, ʻōpeʻapeʻa have been reported from all the Main Hawaiian Islands except for Niʻihau, although specimen records exist only for Kauaʻi, Oʻahu, Maui, Molokaʻi, and the island of Hawaiʻi. ʻŌpeʻapeʻa occur in a wide range of habitats across a wide elevation gradient. On the island of Hawaiʻi, bats are found primarily from sea level to 2,288 meters (7,500 feet) elevation, although they have been observed near the island's summits (above 3,963 meters or 13,000 feet). See "Location and Condition of Key Habitat," below, for distribution by seasons.

West EcoSystem Technology performed a distribution and occupancy study of ʻōpeʻapeʻa on the island of O ʻahu from 2016 to 2021. This study found pockets of higher detections on the North Shore of O ʻahu throughout the year (Thompson and Starcevich 2022). Further data collection is needed to determine if there are any patterns or trends to ʻōpeʻapeʻa distribution and occupancy on O ʻahu.



ABUNDANCE: Collecting actual population estimates for this species is extremely labor intensive due to their cryptic and solitary behavior. Therefore, actual population estimates for each island are unknown. Pinzari et al. 2014 study suggests that the population on the island of Hawaiʻi has been stable or is slightly increasing based on occupancy models from acoustic monitoring. Genetic studies of ʻōpeʻapeʻa using mitochondrial and microsatellite markers collected from the islands of Kaua'i, O'ahu, Maui, and Hawai'i indicate that populations may be lower on the islands of O'ahu and Maui when compared to the islands of Kaua'i and Hawai'i (Pinzari et al. 2023).

LOCATION AND CONDITION OF KEY HABITAT: ʻŌpeʻapeʻa have been found roosting in ʻōhiʻa (*Metrosideros polymorpha*), pu hala (*Pandanus tectorius*), coconut palms (*Cocos nucifera*), kukui (*Aleurites moluccana*), kiawe (*Proscopis pallida*), avocado (*Persea americana*), shower trees (*Cassie javanica*), pūkiawe (*Styphelia tameiameiae*), fern clumps, eucalyptus (*Eucalyptus* spp.), cook pine (*Araucaria columnaris*), and Norfolk Island pine (*Araucaria heterophylla*) stands. A study on the island of Hawaiʻi found that bat activity varied with season and altitude, and the greatest level of activity occurred at low elevations (below 1,280 meters or 4,200 feet) from April to December (Bonaccorso et al. 2015). Because warm temperatures are strongly associated with reproductive success in this and other bat species, it has been suggested that key breeding habitat is likely to occur at sites where the average July minimum temperature is above 11°C (52°F). If true, key breeding habitat on the island of Hawaiʻi would occur below 1,280 meters (4,200 feet) elevation (Bonaccorso et al. 2015). Because bats use both native and non-native habitat for foraging and roosting, the importance of non-native timber stands, particularly those at low elevations, should be determined. Breeding sites are known for Mānuka Natural Area Reserve and scattered areas along the Hāmākua Coast.

From September 2017 to September 2018, HT Harvey conducted a study within 34, 226 hectares on this island of Maui near Haleākala to identify ʻōpeʻapeʻa habitat use and any limiting factors affecting ʻōpeʻapeʻa habitat use. ʻŌpeʻapeʻa on Maui use gulch habitat, developed low density habitat, low elevation forest woodland, and grassland habitat, in areas surrounding Haleākala (H.T. Harvey & Associates 2020).

THREATS: Bats are affected by habitat loss, pesticides, collisions with structures, and roost disturbance. A reduction in tree cover (e.g., roost sites) might be the primary reason for the species' decline in Hawaiʻi. Pesticides also may have reduced populations. Bats are known to interact and collide with wind turbines. Lastly, bats of many species are affected by predation, so predation by cats, rats, and mongoose found in Hawai'i may impact ʻōpeʻapeʻa populations.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations and key breeding habitats, but also to establish additional populations thereby reducing the risk of extinction (U.S. Fish and Wildlife Service 1998). In addition to common statewide and island conservation actions, specific management directed toward ʻōpeʻapeʻa should include the following:

- Conserve known occupied habitat.
- Develop and implement conservation plans and strategies that guide the management and use of forests to reduce negative effects on known ʻōpeʻapeʻa populations.
- Support ʻōpeʻapeʻa research.

MONITORING: Continue surveys of occupancy and distribution in known and likely habitats and identify key limiting factors affecting the recovery of the species.

RESEARCH PRIORITIES: Given that little is known about ʻōpeʻapeʻa any research would contribute to the understanding of and ability to conserve this species. Research priorities for the ʻōpeʻapeʻa include the following:

- Develop standard survey and monitoring methods and procedures that will allow the accurate estimation of populations and changes in activity and/or occupancy.

- Continue to conduct occupancy and distribution surveys of all the Main Hawaiian Islands where ʻōpeʻapeʻa are found to examine distribution and habitat use trends.
- Identify key roosting and wintering sites.
- Better describe roost site characteristics and preferences.
- Increase efforts to track and monitor movements and behaviors.
- Determine the extent to which Hawaiian hoary bats use torpor.
- Better describe threats and important factors limiting recovery such as whether depredation by introduced animals or availability of prey represent constraints for populations.
- Continue to support the development of avoidance and minimization measures that can be effectively implemented to reduce collisions with wind turbines.
- Direct research findings toward the development of conservation and management actions that address the needs and deficiencies of the species and refine these approaches using an adaptive management approach.

References:

Baird, A. B., J. K. Braun, M. A. Mares, J. C. Morales, J. C. Patton, C. Q. Tran, and J. W. Bickham. 2015. Molecular systematic revision of tree bats (Lasiurini): doubling the native mammals of the Hawaiian Islands. *Journal of Mammology* 96:1255-1274. DOI 10.1093/jmammal/gyv135

Bonaccorso, F.J., C. M. Todd, A. C. Miles, and P. M. Gorresen. 2015. Foraging range movements of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus* (Chiroptera: Vespertilionidae). Journal of Mammalogy 96(1):64-71. 2015

Bonaccorso, F.J., K. Montoya-Aiona, C.A. Pinzari, C.M. Todd, 2016. Winter distribution and use of high elevation caves as foraging sites by the endangered Hawaiian hoary bat, Lasiurus cinereus semotus. Technical Report HCSU-068

Harvey, H. T. & Associates. 2020. Hawaiian hoary bat research: Maui. Final Report 2019. 117pp.

Hawaiian Hoary Bat Research Cooperative. Available at: http://www.dofaw.net/fbrp/projects.php?id=39.Hawai'i Natural Heritage Program [Hawai'i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai'i, Center for Conservation Research and Training. Honolulu, HI.

Pinzari, C. A., F. J. Bonaccorso, and K. Montoya-Aiona. 2014 Hawaiian Hoary bat occupancy at kaloko-honokohau National Historical Park Hawaii Cooperative Studies Unit, University of Hawaii at Hilo, Technical Report 51:1-19

Pinzari, C. A., L. Kang, P. Michalak, D. K. Jermiin Ls Price, and F. J. Bonaccorso. 2020. Analysis of genomic sequence data reveals the origin and evolutionary separation of Hawaiian Hoary Bat populations. *Genome Biology and Evolution* 12: 1504-1514. doi 10.1093/gbe/evaa137.

Pinzari, C. A., M. R. Bellinger, D. Price, and F. J. Bonaccorso. 2023. Genetic diversity, structure, and effective population size of an endangered, endemic hoary bat, ʻōpeʻapeʻa, across the Hawaiian Islands. *PeerJ* 11: e14365. http://doi.org/10.7717/peerj.14365.

Russell AL, CA Pinzari, MJ Vonhof, KJ Olival, FJ Bonaccorso. 2015. Two Tickets to Paradise: Multiple Dispersal Events in the Founding of Hoary Bat Populations in Hawai'i. PLoS ONE 10(6): e0127912. doi:10.1371/journal.pone.0127912

Thompson, J. and L. A. Starcevich. 2022. Oahu Hawaiian hoary bat occupany and distribution study. Final Report. 32pp.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

Photo: Jim Denny

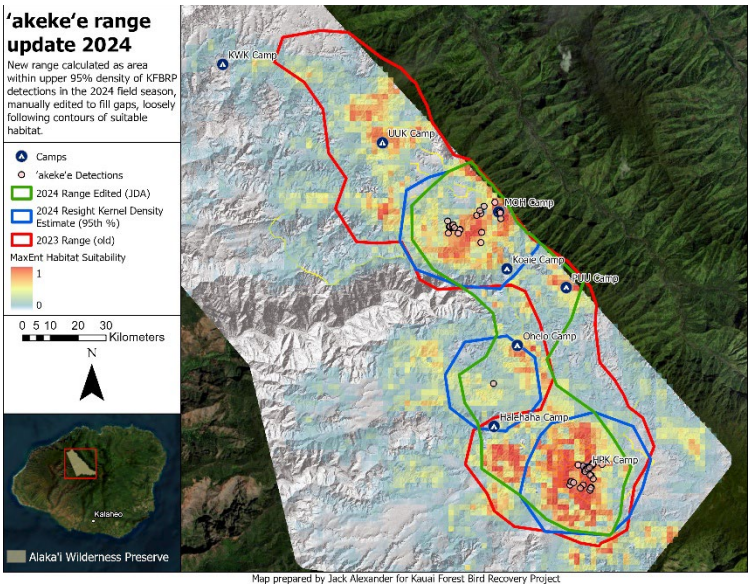
Forest Birds

‘Akeke‘e

Loxops caeruleirostris

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006
Kauai Islandwide Recovery Plan – USFWS 2021

SPECIES INFORMATION: The ‘akeke‘e, or Kaua‘i ‘ākepa, is a small, slightly sexually dichromatic, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to Kaua‘i. Adult males and females are greenish above and yellow below with a yellow crown and a black mask; females are slightly duller than males. Unlike the similar Kaua‘i ’amakihi (*Hemignathus kauaiensis*), the ‘akeke‘e’s bill is conical. Although not visible in the field, the lower mandible of the ‘akeke‘e is slightly bent to one side which results in the mandible tips being offset; a characteristic shared with the ‘ākepa (*L. coccineus*). The ‘akeke‘e uses its bill to pry open ‘ōhi‘a (*Metrosideros polymorpha*) leaves and flower buds in search of arthropods, primarily spiders, psyllids, and caterpillars. The species is an ‘ōhi‘a specialist and rarely even perches on other trees or shrubs. Its methodical probing of leaf buds is distinctive and can be used to identify the species. keke‘e are most often observed in pairs or family groups. A study of 22 ‘akeke‘e nests monitored from 2012-2017 found a preference for nesting in small terminal branches of ōhi‘a trees at higher elevation and taller canopy heights, as well as a negative relationship with slope (Fricker et al. 2021). In a sample of eight nests monitored in 2012 and 2013, mean nest height was 11.1 ± 2.3 m, and all nests were also located in the small terminal branches of ‘ōhi‘ . 2015). On one occasion a male was observed helping the female build the nest, btu on all other occasions, only the presumed female has built the nest (few ’akeke’e are color banded so it is often difficult to determine which bird is the female unless she is incubation. The species has been observed to renest and double brood in at least one instance. Multiple adults and subadults attend nests.



DISTRIBUTION: Formerly found in native forests of the Alakaʻi swamp, upper Waimea, and Kōkeʻe regions mostly above 1,000 meters (3,280 feet) elevation but are now restricted only to the Alakaʻi Wilderness Preserve (DOFAW, unpublished data) at a mean elevation of 1298.7m (± 50.6m; Fricker et al. 2021). Although historically widespread, ʻakekeʻe apparently did not occur at lower elevations. Occupancy rates in 2012 increased from west to east along the plateau ($\psi = 0.03 \pm 0.10$ to 0.53 ± 0.33) but were low throughout its range (Behnke et al. 2016). The estimated suitable habitat range based on surveys from 2012-2017 was 58km^2 (Fricker et al 2021), which represented a small fraction of the former range. Based on data from 2023 and 2024, the range is now much smaller at approximately 1234 ha (3049 ac; KFBRP, unpublished data), and the species occurs primarily at Halepaʻakai and Mohihi .

ABUNDANCE: In the early 1970s the island-wide population was estimated at 5,066 ± 1,680 (SE) individuals. The Kauaʻi Forest Bird Survey in 2012 suggested that the population was rapidly declining, especially in the periphery of its range; the 2012 population estimate was 945 (95% confidence interval: 460 to 1,547) individuals (Paxton et al. 2016). Surveys in 2018 suggested that the population was relatively stable (Paxton et al. 2020), however the 2023 surveys showed ongoing declines to 765 (95% confidence interval: 297 to 1285) individuals (U.S. Geological Survey unpublished data). Preliminary data from occupancy surveys in 2024 suggest further declines in abundance to fewer than 100 individuals, and ongoing range contraction (Kauai Forest bird Recovery Project, unpublished data). Densities are highest in the interior of the Alakaʻi Wilderness Preserve.

LOCATION AND CONDITION OF KEY HABITAT: Occurs above 600 meters (1,950 feet), although populations are densest above 1,100 meters (3,600 feet), in lowland mesic and wet forests dominated by ʻōhiʻa, koa (*Acacia koa*), ʻōlapa (*Cheirodendron trigynum*), and lapalapa (*C. platyphyllum*). Most of the current range the southern Alakaʻi Wilderness Preserve; the species no longer occurs in Kōkeʻe State Park or the northern or western Alakaʻi. Occupancy is positively correlated with canopy height and maximum ʻōhiʻa diameter at breast height.

THREATS:

- Habitat degradation. The spread of non-native plants and degradation by ungulates may reduce habitat suitability. The correlation of occupancy with large tree metrics suggest that damage done by two hurricanes may also limit distribution and abundance.

- Disease. ‘Akeke‘e is highly susceptible to mosquito-borne avian malaria. Two of 11 ‘akeke‘e have tested positive for malarial antibodies since 2011; since malaria is established on the Alaka‘i Plateau, the most likely explanation for this result is high mortality after infection with malaria. Disease, habitat degradation, and predation are the most probable causes of population declines in this species in the last decade.
- Competition. Non-native insects, especially yellow-jackets (*Vespula pensylvanica*) and ants (*Linepithema humile*), may compete with or prey on the native arthropods on which ‘akeke‘e feed. The role of non-native insects in native Hawaiian forests is unclear.
- Predation. Rats (*Rattus* spp.), cats (*Felis catus*), Hawaiian short-eared owls (*Asio flammeus sandwichensis*), and barn owls (*Tyto alba*) occur throughout the forests of Kaua’i and may prey on young and adults. Rat predation on a female ‘akeke‘e and her young was observed at Halepa‘akai.
- Small population dynamics. The observed hatching failures may indicate genetic issues associated with small population sizes.

CONSERVATION ACTIONS: ‘Akeke‘e likely benefited from actions to conserve other endangered forest birds including the establishment of the Alaka‘i Wilderness Preserve, regular surveys of forest bird populations, habitat monitoring, studies of disease and disease vectors, control of feral ungulates through public hunting and fencing, suppression of rats on two A24 trapping grids over approximately 150 ha (470 ac), and public education featuring Kauai’s endangered forest birds. In 2015-2018, an effort to form a captive flock was initiated by collecting ‘akeke‘e eggs from the wild. Twenty-six eggs were harvested from ten nests; most eggs hatched but many chicks did not survive to fledging, resulting in a 10 adult ‘akeke‘e. The flock has since suffered more attrition, but successful breeding was achieved in 2023 and there are currently seven ‘akeke‘e in human care. In addition to these efforts, future actions specific to the ‘akeke‘e may include the following:

- Resume collections of 'akeke‘e to increase the size of the captive flock
- Aggressively control ungulates to improve habitat quality, facilitate the recovery of degraded habitat, and potentially reduce breeding habitat for mosquitoes. Control of non-native plants should be part of forest restoration efforts.
- Eradicate or manage mosquito breeding habitat on the Alaka‘i Plateau
- Suppress mosquito populations through releases of incompatible or sterile mosquitoes
- Investigate options to eradicate mosquitoes, including use of genetic manipulation.
- Suppress/control rats, feral cats, and barn owls from the Alaka‘i Wilderness Preserve, Na Pali-Kona Forest Reserve, and Kōke‘e State Park
- Prevent the introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other predators.
- Prevent the spread of Rapid ‘ōhi‘a Death on the Alaka‘i Plateau
- Conduct public outreach and education
- Continue protection and management of wildlife sanctuaries and refuges
- Collect genetic samples from as many individuals as possible for bio-banking, ge rescue, and cloning
- Explore translocating birds from Kaua‘i to other locations

MONITORING: Continue Forest bird surveys and habitat monitoring. Conduct species-specific monitoring for ʻakekeʻe (e.g., occupancy surveys with play back, territory monitoring, use of ARUs) that take into account the inability of the HFBS to accurately track populations of rare species

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the ʻakekeʻe include the following:

- Investigate techniques for improving survival and reproduction of the captive flock
- Conduct PVAs for both wild and captive flocks
- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology, and success of this poorly known species.
- Continue to assess the species' susceptibility to avian malaria and avian pox.
- Determine sources of mosquitoes and investigate appropriate methods of mosquito control.
- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps)
- Determine the effects of recently established non-native insects on native arthropods, especially those that are part of the species' diet.

References:

Atkinson, CT, RB Utzurrum, DA LaPointe, RJ Camp, LH Crampton, JT Foster, and TW Giambelluca. 2014. Changing Climate and the Altitudinal Range of Avian Malaria in the Hawaiian Islands - an Ongoing Conservation Crisis on the Island of Kauaʻi. Global Change Biology 20, 2426–2436, doi: 10.1111/gcb.12535.

Behnke, L. 2014. Habitat use and conservation implications for Akikiki (*Oreomystsis bairdi)* and Akekee (*Loxops caeruleirostris)*, two endangered Hawaiian honeycreepers. M.S. Thesis. Colorado State University, Fort Collins, CO.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

Fricker GA, Crampton LH, Gallerani EM, Hite JM, Inman R, Gillespie TW. 2021. Application of lidar for critical endangered bird species conservation on the island of Kauai, Hawaii. Ecosphere 12(6).

Hammond, RL, Crampton, LH, and Foster, JT. 2015. Breeding biology of two endangered forest birds on the island of Kaua'i. Condor 117: 31-40.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK, Pratt HD. 1997. ʻAkekeʻe (*Loxops caeruleirostris*). *In* The Birds of North America, No. 295 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Paxton ER, Camp MG, Crampton LH, Leonard DL, VanderWerf EA. 2016. Collapsing avian community on a Hawaiian island. Science Advances 2:e1600029.

Paxton ER, Brinck KW, Crampton LH, Hite J, Constantini M. 2020. 2018 Kaua‘i forest bird population estimates and trends. Technical Report Hawai’i Cooperative Studies Unit. University of Hawai’i at Hilo.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2021. Kauai Islandwide Recovery Plan. Portland, (OR): U.S. Fish and Wildlife Service. https://www.fws.gov/node/264716

Photo: UH EECB

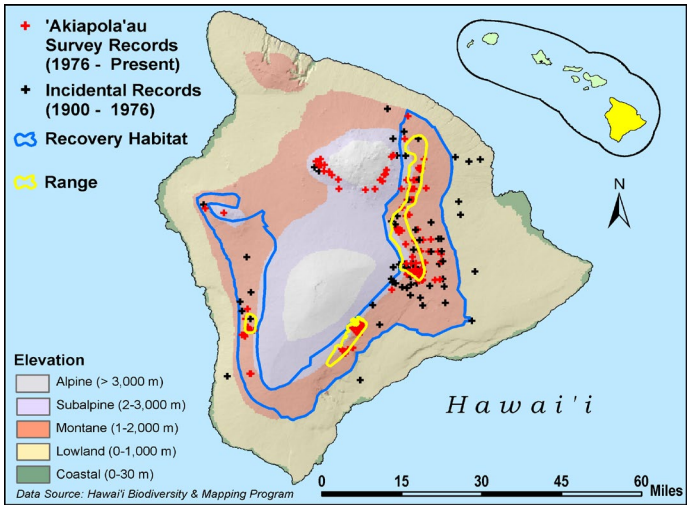
Forest Birds

ʻAkiapōlāʻau

Hemignathus munroi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: Theʻakiapōlāʻau is a stocky Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawaiʻi and most famous for their specialized bills, which have a long, decurved upper mandible and a short woodpecker-like lower mandible. Adult males have a bright yellow head and underparts, yellow-green back and wings, and a small, black mask. Adult females are olive above with grayish-yellow to yellow underparts. Males are larger than females and have longer bills. They often join mixed species foraging flocks; the constituent species vary depending on habitat. ʻAkiapōlāʻau are mainly insectivorous, with Lepidoptera larva, spiders, and beetle larva being the most important prey items; rarely takes nectar but takes sap from holes it excavates in ʻōhiʻa (*Metrosideros polymorpha*) trees. Most frequently, creeps along lichen covered and dead branches of koa (*Acacia koa*), kōlea (*Myrsine lessertiana*), māmane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*) trees tapping branches with their lower mandible to locate prey. Once a food item is located, lower mandible is used similar to that of a woodpecker bill to chisel open a hole. The upper mandible is then used to fish out the prey item. Upper mandible also used to probe natural cracks and crevices. Breeding has been documented year-round, although most activity occurs from May to August with a second peak in November. The species' open cup nest is most often placed in ʻōhiʻa trees. Clutch size is usually one, rarely two, and females perform all incubation and brooding. Males provide females and nestlings with the majority of food. Only one fledgling is produced per year, and a long period of parental dependency, usually four to six months, is typical,



but can be as long as 18 months. Family groups consisting of hatch-year and second-year young have been observed. This species is characterized by low annual productivity.

DISTRIBUTION: Occurs in three disjunct populations between 1,500 and 2,000 meters (4,875–6,500 feet) elevation on the Island of Hawai‘i. Original range likely included all forested areas of the island, however now extirpated from their range in Kona and sub-alpine Maunakea.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 1,500 ± 400 (95% confidence interval). Surveys conducted between 1990 and 1995 estimated the population at 1,109-1,217 birds and most recent analysis puts the population closer to 1,900. Populations at Hakalau NWR were estimated at 1,163 in 2022. Significant declines occurred in two of the four populations known in the 1980s. The Ka‘ū /Kapāpala population decreased from approximately 530 individuals to 44, and a Mauna Kea population dropped from approximately 50 birds to less than 10; in 2000 only three birds remained on Maunakea and this and the Kona populations are now extinct. The Ka‘ū /Kapāpala population has since stabilized or increased at upper elevations.. ‘Akiapōlā‘au however have responded extremely well to koa reforestation, and populations at Hakalau forest have increased by more than 900% in the koa planting areas.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in mesic and wet montane forests dominated by koa and ‘ōhi‘a. The now extinct population of Maunakea ea occurred in subalpine dry forest dominated by māmane and naio. A studies have documented ‘akiapōlā‘au occurring entirely in areas reforested with koa (i.e., second-growth, young forests). Habitat quality varies across the species’ occupied range, but reforestation and fencing have drastically improved some key forestes in the last 50 years. Most remaining populations occur on lands managed by the State of Hawai‘i and the U.S. Fish and Wildlife Service.

THREATS: ‘Akiapōlā‘au are susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For ‘akiapōlā‘au populations, the following are of particular concern:

- Low reproductive potential. ‘Akiapōlā‘au have low annual fledgling production. This life history characteristic may be related to their very specialized foraging strategy. Regardless, the species is very susceptible to factors that reduce population size.
- Disease. Unlike several other honeycreepers found on the island of Hawai‘i (e.g., Hawai‘i ‘amakihi [*H. virens*]), the ‘akiapōlā‘au is absent from most areas below 1,350 meters (4,500 feet). This suggests that the species is particularly susceptible to mosquito-borne avian disease.
- Predation. Predation by rats (*Rattus* spp.), cats (*Felis* silvestris), small Indian mongoose (*Herpestes auropunctatus*), and raptors (Pueo *Asio flammeus sandwichensis,* Barn owl *Tyto alba,* and ‘Io *Buteo solitarius*) may limit ‘akiapōlā‘au populations. Surveys have determined that rat density in the Hakalau Forest National Wildlife Refuge, which supports a significant portion of the ‘akiapōlā‘au population, is high. In addition, the loud, persistent begging of juveniles may make them especially vulnerable to predators.
- Habitat degradation. Habitat loss and degradation from development, logging, and grazing, and feral ungulates has greatly fragmented the species’ habitat.

- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.

CONSERVATION ACTIONS: To date, conservation actions specific to ʻakiapōlāʻau have been restricted to annual population surveys of the Hakalau, ʻŌlaʻa/Kīlauea, Kona, and Mauna Kea populations. However, ʻakiapōlāʻau likely have benefited from actions to conserve other endangered forest birds in the Kapāpala Forest Reserve, Hakalau Forest National Wildlife Refuge, Puʻu Lāʻau, Hawaiʻi Volcanoes National Park, and the ʻŌlaʻa/Kīlauea Watershed Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the ʻakiapōlāʻau may include the following:

- Add Hāmākua, the upper Waiākea kīpuka, Kaʻū /Kapāpala and south Kona to annual surveys
- Expand fencing efforts of key habitats above 4500ft in the above metntioned reserves
- Continue koa forest restoration and fencing in the Hakalau Forest National Wildlife Refuge.
- Continue restoration of māmane forests on Maunakea.
- Conduct public outreach and education and expand community conservation efforts
- Continue protection and management of wildlife sanctuaries and refuges
- Expand and diversify predator control throughout the species range
- Translocate birds back to Maunakea and other suitable habitats in their former rang
- Collect genetic samples from as many individuals as possible for bio-banking, genetic rescue, and cloning

MONITORING:

- Continue forest bird surveys and habitat monitoring
- Expand the use of Automatic Recording Units (ARU) to remotly monitor poulations
- Test survey methods for ʻakiapōlāʻau, and continue regular population surveys with improved methods.
- Monitor small mammal populations to assess effectiveness of control efforts, especially in dry forest sites.
- Conduct range wide population estimates and determine population trends.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻakiapōlāʻau include the following:

- Conduct life history studies to quantify population structure, dispersal patterns, survivorship, nesting phenology, and success
- Document habitat selection, preference, and foraging ecology, particularly in young forests

- Document the response of ʻakiapōlāʻau to control of mammalian predators
- Develop captive propagation techniques.
- Determine the feasibility of ʻakiapōlāʻau re-introductions to suitable locations (e.g., Puʻu Waʻawaʻa, Hawaiʻi Volcanoes National Park)
- Record vocalizations of distinct populations for archival analysis

References:

Gorreson, PM, Camp RJ, Reynolds MH, Woodworth BL, Pratt TK. 2009. Status and Trends of Native Hawaiian Songbirds. *In* Conservation Biology of Hawaiian Forest Birds (Pratt TK, Atkinson CT, Banko PC, Jacobi JD, Woodworth BL, editors). Yale University Press.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kendall SJ, Rounds RA, Camp RJ, and Genz AS. 2022. Forest Bird Populations at the Big Island National Wildlife Refuge Complex, Hawaii. Hawaiʻi Cooperative Studies Unit Technical Report HCSU-102. University of Hawaiʻi at Hilo, Hawaii, USA. 141 pages.

Pejchar, L. 2005. Home range size varies with habitat type in a Hawaiian honeycreeper: implications for native *Acacia koa* forestry. Ecological Applications 15:1053-1061.

Pratt TK, Fancy SG, Ralph CJ. 2001 ʻAkiapolaʻau (*Hemignathus munroi*) and nukupuʻu (*Hemignathus lucidus*). *In* The Birds of North America, No. 600 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Strommer L. University of Hawaiʻi graduate student. Unpublished data.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Forest Birds

ʻAkikiki

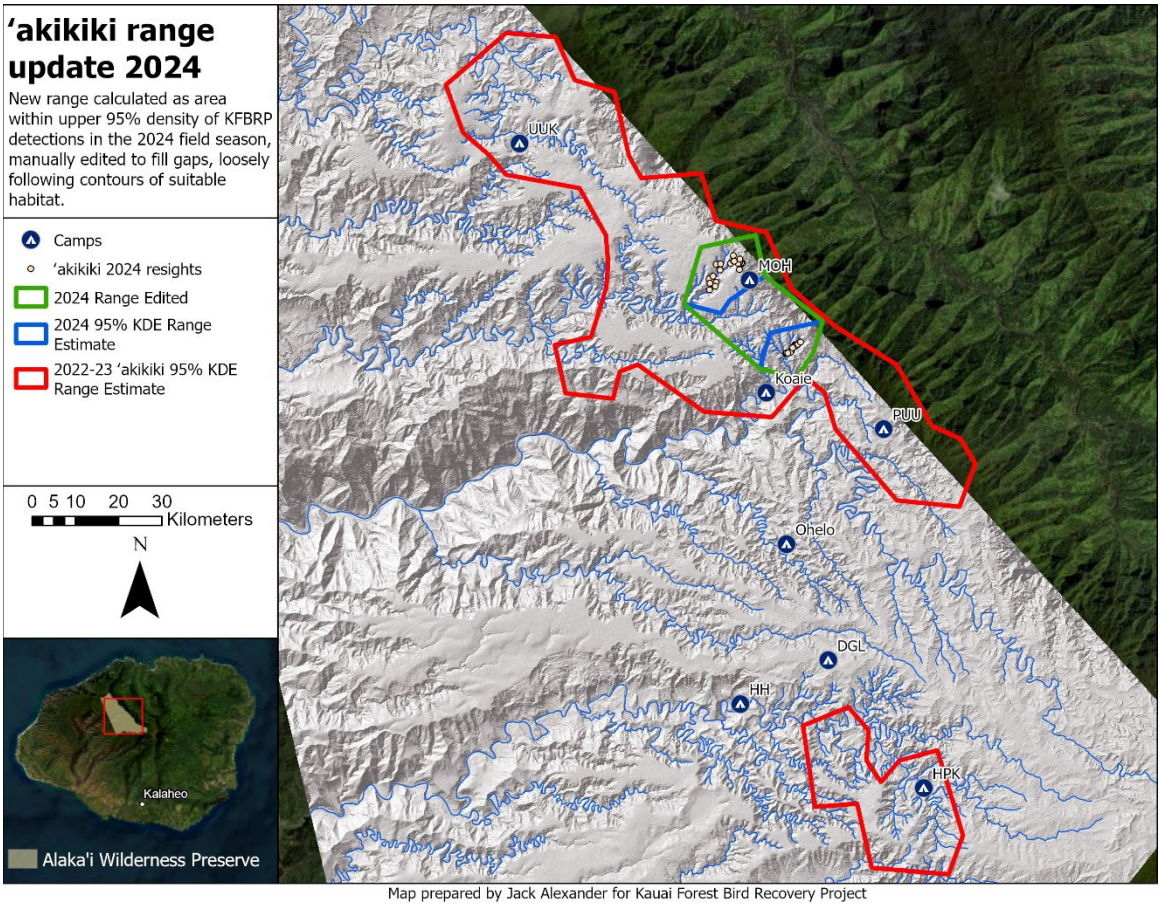
Oreomystis bairdi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
ł Recovery Plan for Hawaiian Forest Birds—USFWS 2006
Kauai Islandwide Recovery Plan – USFWS 2021

SPECIES INFORMATION: The ʻakikiki, or Kauaʻi creeper, is a small, drab Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Kauaʻi. Both males and females are predominantly dark gray to olive above, whitish below. ʻAkikiki have pinkish legs and feet, and their short, slightly decurved bill also is pink. Usually found in pairs, family groups, or small flocks (8 – 12 individuals); during the non-breeding season ʻakikiki join mixed species foraging flocks. ʻAkikiki gleans and probes the bark and lichens and moss on trunks, branches, and twigs of live and dead ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees for insects and spiders. They usually nest high (9 meters or higher) in the terminal branches of ʻōhiʻa, but one female has been observed nesting in ʻōlapa on two occasions. Nest construction begins in early March, and continues into June; males occasionally help with nest building. Most nests contain two eggs, some contain only one egg. Both males and females feed chicks. Despite a long period of parental dependency, many cases of double brooding have been observed, with the male provisioning both the incubating female and the older chicks. Causes of nest failure include predation by rats, poor female attendance, infertility, weather, and hatch failure.

DISTRIBUTION: As of 2024, apparently extirpated throughout most of its recent range in the Alakaʻi Wilderness Preserve, including Halepaʻakai, with a few individuals still occuring in and near the headwaters of Mohihi Stream and side drainages feeding Koaiʻe Stream where it turns west. Occupancy rates in 2012 increased from west to east along the plateau, from 0.02 ± 0.07 near Kokeʻe State Park to 0.55 ± 0.21 in the southeast part of the range, and were positively correlated with canopy height. The suitable habitat range was recently estimated at ~38km^2 and suitable nesting habitat ~18 km^2 (Fricker et al. 2021), but newer estimates in 2004 suggest that it is only 94 ha (233 ac; KFBRP, unbubl. data). Historically occupied high- and low-elevation forests, although by the 1960s was most common above 1,140 meters (3,750 feet), and is now restricted to those higher elevations. Subfossil remains suggest a prehistoric island-wide distribution.

ABUNDANCE: The Kauaʻi Forest Bird Survey (KFBS 2000), estimated the population at 2,448 ± 1,200 (SE) birds. Density estimates were 26 birds per square kilometer; 15 percent lower than in 1981. In 2012, the KFBS estimated density at 8.8 birds per square kilometer, and the population at only 468 (95% confidence interval: 231-916) birds. In 2024, despite extensive surveys through its former range, only four-five individuals were detected, although it is possible that a few more individuals occur on private land or escape detection due to lack of intensive survey effort.



Map prepared by Jack Alexander for Kauai Forest Bird Recovery Project

LOCATION AND CONDITION OF KEY HABITAT: Currently restricted to elevations > 1200 m (mean 1304.5 ± 38.5 m; Fricker et al. 2021) and are found only in the wet tropical rainforest of the eastern Plateau. Occupancy is positively correlated with elevation and large trees (i.e., canopy height) and canopy density. They also exhibit a tendency to nest along lower slopes (e.g., along streams in areas of higher canopy height, and more complex understory (Fricker et al. 2021). The montane forests of Kauaʻi are dominated by ʻōhiʻa with a subcanopy comprising ʻōlapa or lapalapa (*Cheirodendron* spp.) and ʻōhiʻa hā (*Syzygium sandwicensis*). Common understory species include ʻōhelo (*Vaccinium calycinum*), kanawao (*Broussaisia arguta*), ʻōhā wai (*Clermontia* spp.), kāwaʻu (*Ilex anomala*), kōlea (*Myrsine lessertiana*), naʻenaʻe (*Dubautia spp.*), and pūkiawe (*Styphelia tamieameiae*). Occupancy is very low in areas invaded by non-native plants.

THREATS:

- Disease. Mosquitoes likely are ubiquitous on Kaua‘i, and avian malaria and avian pox are likely the most important factors limiting the species’ distribution. Five of 42 ‘akikiki have tested positive for malarial antibodies between 2011 and 2023; some were later resighted, indicating that a few individuals have resistance or tolerance. However, three of the individuals that tested positive were caught in 2022, and one was resighted up to nine months later, but then disappeared. The recent dramatic population declines indicate that avian malaria is a primary threat to this species. Pox lesions have been observed on several birds in the wild, and pox was implicated in the mortality of several individuals transferred to human care in 2023 (KFBRP and SDZWA, unpubl. data).
- Habitat degradation. Pigs (*Sus scrofa*) and goats (*Capra hircus*) have contributed to the spread of non-native plants, but effects to ‘akikiki are unknown. Severe hurricanes in 1982 and 1992 heavily damaged native forests, possibly resulting in short-term reductions in arthropod food resources and long-term damage to forest structure preferred by ‘akikiki, given their affinity for large trees, which are now rare on the landscape
- Natural disasters. Hurricanes in 1982 and 1992 likely caused the death of an unknown number of individuals.
- Competition. Although little evidence exists, it has been suggested that competition with introduced Warbling white-eyes (*Zosterops japonicus*) and Japanese bush warblers (*Horornis diphone*) may negatively affect ‘akikiki. Non-native insects, especially yellow jackets and ants, may compete with or prey on the native arthropods on which ‘akikiki feed. The role of non-native insects in native Hawaiian forests is unclear.
- Predation. Predation by rats (*Rattus* spp.), on eggs has been documented in several instances; predation on chicks and females is suspected in a few cases. Cats (*Felis catus*), Hawaiian short-eared owls (*Asio flammeus sandwichensis*), and barn owls (*Tyto alba*) occur throughout the forests of Kaua’i, and may prey on young and adults.
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems. Some of the observed infertility and failure to hatch may be due to these small population issues.

CONSERVATION ACTIONS: ‘Akikiki likely have benefited from actions to conserve other endangered forest birds including establishment of the Alaka‘i Wilderness Preserve, regular surveys of forest bird populations, monitoring habitat conditions, studies of disease and disease vectors, control of feral ungulates through public hunting and fencing, control of feral ungulates through public hunting and fencing, suppression of rats on two A24 trapping grids over approximately 150 ha (470 ac), and public education efforts. Between 2015 and 2018, eggs were collected to initiate captive flock of about 45 individuals. Six adults and subadults were added to the flock between 2021 and 2023, but they did not survive. Overall, mortality and reproduction are approximately even in the captive population, thus the current flock numbers still about 43 birdss. In addition to these efforts, future management specific to the recovery of ‘akikiki may include:

- Continue to collect wild ‘akikiki adults, subadults, chicks, and eggs; Aggressively control ungulates to improve habitat quality and facilitate recovery of degraded, but potential, habitat. It could also reduce breeding habitat for mosquitoes. Control of non-native plants should be part of forest restoration efforts.
- Reduce or manage mosquito breeding habitat on the Alaka‘i Plateau a
- Suppress mosquito populations through releases of incompatible or sterile mosquitoes
- Investigate options to eradicate mosquitoes, including use of genetic manipulations.
- Suppress/control rats, feral cats, and barn owls from the Alaka‘i Wilderness Preserve, Na Pali-Kona Forest Reserve, and Koke‘e State Park.
- Tranlocations to areas with low disease prevelance on other islands
- Prevent the introduction of the small Indian mongoose *(Herpestes auropunctatus*) and other potential predators.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.
- Prevent the spread of Rapid Ohia Death on the Alaka‘i Plateau
- Collect genetic samples from as many individuals as possible for bio-banking, genetic rescue, and cloning

MONITORING: Conduct species-specific monitoring for ‘akikiki (e.g., occupancy surveys with play back, territory monitoring) that take into account the inability of the HFBS to track populations of rare species.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the ‘akikiki include the following:

- Investigate techniques for improving survival and reproduction of the captive flock
- Conduct PVAs for captive flock, including impact of reintroduction back into the wild once malaria is controlled
- Explore the use of surrogate species such as ‘alawī to restore wild behaviors and or to establish birds in the wild on Hawai‘i Island
- Investigate and evaluate different strategies for reintroducing the population to the wild
- Continue to assess the susceptibility of this species to avian malaria and avian pox.
- Determine sources of mosquitoes and investigate methods of mosquito control.
- Determine the effects of recently established non-native insects on native arthropods, especially those that are part of the species’ diet.
- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps).
- Assess the impact of introduced rodents on food sources important to 'akikiki.
- Investigate the feasibility of food supplementation.

References:

Atkinson, CT, RB Utzurrum, DA LaPointe, RJ Camp, LH Crampton, JT Foster, and TW Giambelluca. 2014. Changing Climate and the Altitudinal Range of Avian Malaria in the Hawaiian Islands - an Ongoing Conservation Crisis on the Island of Kaua‘i. Global Change Biology 20, 2426–2436, doi: 10.1111/gcb.12535.

Behnke, L. 2014. Habitat use and conservation implications for Akikiki (*Oreomystsis bairdi)* and Akekee (*Loxops caeruleirostris)*, two endangered Hawaiian honeycreepers. M.S. Thesis. Colorado State University, Fort Collins, CO.

Foster JT, Scott JM, Sykes PW. 2000. ‘Akikiki (*Oreomystis bairdi*). *In* The Birds of North America, No. 552 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alaka‘i swamp, Kaua‘i. Conservation Biology 18:716-725.

Fricker GA, Crampton LH, Gallerani EM, Hite JM, Inman R, Gillespie TW. 2021. Application of lidar for critical endangered bird species conservation on the island of Kauai, Hawaii. Ecosphere 12(6).

Hammond, RL, Crampton, LH, and Foster, JT. 2015. Breeding biology of two endangered forest birds on the island of Kaua'i. Condor 117: 31-40.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2021. Kauai Islandwide Recovery Plan. Portland, (OR): U.S. Fish and Wildlife Service. https://www.fws.gov/node/264716

Photo: Robby Kohley

Forest Birds
‘Ākohekohe

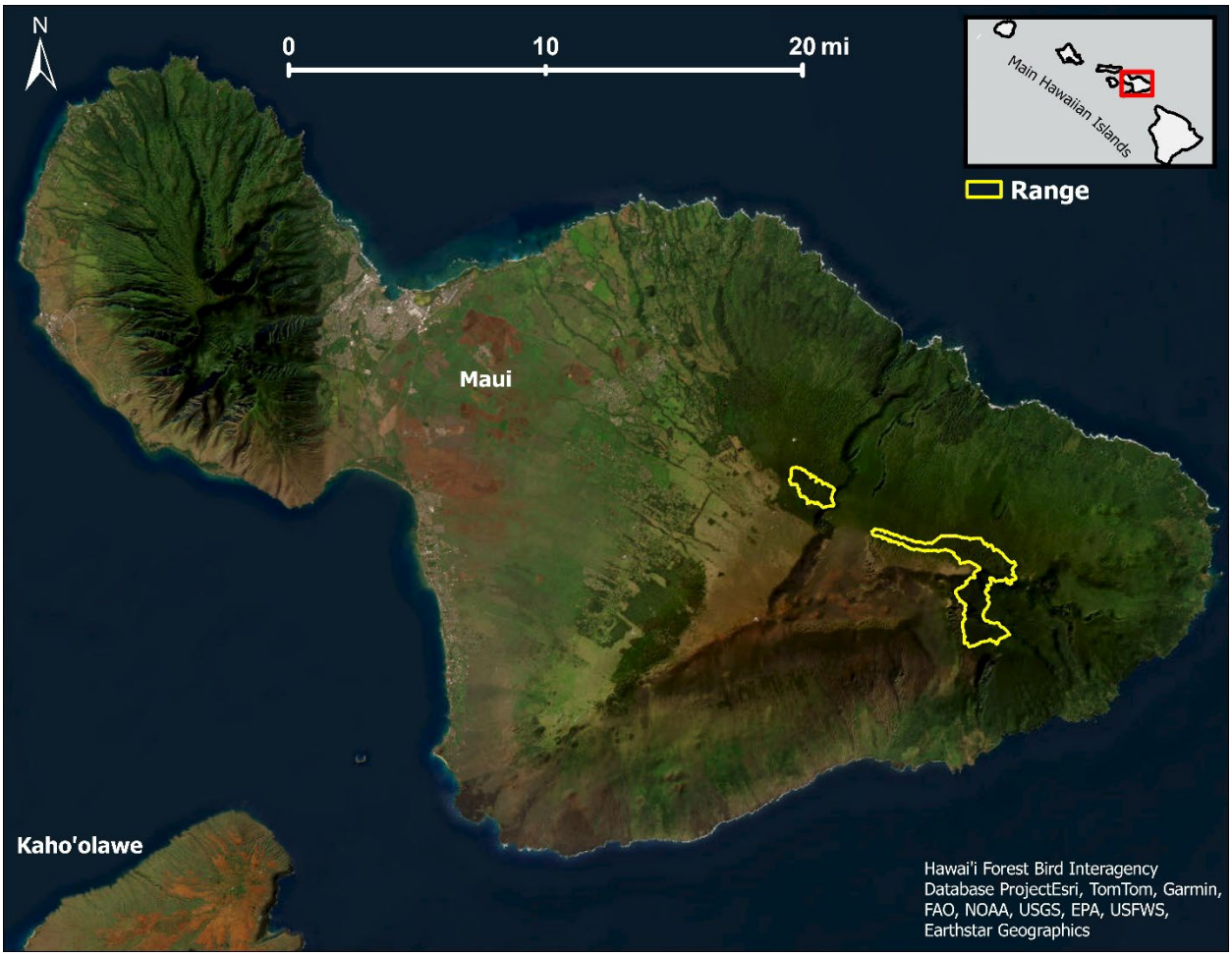
Palmeria dolei

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ‘ākohekohe, or crested honeycreeper (Family: Fringillidae), is the largest extant honeycreeper on Maui Nui (Lāna‘i, Moloka‘i, Maui, and Kaho‘olawe). Although primarily black, the plumage of the ‘ākohekohe is striking. Depending on their location, feathers are tipped with orange-yellow, gray, silver, or white. Orange feathers surround the eyes and extend over the nape, orange or yellow-white feathers cover the thighs, the epaulettes are white with orange tips, and there is a distinctive plume of white feathers that curl forward over the bill. They do not sing, but produce a random series of buzzes, croaks, and whistles. They are primarily nectarivorous, feeding mainly on ‘ōhi‘a (*Metrosideros polymorpha*), but also from the flowers of other trees and shrubs, such as ‘ākala (*Rubus hawaiensis*) and kōlea (*Myrsine* species). Like ‘apapane (*Himatione sanguinea*) and ‘i‘iwi (*Vestiaria coccinea*), ‘ākohekohe are strong fliers and will move from low to high elevations in search of blooming ‘ōhi‘a. Arthropods, mainly gleaned from ‘ōhi‘a, are also part of the species’ diet. They spend up to 70 percent of the day foraging. They aggressively defend feeding and nesting territories year-round. Females build open-cup nests primarily in ‘ōhi‘a, incubate the clutch of one or two eggs, and brood nestlings; male feeds female on nest. Fledglings can forage independently 10 to 14 days after leaving the nest. Pairs successfully fledge two to three broods per season.

DISTRIBUTION: Restricted to a 24 square kilometer (9 square mile) area on the northeastern slope of Haleakalā at 1,600 to 2,300 meters (5,200 – 7,000 feet). Subfossil evidence indicates they once occurred in Maui’s lowland dry forests, and historically they also once occurred on eastern Moloka‘i. They currently occupy 2 percent of their historical range.

ABUNDANCE: The Hawai‘i Forest Bird Survey from 2022 estimated the population at 1768 ± 315 (95% CI 1193–2411) individuals, a 78% decline from 2001.



LOCATION AND CONDITION OF KEY HABITAT: Wet and mesic montane forests dominated by ʻōhiʻa and ʻōlapa (*Cheirodendron trigynum*); koa (*Acacia koa*) and kāwaʻu (*Ilex anomala*) occur at lower densities. Nearly all birds occur in forest between 1,700 and 2,100 meters (5,700 – 6,900 feet) elevation in rugged, steep terrain with a dense understory. The entire known range of the species occurs within State (e.g., Forest Reserve and Natural Area Reserve), Federally (e.g., National Park), or Privately (e.g. The Nature Conservancy) managed lands.

THREATS: ʻĀkohekohe are susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For ʻākohekohe, the following are of particular concern:

- Disease. Similar to ʻapapane and ʻiʻiwi, movements between low- and high-elevation foraging sites may increase these birds' exposure to mosquito-borne diseases.
- Habitat degradation. Feral pig (*Sus scrofa*), deer (*Axis axis*), and goats (*Capra hircus*) damage understory vegetation may reduce the availability of nectar-producing plants important to ʻākohekohe, especially those flowering when ʻōhiʻa nectar is less available.
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and

stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.

CONSERVATION ACTIONS: Captive propagation of ʻākohekohe was attempted decades ago but was not successful. ʻĀkohekohe likely benefited from actions to conserve other endangered forest bird species on the northeastern slope of Haleakalā, including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future actions specific to ʻākohekohe may include the following:

- Establish a second population to reduce the chances that a catastrophe could result in the species' extinction. Potential re-introduction sites (e.g., West Maui and Molokaʻi) are limited because of the presence of mosquitoes; therefore, it has been prioritized to research potential locations for a conservation translocation on Hawaiʻi Island (e.g. Kaʻū FR, Hilo FR, Hakalau NWR, Puʻu Makaʻala NAR, or Puʻu Waʻawaʻa FBS) which has more high elevation native protected forest than Maui.
- Capture and hold a small number of individuals to develop and adaptively manage captive holding conditions to reduce stress and promote breeding/cohabitation. These efforts would inform if and/or how captive holding can be used as part of the conservation strategy for this species.
- Develop and deploy mosquito control techniques as soon as possible to reduce the mosquito vector of avian disease.
- Continue fence management and feral animal control to improve understory conditions in occupied habitat and potentially facilitate expansion of ʻākohekohe populations if and when mosquito control occurs.
- Conduct public outreach and education. Incorporate Hawaiian knowledge and practices in conservation strategies
- Continue protection and management of wildlife sanctuaries and refuges.Collect genetic samples from as many individuals as possible for bio-banking, genetic rescue, and cloning
- Develop and deploy new tools and evaluate above approaches.

MONITORING: Continue forest bird surveys,habitat monitoring, and use or automated recording units (ARU).

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻākohekohe include the following:

- Determine if disease-resistant individuals exist, and if so, if resistance is passed to offspring. Disease-resistant individuals could be used to establish new populations.
- Determine the role of ʻākohekohe in transmitting disease between high- and low-elevation habitats.
- Determine if a conservation translocation if feasible to Hawaiʻi Island and develop translocation and field holding protocols.

References:

Berlin KE, VanGelder EM. 1999. ‘Akohekohe (*Palmeria dolei*). *In* The Birds of North America, No. 400 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Judge, SW, Camp RJ, Warren CW, Berthold LK, Mounce HL, Hart PJ, and Monello RJ. 2021. Population Estimates and Trends of Three Maui Island-endemic Hawaiian Honeycreepers. Journal of Field Ornithology. https://onlinelibrary.wiley.com/doi/full/10.1111/jofo.12364

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Wang AX, Paxton EH, Mounce HL, Hart PJ. 2020. Divergent movement patterns of adult and juvenile ‘ākohekohe, an endangered Hawaiian Honeycreeper. Journal of Field Ornithology.

Photo: DOFAW

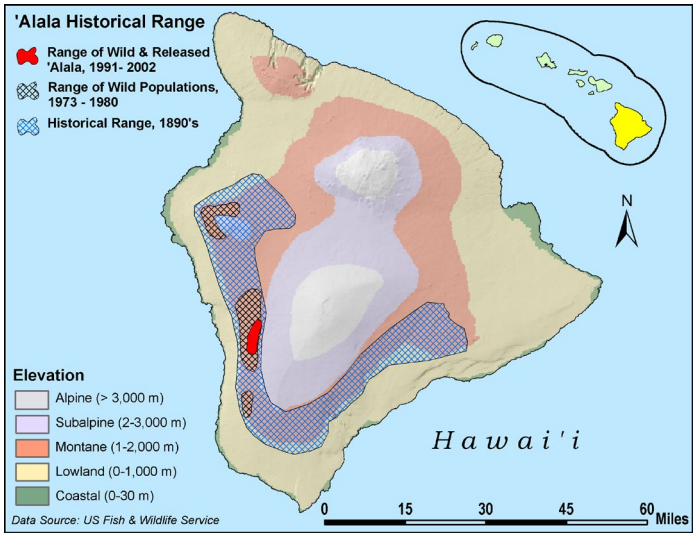
Forest Birds

ʻAlalā

Corvus hawaiiensis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank: GXC-Presumed Extinct/ Captive Population
IUCN Red List Ranking—Extinct in the Wild
Revised Recovery Plan for the ʻAlalā —USFWS 2009

SPECIES INFORMATION: Historically at least five crow species (Family: Corvidae) occurred in Hawaiʻi, only the ʻalalā, or Hawaiian crow survives. Like other crows, ʻalalā are raucous, gregarious and vocal; young, captive-raised birds often engage in tug-of-war with sticks. Like many corvids, ʻalalā are long-lived with a life span of 20 or more years. The diet primarily consists of native and introduced fruits, invertebrates, and eggs and nestlings of other forest birds, as well as nectar, flowers and carrion. Seasonal movements in response to weather and availability of food plants (e.g., ʻieʻie [*Freycinetia arborea*]) have been noted. Although individuals form long-term pair bonds, extra-pair copulations have been observed. Nests are predominantly constructed in ʻōhiʻa (*Metrosideros polymorpha*) trees. Both sexes participate in nest construction, although only females incubate eggs and brood young. Clutch size ranges from two to five, although usually only one or two nestlings fledge. Fledglings typically cannot fly and often remain near the ground for long periods, likely increasing their susceptibility to disease (i.e., toxoplasmosis) and predation. Juveniles depend on their parents for at least eight months and remain with their family group until the following breeding season. Large flock's characteristic of American crows (*C. brachyrhynchos*) have not been reported, but there are historical reports of small local flocks after the breeding season.



DISTRIBUTION: No individuals are known to exist in the wild. Historically occurred in high- and low-elevation forests of the western and southeastern regions of the island of Hawai‘i.

ABUNDANCE: World population of 108 individuals in 2024, housed entirely in the Keauhou and Maui Bird Conservation Centers.

LOCATION AND CONDITION OF KEY HABITAT: Historically, ‘alalā occupied dry and seasonally wet ‘ōhi‘a and ‘ōhi‘a/koa (*Acacia koa*) forests between 300 and 2,500 meters (1,000 – 8,200 feet) elevation. Because the last wild individuals were confined to a small subset of the species’ former range, specific knowledge of key habitat requirements are unknown. Currently, all potential habitat is degraded. The presence of non-native mammalian predators and birds, which can act as disease reservoirs, further reduces habitat quality. Core areas of the species’ former range are now managed by the State of Hawai‘i and the U.S. Fish and Wildlife Service.

THREATS: ‘Alalā are susceptible to the same factors that threaten other native Hawaiian forest birds, including: loss and degradation of habitat, predation by introduced mammals, and disease. For ‘alalā populations, the following are of particular concern:

- Predation. The small Indian mongoose, rats, and feral cats prey on ‘alalā. The ‘io (*Buteo solitarius*) and presumably pueo (*Asio flammeus sandwichensis*) also prey on juvenile and adults. ‘Io have been documented killing captive-raised birds released into the wild. Fledglings are unable to fly and this likely contributes to high rates of predation.
- Shooting. Many ‘alalā were killed around farms between 1890 and 1930. Despite legal protection in 1931, shooting of individuals occurred into the 1980s.
- Disease. Population declines were noted between 1890 and 1910, a period when other native bird populations declined, presumably because of the introduction of rats and increased rates of deforestation. In general ‘alalā have proven resistant to avian malaria and pox virus, but they are susceptible to toxoplasmosis spread by the parasite’s obligate host, domestic cats (*Felis catus)*
- Habitat degradation. Habitat conversion by human activity as well as by grazing ungulates and seed predation by rats has severely degraded former ‘alalā habitat. These changes may have limited food or nesting resources and may have increased the vulnerability of ‘alalā to predation by ‘io. Currently, little suitable habitat exists for the species.
- Population size. Small populations are plagued by a variety of potentially irreparable problems which fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios.
- Captive-breeding. There is some evidence that captive-reared birds lack important foraging and predator-avoidance behaviors.

CONSERVATION ACTIONS: The ‘alalā has been legally protected by the State of Hawai‘i since 1931 and was listed as federally endangered in 1967. A captive propagation program was established in 1973; crows are now housed at the Keauhou Bird Conservation Center and the Maui Bird Conservation Center. The ‘Alalā Recovery Team was formed to facilitate the species recovery, and a related second group, the ‘Alalā Partnership, was formed to facilitate program

implementation on private lands. Between 1993 and 1998, 27 captive-raised juvenile ʻalalā were released at McCandless Ranch. Of these, 21 died in the wild and six were recaptured and returned to the captive flock. Predator control was ongoing during the release program. Intensive field studies of the wild population and released juveniles were conducted between 1992 and 2002. In 1999, the Kona Forest Unit of Hakalau Forest National Wildlife Refuge was acquired, with the goal of restoring habitat in the core of the species' historic range. Recent release efforts were made from 2016 to 2019 in the Pu'u Maka'ala Natural Area Reserve on Hawai'i Island. This is a fenced area, free of ungulates, creating a dense understory containing many plants suitable for ʻalalā to eat. This set of releases showed improvements and were considered successful due to birds surviving for multiple years and one pair observed nesting. ʻAlalā mortalities increased in 2020 due to predation from ʻio or Hawaiian hawk (*Buteo solitarius*) and other factors, ultimately causing the remaining five individuals to be brought back into captivity. Five ʻalalā were released on Maui within the Kipahulu Forest Reserve in 2024. The Birds have fared well without the presence of ʻio and any new findings from this release can apply to future releases.. Additionally, efforts have be made to research ʻio behavior to help inform site selection for Hawaii' island. Future releases will also occur elsewhere on Maui Nui or at a site on Hawaiʻi Island.

Restoration of future re-introduction sites is ongoing and re-introductions are expected to occur by 2027 within the Kaʻū Forest Reserve. In addition to the above efforts, ʻalalā likely will benefit from management activities to conserve other endangered forest birds on the island of Hawaiʻi including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the ʻalalā should include the following:

- Continue restoration of future reintroduction areas throughout historic range.
- Maintain and increase the captive flock without further loss of genetic diversity.
- Continue protection and management of wildlife sanctuaries and refuges.
- Evaluating habitat on additional islands for releases.
- Expand and improve collecting genetic samples from as many individuals as possible for bio-banking, genetic rescue, and cloning.

MONITORING: The captive flock is monitored. Wild populations are intensively monitored using a suite of remote and in the field techniques including game cameras, transmitters, and direct observation.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the ʻalalā include the following:

- Review all data from studies on captive and wild populations.
- Determine methods to increase the reproductive output of captive individuals.
- Conduct field studies to determine if understory restoration will reduce the ability of ʻio to prey on ʻalalā.
- Establish a set of habitat criteria to inform releases of birds at a any particular site.

- Develop methods to habituate captive-raised individuals to respond appropriately to mammalian and avian predators, and sources of toxoplasmosis.
- Determine potential reintroduction sites on other islands.
- Develop methods to assess the impact of ʻalalā on other rare taxa such as snails and forest birds and mitigation strategies.

References:

Banko PC, Ball DL, Banko WE. 2002. Hawaiian crow (*Corvus hawaiiensis*). *In* The Birds of North America, No. 648 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Berger AJ. 1981. Hawaiian birdlife. Honolulu: University of Hawaiʻi Press. 260 pp.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

U.S. Fish and Wildlife Service. 2009. Revised recovery plan for the ʻAlala (*Corvus hawaiiensis*). Portland, (OR): U.S. Fish and Wildlife Service. Xiv+105 pp.

Photo: Jim Denny

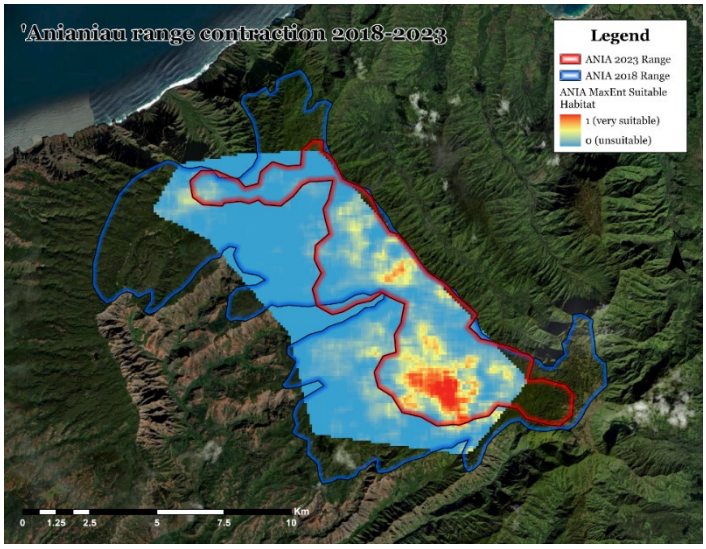
Forest Birds

ʻAnianiau

Magumma parva

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G2—Imperiled
IUCN Red List Ranking—Endangered

SPECIES INFORMATION: The ʻanianiau is the smallest Hawaiian honeycreeper (Family: Fringillidae). Endemic to Kauaʻi, the ʻanianiau also is one of the most common native birds of the island's high-elevation forests. Adult males are brilliant yellow; females also are yellow, but may be duller, although some bright females have been observed. Constantly on the move, ʻanianiau feed on nectar from ʻōhiʻa (*Metrosideros polymorpha*), ʻōhelo (*Vaccinium* spp.), ʻalani (*Melicope* spp.), and other native and introduced plants. They also glean arthropods from the outer canopy and smaller twigs and branches of ʻōhiʻa and koa (*Acacia koa*) trees as well as from the foliage of shrubs, vines, and the fronds of tree ferns (*Cibotium* spp.). Nectar, spiders, and Lepidoptera larvae compose the bulk of the species' diet. ʻAnianiau are occasionally seen in small flocks, especially at favored nectar sources. Males sing a sweet, high-pitched trill, and predominantly defend breeding territories that may be as small as 9 meters (29.3 feet) in diameter. Both sexes build the open-cup nest, females incubate eggs and brood young, and males provision females, generally away from the nest. No information on post-fledgling behavior or dependency. ʻAnianiau nest success rate in 2012 and 2013 was 0.56 (±0.09, Hammond et al. 2015).



DISTRIBUTION: May occur as low 774 m elevation in native forests of the Kōkeʻe and Alakaʻi regions, but are becoming scarce in the former regions. However, the lowest elevation detection in 2024 was at 1131 m (KFBRP, unpubl. data). Original range likely included all forested regions of Kauaʻi. **N**otable range contractions of more than 60% occurred between 2018 and 2023 with the ʻanianiau now occupying a range of approximately 3648 ha (9014 ac; Kaua'i

Forest Bird Recovery Project, unpubl. data).

ABUNDANCE: In the early 1970s the island-wide ʻanianiau population was estimated at 24,000 ± 3,000 (SE) individuals. The Kauaʻi Forest Bird Survey (2000) estimated the population within the Alakaʻi Wilderness Preserve and Kōkeʻe region at close to 35,000 individuals, with a significant population increase between 1981 and 2000. Although the 2008 surveys suggested that the population appeared stable in its current range, the population was estimated around only 10,000 individuals in 2018 (Paxton et al. 2020). The 2023 surveys suggested further declines to 3,827 individuals (DOFAW, unpublished data). .

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forests above 1,000 meters (2,000 feet), with the highest densities above 1,200 meters (3,600 feet). These forests are dominated by ʻōhiʻa, koa, ʻōlapa (*Cheirodendron trigynum*), and lapalapa (*C. platyphyllum*). At lower elevations, where the species historically occurred, native habitats are severely degraded. Although public hunting reduces the number of feral ungulates in the most accessible parts of the species' range, hunting is not an effective method to prevent habitat degradation across its entire range. Occupied habitats are largely managed by the State of Hawaiʻi, although a few individuals may occur on private lands around the Plateau.

THREATS:

- Disease. Thirteen of 129 ʻanianiau sampled between 2011 and 2023 tested positive for malarial parasites (*Plasmodium relictum*) in areas where parasites were common in other species. Since malaria is established on the Alakaʻi Plateau, the most likely explanation for this low prevalence is high mortality after infection with malaria. Avian malaria is likely the primary threat to the species. Research comparing mortality between Kauaʻi honeycreepers (ʻanianiau and ʻakikiki) and non-honeycreepers (puaiohi and Kauaʻi ʻelepaio), found that the honeycreepers were much more susceptible to avian malaria (Whitaker 2022).
- Habitat degradation. The species is tolerant to habitat alteration, but it is most common in undisturbed native forest. Introduction of non-native plants is the most important threat as ʻanianiau density is negatively related to the presence of non-native shrubs.
- Competition. Competition with introduced Japanese white-eyes (*Zosterops japonicus*) may negatively affect ʻanianiau. Non-native insects, especially yellow-jackets (*Vespula pensylvanica*) and ants (*Linepithema humile*), may compete with or prey on the native arthropods on which ʻanianiau feed. The role of non-native insects in native forest ecosystems is unclear.
- Mammalian predators. Rats (*Rattus* spp.), cats (*Felis catus*), Hawaiian short-eared owls (*Asio flammeus sandwichensis*), and barn owls (*Tyto alba*) occur throughout the forests of Kaua'i. Hammond et al. 2015 found evidence of ʻanianiau nest predation in the form of trail camera pictures, egg-shell fragments in the nest and even chick remains.

CONSERVATION ACTIONS: ʻAnianiau likely benefit from actions to conserve other endangered forest birds including establishment of the Alakaʻi Wilderness Preserve, regular

surveys of forest bird populations, habitat monitoring, studies of disease and disease vectors, control of feral ungulates through public hunting and fencing, suppression of rats on two A24 trapping grids over approximately 150 ha (470 ac), and public education featuring Kauai's endangered forest birds. Conservation efforts should include continued protection and management of wildlife sanctuaries and refuges Since the population is declining rapidly, collection of ʻanianiau adults and eggs has been implemented to establish an ex-situ insurance population, with 13 birds currently in human care. In addition to these efforts, future actions specific to the ʻanianiau may include the following:

- Aggressively control ungulates to improve habitat quality, facilitate the recovery of degraded habitat, and potentially reduce breeding habitat for mosquitoes. Control of non-native plants should be part of forest restoration efforts.
- Eradicate or manage mosquito breeding habitat on the Alakaʻi Plateau
- Suppress mosquito populations through releases of incompatible or sterile mosquitoes
- Investigate options to eradicate mosquitoes, including use of genetic manipulation
- Translocate individiuals to habitat with low levels of disease prevelance on Hawaiʻi Island
- Suppress/control rats, feral cats, and barn owls from the Alakaʻi Wilderness Preserve, Na Pali-Kona Forest Reserve, and Kōkeʻe State Park
- Prevent the introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other predators.
- Prevent the spread of Rapid Ohia Death on the Alakaʻi Plateau
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges
- Expand and improve collecting genetic samples from as many individuals as possible for bio-banking, genetic rescue, and cloning

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the ʻanianiau include:

- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology and success of this poorly known species.
- Investigate techniques for improving survival and reproduction of the captive flock
- Conduct PVAs for both wild and captive flocks
- Investigate the feasibility of ʻanianiau translocation to Hawai'i Island
- Determine species specific avian malaria mortality rate and if potential resistance is passed to offspring. Disease-resistant individuals could be used as founders for new populations.
- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps)
- Assess the impact of introduced rodents on food resources (e.g., floral, invertebrates) important to 'anianiau

- Determine if competition with Warbling white-eyes or Japanese Bush-warblers occurs, and if so, its effect on ‘anianiau populations.
- Determine the effects of recently established non-native insects on native arthropods, especially on those arthropods that are part of the species’ diet.
- Determine the status of populations outside of the greater Alaka‘i Swamp region.

References:

Camp, RJ and PM Gorresen. 2011. Design of forest bird monitoring for strategic habitat conservation on Kaua‘i Island, Hawai‘i. Hawai‘i Cooperative Studies Unit Technical Report HCSU-022. University of Hawai‘i at Hilo.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alaka‘i swamp, Kaua‘i. Conservation Biology 18:716-725.

Hammond RL, Crampton LH, Foster JT. 2015. Nesting success of native and introduced forest birds on the island of Kauai. Journal of Avian Biology 47: 252-262.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK. 1997. ‘Anianiau (*Hemignathus parvus*). *In* The Birds of North America, No. 312 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Paxton ER, Camp MG, Crampton LH, Leonard DL, VanderWerf EA. 2016. Collapsing avian community on a Hawaiian island. Science Advances 2:e1600029.

Paxton ER, Brinck KW, Crampton LH, Hite J, Constantini M. 2018 Kaua‘i forest bird population estimates and trends. Technical Report Hawai’i Cooperative Studies Unit. University of Hawai’i at Hilo.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Whitaker K. 2022. Avian malaria on Kaua’i: prevalence and survival as a function of sex, age, and species. Master’s thesis, Northern Arizona University.

Photo: Eric Nishibayashi

Forest Birds

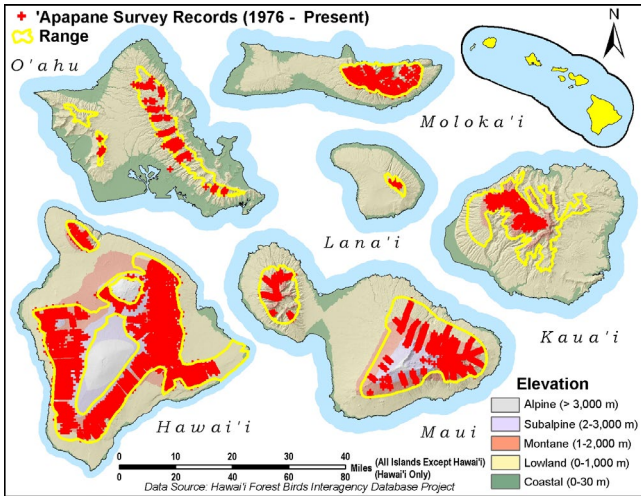
‘Apapane

Himatione sanguinea

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking— Least Concern

SPECIES INFORMATION: The ‘apapane is a small, crimson, primarily nectarivorous Hawaiian honeycreeper (Family: Fringillidae) and is an important ‘ōhi‘a (*Metrosideros polymorpha*) pollinator. It is the most abundant and widely distributed Hawaiian honeycreeper, and is often seen flying above the canopy in search of patches of flowering ‘ōhi‘a. Wide-ranging movements may facilitate disease transmission among native forest birds. ‘Apapane often forage in conspecific flocks, likely to overwhelm ‘i‘iwi (*Vestiaria coccinea*) and ‘ākohekohe (*Palmeria dolei*), which often defend flower-rich trees. Outside the breeding season, ‘apapane also join mixed-species flocks. They feed on insects, which they glean from outer foliage and twigs in the upper- and mid-canopy. Sexual chasing and courtship feeding often precede nest building, a task shared by both male and female. Pairs defend small territories around nests. Females incubate three eggs and brood young; males feed females away from the nest. Both parents feed nestlings, and fledglings may remain with their parents for up to four months.

DISTRIBUTION: Occurs in native forests on the islands of Hawai‘i, Maui, and Kaua‘i. On O‘ahu, occurs in the Ko‘olau Range from 300 meters (975 feet) to summit at 946 meters (3,075 feet), and are less common in the Wai‘anae Range above 600 meters (1,950 feet). Rare on Moloka‘i and Lāna‘i. Historically were common at low elevations on all islands with appropriate habitat.



ABUNDANCE: Based on Hawaiian Forest Bird Surveys (1976-1981): 1,080,000 ± 25,000 (95% confidence interval) birds on island of Hawai‘i, 110,000 ± 9,000 on Maui (86% on Haleakalā), 39,000 ± 5,000 on Moloka‘i, 540 ± 213 on Lāna‘i, and 30,000 ± 1,500 on Kaua‘i (O‘ahu was not included in surveys). On Kaua‘i, populations declined after the 1992 hurricane but have significantly increased since, estimated at 64,972 ± 2,014 (SE) birds in

2000 then at 95,511 in 2023 (95% CI: 85,433-107,052; DOFAW, unpublished data). Rare on Molokaʻi and Lānaʻi.

Maui nui updated numbers-
East Maui- 228,480 ± 19,855 individuals
West Maui- we don't have an updated estimate, but they are the most commonly detected species on counts. 4.53 detections per station.
Lanai- they continue to be detected on Lanai in small numbers, based on surveys from 2023.
Molokai- 81,896 ± 10, 836

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forests dominated by ʻōhiʻa and koa (*Acacia koa*), primarily at elevations greater than 1,250 meters (4,100 feet) but can be found as low as 150m (500ft). The primary reason for this limitation is the high density of cold-intolerant *Culex* mosquitoes, an important disease vector, below this elevation. Occupied habitats also contain kōlea (*Myrsine lessertiana*), naio (*Myoporum sandwicense*), and hapuʻu tree ferns (*Cibotium* spp.). Māmane (*Sophora chrysophylla*) is common in high-elevation foraging habitat. Although much of the species' current range is under State or Federal jurisdiction, habitat protection and restoration efforts vary considerably.

THREATS: Although populations appear stable on the islands of Hawaiʻi, Maui, and Kauaʻi, they are susceptible to the same factors that threaten other native Hawaiian forest birds including habitat loss and degradation, predation by introduced mammals, and disease. For ʻapapane the following is of particular concern:

- Disease. Of Hawaii's native forest birds, ʻapapane have the highest prevalence of avian malaria. Individuals infected with avian pox also are more likely to be infected with malaria. Foraging movements may increase their exposure to disease. ʻApapane breed in mid-elevation forests, which suggests some disease resistance.
- Predation. Predation on adults and nests by rats (*Rattus* spp.), cats (*Felis catus*), the small Indian mongoose (*Herpestes auropunctatus*), and owls (Pueo; *Asio flammeus sandwichensis,* Barn owl; *Tyto alba*) may limit the species. Likely because ʻapapane are so abundant, observations have been made of direct depredation events by these predators.

CONSERVATION ACTIONS: ʻApapane likely benefit from actions to conserve other endangered forest birds on northeastern Haleakalā, Hakalau Forest National Wildlife Refuge, Hawaiʻi Volcanoes National Park, the ʻŌlaʻa/Kīlauea Watershed Partnership, and Alakaʻi Wilderness Preserve and surrounding areas. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future actions specific to the protection of ʻapapane may include the following:

- Control mosquitos and non-native predators across native forest habitat.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.
- Encourage more native tree planting in backyards, community parks, and landscaping.

MONITORING: Continue traditional forest bird surveys, expand use of automatic recording units (ARU), and habitat monitoring on all islands.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻapapane include the following:

- Determine if disease-resistant individuals exist and if so, if resistance is passed to offspring. Disease-resistant birds could be used to found of new populations.
- Determine the role of ʻapapane in disease transmission between high- and low-elevation habitats.
- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology, and success of this poorly known species, especially with small populated locations like Lāna'i.
- Explore reintroducing ʻapapane to the Papahānaumokuākea Marine National Monument.
- Conduct range wide population estimates and determine population trends.
- Evaluate metrics and requirements to allow for reestablishment of cultural use of the species.

References:

Fancy SG, Ralph CJ. 1997. ʻApapane (*Himatione sanguinea*). *In* The Birds of North America, No. 296 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org.

Judge SW, Camp RJ, Warren CC, Berthold LK, Mounce HL, Hart PJ, Monello RJ. 2019. Pacific island landbird monitoring annual report, Haleakalā National Park and East Maui Island, 2017. Natural Resource Report. NPS/PACN/NRR—2019/1949. National Park Service. Fort Collins, Colorado.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Smith L, Judge S, Camp R, Genz A, Berry L, Berthold L, Mounce H. 2023. The Status and Trends of Forest Birds on Molokaʻi. Poster Presentation. Hawai'i Conservation Conference. Honolulu, HI.

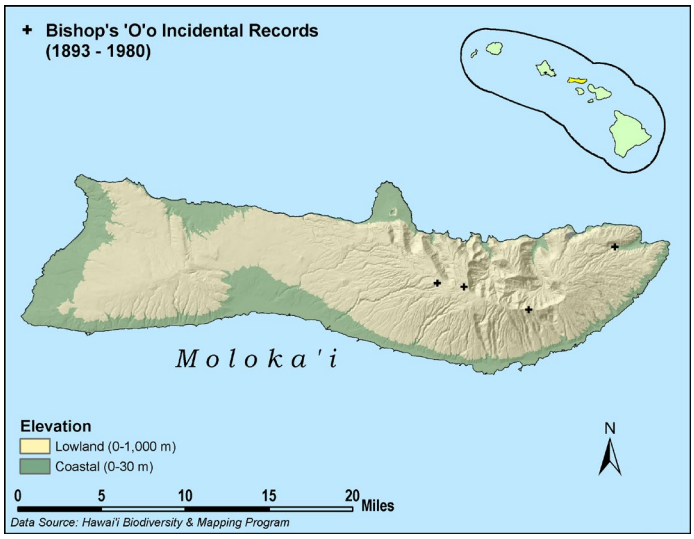
Molokaʻi ʻŌʻō

Moho bishopi

SPECIES STATUS:
Federally Listed as Extinct
State Recognized as Extinct
NatureServe Heritage Rank GH—Possibly Extinct
IUCN Red List Ranking—Extinct
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: Known only from Molokaʻi, Bishop's ʻōʻō is a large, noisy honeyeater (Family: Meliphagidae). This striking species is black with yellow ear patches, under tail coverts, and maxillary tufts; sexes are similar. The bird's vocalizations have been described as varied and "unlike any other native bird." Bishop's ʻōʻō appears to be primarily nectavorous, preferring lobelia (Campanulaceae) flowers. Little is known about this species' life history and nothing is known about its nesting biology.

DISTRIBUTION: Unknown. Probably extinct. Historic range of Bishop's ʻōʻō likely included all native forests of eastern Molokaʻi**.** Subfossils suggest it may have occurred on Maui. Sightings in the 1980s of a possible ʻōʻō species on Maui were never confirmed.



ABUNDANCE: Bishop's ʻōʻō was last observed in 1904 and is probably extinct. No information on historical abundance.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Bishop's ʻōʻō occupied the montane forests of eastern Molokaʻi. The areas where the species was last observed are managed by the State of Hawaiʻi as a Natural Area Reserve or by private conservation entities (e.g., The Nature Conservancy) as a Natural Area Partnership Preserve.

THREATS: Unknown. However, Bishop's ʻōʻō likely were susceptible to the same factors that threaten other native Hawaiian forest birds including: loss and degradation of habitat, predation by introduced mammals, and disease, and possible human exploitation. For Bishop's ʻōʻō populations, the following likely were of particular concern:

- Predation. The introduction of black rats in Hawai‘i seems to have been the primary early driver of extinction. Rats were first introduced to O‘ahu and Maui, and then around the late 1890s were introduced to Moloka‘i and Hawai‘i resulting in rapid waves of extinciton on both islands. ‘Ō‘ō may have also nested in cavities making them even more susceptible to the highly arboreal pest.
- Disease. The fact that no habitat above 1,250 meters (4,100 feet) occurs on Moloka‘i suggests disease may have played an important role in the species’ decline.

CONSERVATION ACTIONS: If the species persists, it likely benefits from management activities to conserve other forest birds on eastern Moloka‘i, including the establishment and management of protected areas, regular surveys of forest bird populations, monitoring of habitat conditions, and studies of disease and disease vectors. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continuing to protect and manage wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to Bishop’s ‘ō‘ō.

References:

I.A.E. Atkinson. 1977. A Reassessment of Factors, Particularly *Rattus rattus* L., That Influenced the Decline of Endemic Forest Birds in the Hawaiian Islands. University of Hawaii Press

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Sykes PW, Kepler AK, Kepler CB, Scott JM. 2000. Kaua‘i o‘o (*Moho braccatus*), O‘ahu ‘o‘o (*Moho apicalis*), Bishop’s ‘o‘o (*Moho bishopi*), Hawai‘i ‘o‘o (*Moho nobilis*), and kioea (*Chaetoptila angustipluma*). *In* The Birds of North America, No. 535 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

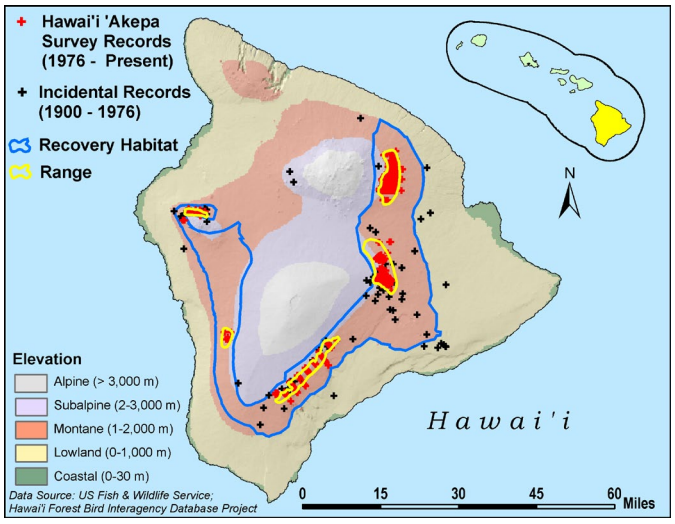
Forest Birds

Hawai‘i ‘ākepa

Loxops coccineus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Hawai‘i ‘ākepa is a small, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawai‘i. Separate species of ‘Ākepa also are known from Maui (*L. ochraceus*) and O‘ahu (*L. rufus*); both of which are likely extinct.. After three-four years, males obtain their bright orange adult plumage; subadult plumage is dull brownish orange, although individual variation is high. Females are grayish-green with a yellow-orange breast band. The lower mandible of the ‘ākepa is slightly bent to one side which results in the mandible tips being offset; a characteristic shared with the ‘akeke‘e (*L. caeruleirostris*). The bend can be to the left or right, and depending on the direction of the bend, individuals also possess an accompanying leg asymmetry; the leg opposite the curve in the mandible is slightly longer than the other leg. Together, these adaptations likely improve the species foraging efficiency in the tightly bunched liko or leaf buds of ‘ōhi‘a. They often join mixed-species foraging flocks, particularly those with ‘alawī (*Loxops mana*). They feed mainly on ‘ōhi‘a (*Metrosideros polymorpha*) leaf clusters, but also on koa (*Acacia koa*) leaves and seed pods, where it uses its bill to pry open leaf and flower buds in search of small arthropods. ‘Ākepa are obligate cavity nesters, with most nests placed in natural cavities found in old-growth ‘ōhi‘a and koa trees. Females build nests, incubate eggs, and brood nestlings, and males deliver food to the female on and off the nest. Both parents feed the young, which remain with their parents for two to three months after fledging.



DISTRIBUTION: Occurs in four disjunct populations above 1,300 meters (4,300 feet) elevation. The majority of the population is found on the windward side of Maunakea within the Hakalau Forest National Widlife Refuge and the Hilo Forest Reserve, but substantial

populations persist in windward Mauna Loa, and within the Kaʻū Forest Reserve. A small remnant population of ~50 individuals also persists within the Puʻu Waʻawaʻa Forest Bird sanctuary. Original range likely included all forested regions of the island.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 14,000 ± 2500 (95% confidence interval) birds. Judge et al. in 2018 using combined totals from Camp et al. 2009, Gorresen et al. 2005, and Camp et al. 2016 to estimate that the total range wide population for the species in 2016 was 16,428 (10,074 – 25,198). As of 2024 Populations in Kaʻū and within the ʻŌlaʻa-Kīlauea region appear to have declined, however populations in windward Maunakea appear stable with populations at Hakalau NWR alone estimated to be 7,221 (4,164 – 11,173). The south Kona and Hualālai populations were estimated at 660 ± 250 birds, but as of 2024 are only known from ~50 birds on Hualālai..

LOCATION AND CONDITION OF KEY HABITAT: Occurs in ʻōhiʻa and ʻōhiʻa/koa forests above 1,300 meters (4,300 feet). Density appears to be related to the number of available cavities, and because cavities primarily occur in older, large trees, old-growth forests may be preferred. The highest density of ʻākepa occurs in the Pua ʻĀkala tract of Hakalau Forest National Wildlife Refuge, which has numerous large trees but a degraded understory. Many areas occupied by the species have been degraded by feral ungulates. Most of the current range of the Hawaiʻi ʻākepa is managed by State and Federal agencies or private conservation partnerships.

THREATS:

- Habitat degradation and loss. Logging and ranching has fragmented and reduced the amount of suitable habitat. Breeding density may be limited by nest-site availability and current levels of food availability may limit populations. In forest fragments, the large trees required for nesting may be more susceptible to windfall and desiccation. The slow growth rate of ʻōhiʻa complicates management for ʻākepa. In addition, habitat fragmentation may prevent or restrict natural re-colonization of former range.
- Disease. The Hawaiʻi ʻākepa is not found below 1,300 meters (4,300 feet), which suggests that it is particularly susceptible to mosquito-borne diseases.
- Predation. Cavity nests may be vulnerable to rat predation, although nest success is high at Pua ʻĀkala in the Hakalau Forest NWR, where rat densities are high.

CONSERVATION ACTIONS: Completed or ongoing actions specific to the Hawaiʻi ʻākepa include: demographic and reproductive studies have determined the importance of old-growth trees for nesting and that the species will use artificial cavities for nesting, and captive propagation techniques have been developed. In addition, Hawaiʻi ʻākepa likely benefit from management activities to conserve other endangered forest birds in Hakalau Forest National Wildlife Refuge, the Kona unit of the Hakalau Forest National Wildlife Refuge, ʻŌlaʻa/Kīlauea Watershed Partnership, Kapāpala Forest Reserve, and Puʻu Waʻawaʻa Wilderness Sanctuary. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the Hawaiʻi ʻākepa may include the following:

- Aerially broadcast rodenticides to increase nestling and adult female survival.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the Hawai‘i ‘ākepa include:

- Continue studies designed to refine the suitability of artificial cavities and evaluate their potential to facilitate the establishment of new populations.
- Determine the factors affecting the growth form of regenerating ‘ōhi‘a and potential methods for protecting old-growth trees from wind and desiccation.
- Identify disease-resistant individuals. Determining if genetic markers or genotypes are associated with resistance would allow targeted translocations of individuals possessing this genotype into populations lacking disease resistance.
- Conduct range wide population estimates and determine population trends.

References:

Judge, Seth & Camp, Richard & Hart, Patrick & Kichman, Scott. 2018. Population estimates of the Endangered Hawai‘i ‘Ākepa (Loxops coccineus) in different habitats on windward Mauna Loa. Journal of Field Ornithology. 89.

Kendall SJ, Rounds RA, Camp RJ, and Genz AS. 2022. Forest Bird Populations at the Big Island National Wildlife Refuge Complex, Hawaii. Hawai‘i Cooperative Studies Unit Technical Report HCSU-102. University of Hawai‘i at Hilo, Hawaii, USA. 141 pages.

Lepson JK, Freed LA. 1997. ‘Akepa (*Loxops coccineus*). *In* The Birds of North America, No. 294 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Hawai‘i ‘amakihi

Chlorodrepanis virens

SPECIES STATUS:
State Listed Endangered on Lāna‘i
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable

SPECIES INFORMATION: The Hawai‘i ‘amakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae). Until 1995, the Hawai‘i ‘amakihi, and the O‘ahu (*H. flavus*) and Kaua‘i ‘amakihi (*H. kauaiensis*) were considered a single species: the common ‘amakihi (*H. virens*). Plumage of all species is similar; males are yellow-green to olive with black lores. Females are generally similar, but duller. All have decurved bills. Plumage of males is bright yellow-green above, and there is some inter-island variation, especially among females. The Hawai‘i ‘amakihi is brighter and smaller than the Kaua‘i ‘amakihi. Hawai‘i ‘amakihi are generalized foragers that glean arthropods from the leaves, blossoms, twigs, branches, and less frequently from tree trunks, ferns, and shrubs. Feeds on nectar predominately from the flowers of ‘ōhi‘a (*Metrosideros polymorpha*), māmane (*Sophora chrysophylla*), and native lobelias (Campanulaceae), but also forages on flowers of a number of other native and non-native plants. They also eat fruit from native and non-native plants, but predominately from pilo (*Coprosma* spp.). Forages alone, in pairs, in family groups, or in mixed flocks. Courtship behavior is somewhat complex and includes courtship chases, advertising displays, and courtship feeding. Pairs remain together for successive breeding seasons. Pair selects nest site; female builds an open-cup nest and lays two or three eggs. Only females incubate eggs and brood nestlings. Males deliver food to females who then feed nestlings. Fledglings are dependent on parents for up to three months. The Hawai‘i ‘amakihi usually raise two broods in a season.

DISTRIBUTION: Occurs as low as 300m and as high as 2,900 meters (1,000 – 9,500 feet) on Hawai‘i, Maui and Moloka‘i; not common below 500 meters (1,625 feet). Widely distributed on Hawai‘i and Maui, rare on Moloka‘i. Original range likely included all forested regions of the above islands as well as those on Lāna‘i, where it was last seen in 1976.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-1983) estimated the population at 870,000 ± 5,612 (95% confidence interval) birds on the island of Hawai‘i, 44,000 ± 1,786 birds on east Maui, 3,000 ± 408 on west Maui, and 1,800 ± 357 birds on Moloka‘i. Populations on Hawai‘i and Maui are probably stable; the Moloka‘i population is probably declining.

Updated Maui nui numbers-
East Maui- 77,776 ± 3,694 individuals. Densities have declined in some locations on East Maui.

West Maui- did not have a density estimate in 2020 surveys but continue to be common, but not as widely distributed as ʻapapane.
Molokaʻi- 1,085 ± 510 birds.

LOCATION AND CONDITION OF KEY HABITAT: A range of habitats including native shrubland and dry, mesic, and wet forests in montane and subalpine communities. Densities are highest on the island of Hawaiʻi in subalpine ʻōhiʻa scrub in Kaʻū, and in māmane/naio (*Sophora chrysophylla* and *Myoporum sandiwicense*) forests on Mauna Kea. ʻAmakihi also are common in koa (*Acacia koa*) reforestation areas at higher elevations. On Maui, they are common in subalpine dry communities dominated by ʻōhiʻa, māmane, pūkiawe (*Styphelia tamieameiae*) and ʻaʻaliʻi (*Dodonea viscosa*). They also occupy some non-native tree plantations on Maui, near areas where native vegetation persists. Habitat on Molokaʻi is restricted to the ʻōhiʻa forests of the eastern half of the island and in lower elevation hala (*Pandanus tectorinus*) dominated areas near Kalaupapa. The condition of this habitat varies considerably. Much of the species' current range is under State or federal jurisdiction.

THREATS: Although populations appear stable they are susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease.

CONSERVATION ACTIONS: Hawaiʻi ʻamakihi likely have benefited from management actions to conserve other endangered forest birds in the native habitat on East Maui, Hakalau Forest National Wildlife Refuge, Hawaiʻi Volcanoes National Park, and the ʻŌlaʻa/Kīlauea Watershed Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future management specific to the Hawaiʻi ʻamakihi may include the following:

- Control mosquitos and non-native predators across native forest habitat.
- Translocate captive-bred individuals to Lānaʻi and Kahoʻolawe.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring. Conduct range wide population estimates and determine population trends.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Currently, the U.S. Geological Survey's Biological Resources Division is conducting genetic analyses to determine the species' phylogenetic status and examining the relationship between genetic diversity and disease resistance. Additional research priorities include the following:

- Quantify population structure, dispersal patterns, survivorship, nesting phenology and success, especially for Maui and Molokaʻi populations.

- Determine if competition with Japanese white-eyes (*Zosterops japonicus*) occurs, and if so, its effect on Hawai‘i ‘amakihi populations.
- Conduct translocation experiments using Hawai‘i ‘amakihi to help reestablish this and other Hawaiian honeycreeper populations.
- Evaluate metrics and requirements to allow for reestablishment of cultural use of the species.

References:

Judge SW, Camp RJ, Warren CC, Berthold LK, Mounce HL, Hart PJ, Monello RJ. 2019. Pacific island landbird monitoring annual report, Haleakalā National Park and East Maui Island, 2017. Natural Resource Report. NPS/PACN/NRR—2019/1949. National Park Service. Fort Collins, Colorado.

Fukunaga, K, Berthold L, Warren C, Mounce H. 2019. Tracking Hawai‘i ‘Amakihi (Chlorodrepanis virens wilsoni) in Nakula Natural Area Reserve on East Maui: home range estimation and evaluation of techniques for upcoming Kiwikiu (Pseudonestor xanthophrys) conservation translocation. Poster Presentation. Hawai’i Conservation Conference. Honolulu, HI. Photo of poster. Poster wording.

Lindsey GD, VanderWerf EA, Baker H, Baker PE. 1998. Hawai‘i (*Hemignathus virens*), Kaua‘i (*Hemignathus kauaiensis*), O‘ahu (*Hemignathus chloris*) and greater ‘amakihi (*Hemignathus sagittirostris*). *In* The Birds of North America, No. 360 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Smith L, Judge S, Camp R, Genz A, Berry L, Berthold L, Mounce H. 2023. The Status and Trends of Forest Birds on Moloka‘i. Poster Presentation. Hawai’i Conservation Conference. Honolulu, HI

Forest Birds

ʻAlawī

Loxops mana

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Ranking G2—Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ʻAlawī is a small, inconspicuous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawaiʻi. Adults are predominately olive-green above, dull buff below, and have a dark gray mask extending around the eyes; males are brighter. Their similarity to Hawaiʻi ʻamakihi (*Chlorodrepanis virens*), Hawaiʻi ʻākepa (*Loxops coccineus coccineus*), and introduced Japanese white-eyes (*Zosterops japonicus*) complicates field identification. Unlike many Hawaiian forest birds, their life history is well known. Outside the breeding season, they frequently join mixed-species foraging flocks and forages over home ranges that average 5-11 hectares (up to 17.3 acres). They glean insects, spiders, and other invertebrates from the branches, trunks, and foliage of live ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees. During the breeding season, the species' home range averages 4 to 7 hectares (10 – 17 acres) and a 10 – 20 meter (33 – 66 feet) territory around the nest is defended. Most nests are open cup structures, but about 15 percent are placed in cavities or in bark crevices. Females build nests, incubate eggs, and brood nestlings. Males deliver food to the female on and off the nest. Both parents feed the young for approximately one month. ʻAlawī re-nest after nest failures and pairs may raise two broods in a season. Nest success is very low, but adults have high annual survival.

DISTRIBUTION: Occurs in four disjunct populations above 1,500 meters (5,000 feet) on the island of Hawaiʻi. Historically occurred across the island above 1,070 meters (3,500 feet) elevation. Last detected in the Puʻu Waʻawaʻa Forest Bird Sanctuary in 2016, and nearly extirpated from the Kona District. Extint in Kohala.

ABUNDANCE: The Hawaiian Forest Bird Survey (1976-79, 1983), estimated the population at 12,500 ± 2,000 (95% confidence interval) birds. The largest population consisted of 9,888 (6,115 – 14,974) at Hakalau Forest in 2019. .

LOCATION AND CONDITION OF KEY HABITAT: Most commonly in mesic and wet forests dominated by ʻōhiʻa and koa, with a subcanopy of ʻōlapa (*Cheirodendron trigynum*),

pūkiawe (*Styphelia tameiameiae*), ʻōhelo (*Vaccinium* spp.), ʻakala (*Rubus hawaiiensis*), kōlea (*Myrsine* spp.), kāwaʻu (*Ilex anomala*), and hapuʻu tree ferns (*Cibotium* spp.). Habitat conditions vary across the species' range, with much of it degraded by grazing ungulates, especially cattle and feral pigs. Most of the current range of the ʻalawī is within the boundaries of State and Federally owned lands.

THREATS:

- Predation. Nest success is very low (11 to 50 percent) and rat (*Rattus* spp.) predation may be partially responsible. ʻAlawī place their nests near the main trunks of trees which may facilitate predation by rats.
- Disease. The alawi's absence below 1,350 meters (4,500 feet) elevation suggests that it may be particularly susceptible to mosquito-borne avian disease.
- Habitat loss and degradation. Logging and grazing ungulates have reduced, degraded, and fragmented suitable forest habitats. Habitat fragmentation may be a dispersal barrier preventing or restricting recolonization of the species' former range.
- Competition. Competition with Japanese white-eyes(*Zosterops japonicus*) may negatively affect ʻalawī.

CONSERVATION ACTIONS: Past or ongoing actions specific to the ʻalawī include studies on productivity, recruitment, and survival, and development of captive propagation techniques. They likely have benefited from actions to conserve other endangered forest birds in the Hakalau Forest National Wildlife Refuge, the Kona unit of the Hakalau Forest National Wildlife Refuge, ʻŌlaʻa/Kīlauea Watershed Partnership, Kapāpala Forest Reserve, and Puʻu Waʻawaʻa Wildlife Sanctuary. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future management specific to ʻalawī may include the following:

- Reintroduce the ʻalawī to managed areas in their former range (e.g., Mauna Loa strip in Hawaiʻi Volcanoes National Park).
- Control rodents to enhance nestling and female survival. Aerial broadcast of rodenticides would be the most effective method to treat broad areas.
- Increase public education to engender support for conservation of forest birds.
- Continue and expand protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the ʻalawī include:

- Determining the efficacy and health implications of broadcast rodenticide.
- Explore landscpe use of predator control via lethal traps.
- Conduct range wide population estimates and determine population trends.
- Determine if ʻalawī can be a surrogate species for ʻakikiki.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kendall SJ, Rounds RA, Camp RJ, and Genz AS. 2022. Forest Bird Populations at the Big Island National Wildlife Refuge Complex, Hawaii. Hawai‘i Cooperative Studies Unit Technical Report HCSU-102. University of Hawai‘i at Hilo, Hawaii, USA. 141 pages.

Lepson JK, Woodworth BL. 2001. Hawai‘i creeper (*Oreomystis mana*). *In* The Birds of North America, No. 680 (A. Poole and Fr. Gill, eds.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Bret Nainoa Mossman

Forest Birds

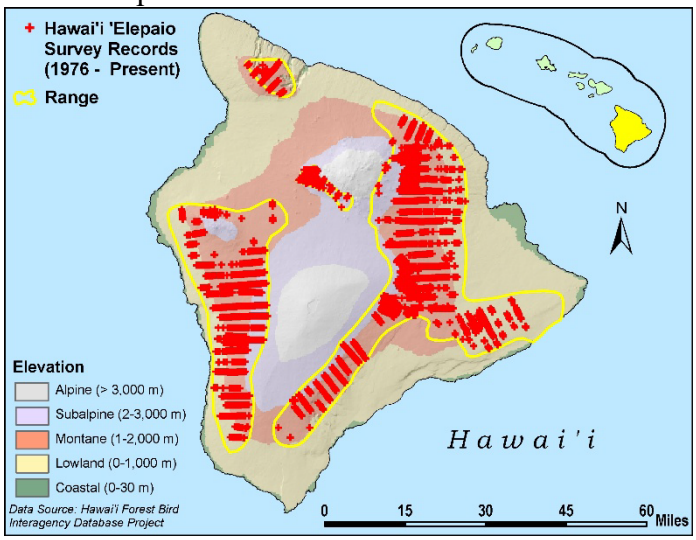
Hawai‘i ‘elepaio

Chasiempis sandwichensis

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Vulnerable
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Hawai‘i ‘elepaio is a small, adaptable monarch flycatcher (Family: Monarchiade) endemic to the island of Hawai‘i. ‘Elepaio also occur on Kaua‘i (*C. sclateri*) and O‘ahu (*C. ibidis*); the latter is federally listed as endangered. Adults are dark brown above and white below with variable amounts of brown streaking; there is considerable variation in pattern based on elevation and precipitation levels;males have black throats and females have white throats. The bird’s name is derived from its primary song which is a shrill whistle given only by males. ‘Elepaio forage in the air, on the ground, logs, rock crevices, snags, and all parts of trees. They use a diversity of foraging maneuvers likely dependent on habitat type: they capture arthropods by flycatching, glean while perched or hovering, and in direct pursuit, and may prefer ‘ōhi‘a (*Metrosideros polymorpha*) and kāwa’u (*Ilex anomola*) for foraging. Pairs remain together year-round, and long-term pair bonds are common; one pair was together for 11 years. Unlike Hawaiian honeycreepers, both males and females participate almost equally in all aspects of rearing. Finely woven cup nests are built in ‘ōhi‘a and in other trees in proportion to their availability. Clutch size is usually two, and second nests are attempted, often while fledglings from first are still being fed. Young are fed by parents for at least a month but remain on their natal territory for up to ten months.

DISTRIBUTION: Occurs in most forested areas above 600 meters (2,000 feet). Isolated populations occur in Kohala and on the western slope of Mauna Kea. Historical distribution likely included all forested areas of the island.



ABUNDANCE: The Hawaiian Forest Bird Surveys (1976-79, 1983) estimated the islandwide population at more than 270,000 birds. The island of Hawai‘i contains four populations (~150,000 birds) in windward Hawai‘i Island, ~12,080 birds in Kohala, one population in Kona and an isolated population on the south slope of Mauna Kea . The Kona and Maunakea

populations have both declined since the 1980s in some areas by as much as 90%. As of 2019 the population at Hakalau Forest National Wildlife Refuge was 21,833 birds with another 5,315 in the Kona unit.

LOCATION AND CONDITION OF KEY HABITAT: A variety of forest types and elevations, but most common in wet or mesic forests at higher elevations. Highest densities occur in ʻōhiʻa or mixed ʻōhiʻa-koa (*Acacia koa*) forests above 1,100 meters (3,600 feet). Much of the current range is managed by State and federal agencies or private conservation partnerships.

THREATS:

- Predation. On Oʻahu, predation by black rats (*Rattus rattus*) has been implicated in the loss of nests and death of adult females, and rat control in these populations resulted in large increases in nest success and in the survival of adult females.
- Disease. Avian pox reduces nesting success and adult survival. On Oʻahu, annual survival and reproductive success of birds with active pox lesions are lower compared to healthy birds; no information is available on the effect of avian malaria.
- Habitat loss and degradation. Historical habitat loss and degradation, especially at low elevations, is a major cause of declines. In Hakalau Forest National Wildlife Refuge, population densities are lower in degraded, open forests than in intact, dense forests.

CONSERVATION ACTIONS: Hawaiʻi ʻelepaio likely have benefited from management actions to conserve other endangered forest birds species at Hakalau Forest National Wildlife Refuge, Hawaiʻi Volcanoes National Park, Puʻu Lāʻau, and the ʻŌlaʻa/Kīlauea Watershed Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the Hawaiʻi ʻelepaio may include the following:

- Protect and restore high elevation native forests and eliminate feral ungulates and non-native invasive plants.
- Conduct public education and outreach about the benefits of rodent control.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the Hawaiʻi ʻelepaio include the following:

- Continue to screen birds for disease resistance. If resistant birds are identified, translocation and/or captive propagation of these birds may help recover populations.
- Continue to develop techniques for captive propagation.
- Conduct range wide population estimates and determine population trends.

References:

Burnett K, Camp RJ, Hart PJ. 2021. Current Distibution and Abundnace of Kohala Forest Birds in Hawai‘i. Journal of Field Ornithology.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kendall, S. J., R. J. Camp, A. Wang, L. Berry, and L. Nietmann. 2023. Forest bird populations at the Pu‘u Wa‘awa‘a Forest Bird Sanctuary and Pu‘u Wa‘awa‘a Forest Reserve, Hawai‘i. Hawai‘i Cooperative Studies Unit Technical Report 108. University of Hawai‘i at Hilo. 57 pages.

Kendall SJ, Rounds RA, Camp RJ, and Genz AS. 2022. Forest Bird Populations at the Big Island National Wildlife Refuge Complex, Hawaii. Hawai‘i Cooperative Studies Unit Technical Report HCSU-102. University of Hawai‘i at Hilo, Hawaii, USA. 141 pages.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

VanderWerf EA. 1998. ‘Elepaio (*Chasiempis sandwichensis*). *In* The Birds of North America, No. 344 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Forest Birds

‘I‘iwi

Drepanis coccinea

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Endangered on O‘ahu, Moloka‘i, Lāna‘i
State Recognized as Endemic
NatureServe Heritage Rank G4/T1/TH—Apparently Secure/
Possibly Extinct on O‘ahu, Moloka‘i and Lāna‘i/Critically imperiled on Kaua‘i
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The ‘i‘iwi is one of the most beautiful of the extant Hawaiian honeycreepers (Family: Fringillidae). Both males and females are vermillion red, with a black tail and wings, and a long, decurved pink bill. Native Hawaiians created feather adornments such as ‘Ahu ‘ula using hundreds of thousands of ‘i‘iwi feathers; such pieces signified power, spirituality, and prestige. Like ‘apapane (*Himatione sanguinea*), ‘i‘iwi often fly long distances in search of flowering ‘ōhi‘a (*Metrosideros polymorpha*). ‘I‘iwi are important pollinators for a wide swath of native plants especially the rare and endangered mints and members of the bell-flower family (Mā‘ohi‘ohi, ‘ōha wai, hāhā, ‘ōpelu, etc). Their diet consists primarily of nectar from a variety of native and non-native flowers and the presence of non-native flowers may have contributed to increases in some populations. In addition to nectar, ‘i‘iwi also eat small arthropods. Both sexes defend small nesting territories and may defend important nectar resources. Courtship chases and feeding may precede breeding. Nest sites are in terminal branches of ‘ōhi‘a trees and both sexes build the open-cup nest. Only females incubate eggs (typically two) and brood young. Young are mostly provisioned by female; males feed females off the nest. Despite their widespread distribution, little is known about their life history.

DISTRIBUTION: Occurs above 1,250 meters (4,500 feet) elevation on the islands of Hawai‘i, Maui, and Kaua‘i; and may occur at reduced densities below. Limmited to East Maui and only a few small areas within the ‘Alaka‘i Wilderness on Kaua‘i. Seemingly extincton O‘ahu and Moloka‘i. Historically, ‘i‘iwi were common down to low elevations on all the Main Hawaiian Islands.

ABUNDANCE: The ‘I‘iwi (*Drepanis coccinea*) is vulnerable to disease and habitat loss due to Rapid Ohia Death and appears to be declining in many areas; as such it was listed as threatened by U.S. Fish & Wildlife Service in October 2017. The following island population estimates are based on Paxton et al. (2013): 543,009 ± 26,697 (95% confidence interval) birds on island of Hawai‘i, 50,252 ± 3,437 individuals on East Maui, 176 ± 74 on West Maui, and 2,551 ± 617 on Kaua‘i. However, preliminary data from 2023 suggests the Kaua’i population declined to 161 (95% CI: 47-304), with a range of only 492 ha (1215 ac);DOFAW, unpublished data). They have

not been detected on Moloka'i since 2010 and on O'ahu since 2018.The population is declining in certain locations, but shows evidence of increases in some areas of Hawai'i Island and East Maui. The species' wide-ranging foraging complicates population estimates and the determination of long-term trends.

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forest dominated by ʻōhiʻa and koa (*Acacia koa*). Loss and degradation of habitat and high densities of cold-intolerant *Culex* mosquitoes, an important disease vector, in lowland areas restrict most birds to elevations above 1,250 meters (4,100 feet). Habitats with the highest ʻiʻiwi densities also support kōlea (*Myrsine lessertiana*), naio (*Myoporum sandwicense*), and hapuʻu tree ferns (*Cibotium* spp.). Māmane (*Sophora chrysophylla*) is common in high-elevation foraging habitat. Although much of the species' current range is under State or Federal jurisdiction, habitat quality and habitat protection and restoration varies considerably.

THREATS: Although populations appear stable on the islands of Hawaiʻi and Maui, they are drastically declining on Kaua'i and likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For ʻiʻiwi, the following is of particular concern:

- Disease. ʻIʻiwi are very susceptible to avian malaria and avian pox. Nine of ten individuals died within 37 days after receiving a single bite from mosquitoes infected with *Plasmodium*. Individuals infected with pox also are more likely to be infected with malaria. Because the highest points on Molokaʻi and Oʻahu are below 1,250 meters (4,100 feet), this susceptibility likely explains the severe population declines noted on these islands. Foraging movements may increase their exposure to disease.

CONSERVATION ACTIONS: ʻIʻiwi likely have benefited from actions to conserve other endangered forest birds on northeastern Haleakalā, Hakalau Forest National Wildlife Refuge, Alakaʻi Wilderness Preserve and surrounding areas, Hawaiʻi Volcanoes National Park, and the ʻŌlaʻa/Kīlauea Watershed Partnership. Future actions specific to the protection of ʻi'iwi may include the following:

- Control mosquitoes across native forest habitat.
- Aggressively control ungulates to improve habitat quality, facilitate the recovery of degraded habitat, and potentially reduce breeding habitat for mosquitoes. Control of non-native plants should be part of forest restoration efforts.
- Eradicate or manage mosquito breeding habitat in areas where ʻiʻiwi occurInvestigate options to eradicate mosquitoes, including use of genetic manipulation.
- Suppress/control rats, feral cats, and barn owls in areas where ʻiʻiwi occur
- Prevent the introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other predators on Kauaʻi
- Prevent the spread of Rapid ʻōhiʻa Death in prime ʻiʻiwi habitat
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.
- Collection for conservation breeding program, especially of the Kauaʻi population
- Supplementation of the Kaua'i population via translocation from other islands

- Reintroduce birds to Molokaʻi, Oʻahu, and other areas where they have been extirpated if habitat can be cleared of mosquitoes.

MONITORING: Continue forest bird surveys and habitat monitoring on all islands.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis catus*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻiʻiwi include the following:

- Determine if disease-resistant birds exist, and if so, determine if resistance is passed to offspring. Disease-resistant birds could be used to establish new populations.
- Determine the role of ʻiʻiwi in transmitting disease between low and high elevations.
- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology and success of this poorly known species.
- Investigate genetic structure and disease prevalence of populations in mid-to- lower elevations, such as the population within West Maui, which had individuals translocated from East Maui in 2001.
- Study the genetics of the Kaua'i population to determine how it may differ since Kaua'i population has the greatest distance separating it from other islands' populations.
- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps)
- Assess the impact of introduced rodents on food resources (e.g., floral, invertebrates) important to 'i'iwi.
- Evaluate recovery priorities, metrics, and requirements to best allow for reestablishment of cultural use of the species.

References:

Burnett K, Camp RJ, Hart PJ. 2021. Current Distibution and Abundnace of Kohala Forest Birds in Hawaiʻi. Journal of Field Ornithology.

Becker CD, Massey G, Groombridge JJ, Hammond R. 2010. Moving ʻI'iwi (*Vestiaria coccinea*) as a Surrogate for Future Translocations of Endangered ʻAkohekohe (*Palmeria dolei*). Technical Report #172.

Fancy S G, Ralph CJ. 1998. ʻIʻiwi (*Vestiaria coccinea*). *In* The Birds of North America, No. 327 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kendall, S. J., R. J. Camp, A. Wang, L. Berry, and L. Nietmann. 2023. Forest bird populations at the Puʻu Waʻawaʻa Forest Bird Sanctuary and Puʻu Waʻawaʻa Forest Reserve, Hawaiʻi. Hawaiʻi Cooperative Studies Unit Technical Report 108. University of Hawaiʻi at Hilo. 57 pages.

Judge SW, Camp RJ, Warren CC, Berthold LK, Mounce HL, Hart PJ, Monello RJ. 2019. Pacific island landbird monitoring annual report, Haleakalā National Park and East Maui Island, 2017. Natural Resource Report. NPS/PACN/NRR—2019/1949. National Park Service. Fort Collins, Colorado.

Paxton, EH, Gorresen, PM, Camp RJ. 2013. Abundance, distribution, and population trends of the iconic Hawaiian Honeycreeper, the ‘I’iwi (*Vestiaria coccinea*) throughout the Hawaiian Islands: U.S. Geological Survey Open-File Report 2013-1150.

Smith L, Judge S, Camp R, Genz A, Berry L, Berthold L, Mounce H. 2023. The Status and Trends of Forest Birds on Moloka‘i. Poster Presentation. Hawai’i Conservation Conference. Honolulu, HI.

USFWS 2023? New recovery plan for iiwi

VanderWerf EA, Rohrer JL. 1996. Discovery of an ‘I‘iwi population in the Ko‘olau Mountains of O‘ahu. ‘Elepaio 56:25–28

Jeremy Snell Coutacy of Bernice Pauahi Bishop Museum

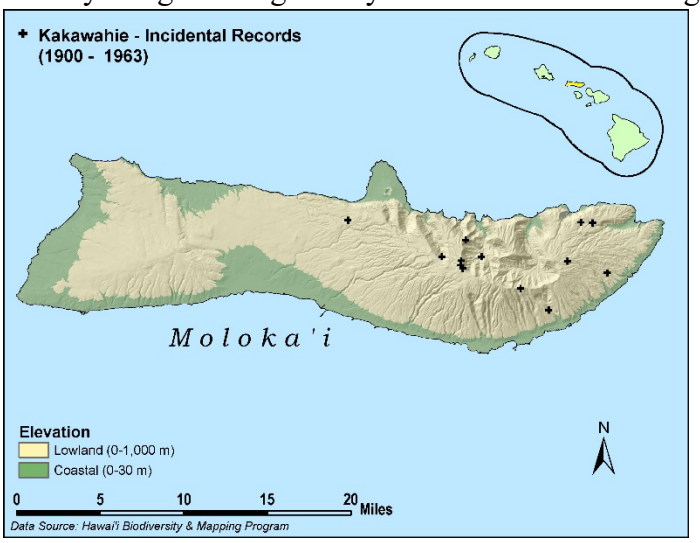
Kākāwahie

Paroreomyza flammea

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank GH—Extinct
IUCN Red List Ranking—Extinct
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The kākāwahie, or Moloka‘i creeper, is a small, sexually dichromatic, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the forests of eastern Moloka‘i. Males are scarlet red; females are a warm light brown on top and pale gray below with an orange red breast. Juvenile males are a patchy dull rusty color. The species' Hawaiian name translates as "woodchopping" and apparently describes the species chipping call. Kākāwahie forage in groups, gleaning invertebrates from leaves, bark, and epiphytes in wet ‘ōhi‘a (*Metrosideros polymorpha*) forests. Little is known about the species' breeding biology, but it is assumed to be similar to that of the Maui creeper (*P. montana*). First described in 1889, the last bird was observed in May 1963

DISTRIBUTION: Unknown. Probably extinct. Last observed on the west rim of Pelekunu Valley. Kākāwahie were common in native forests of eastern Moloka‘i at the end of the 19th century. Original range likely included all forested regions of Moloka‘i



.

ABUNDANCE: Unknown. The last kākāwahie was observed in 1963 and the species is probably extinct.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Was known to occur in wet ‘ōhi‘a (*Metrosideros polymorpha*) forests from low to high elevations, and other heavily wooded native areas of eastern Moloka‘i. The areas where the species was last observed are managed by the State as

Natural Area Reserves or by The Nature Conservancy.

THREATS: Unknown. However, kākāwahie likely were susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For kākāwahie, the following likely was of particular concern:

- Disease. This species rapid decline and the fact that no habitat above 1,250 meters (4,100 feet) occurs on Molokaʻi suggests disease may have played an important role in the species' decline.

CONSERVATION ACTIONS: If the species persists, it likely benefits from actions to conserve other endangered forest birds of eastern Molokaʻi including the establishment of the protected areas, regular surveys of forest bird populations, habitat monitoring, and studies of disease and disease vectors. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue Forest bird surveys and habitat monitoring on all islands.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to kākāwahie.

References:

Baker PE, Baker H. 2000. Kākāwahie (*Paroreomyza flammea*) and Oʻahu alauahio (*Paroreomyza maculata*). *In* The Birds of North America, No. 503 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Jeremy Snell Courtesy of Bernice Pauahi Bishop Museum

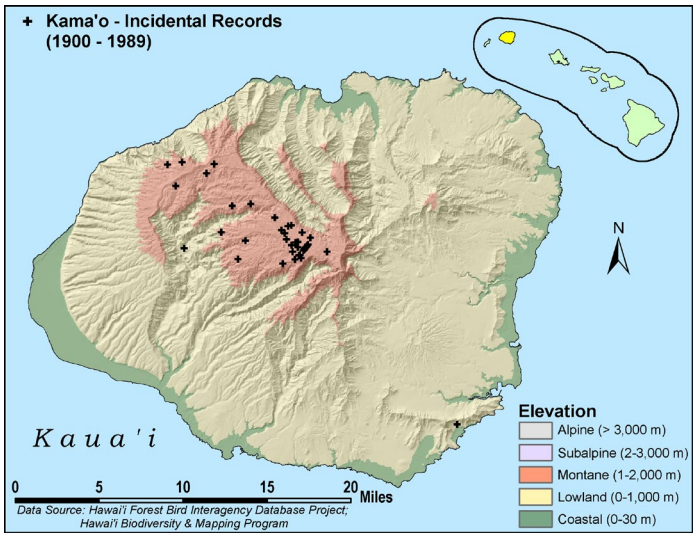
Kāmaʻo

Myadestes myadestinus

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank GH – Possibly Extinct
IUCN Red List Ranking — Extinct
y Plan for the Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The kāmaʻo, or large Kauaʻi thrush, is one of two Hawaiian solitaires (family: Turdidae) endemic to Kauaʻi. The species was noted for flying upward, singing a few loud notes, and then suddenly dropping into the understory. Like all adult Hawaiian solitaires, the kāmaʻo has olive-brown and gray plumage with rusty brown patches in the wings, but it lacks the white-eye ring and pinkish legs of the smaller puaiohi or small Kauaʻi thrush (*M. palmeri*). The species' complex song is composed of a melodic series of liquid warbles, trills, and whistles, and was often heard before dawn and after dusk. The diet is reported to consist of fruits and berries.. Life history characteristics are mostly unknown, but are presumed similar to the ʻōmaʻo (*M. obscurus*). Breeding is thought to occur in spring, although no nest has been described.

DISTRIBUTION: Has not been observed below 1,100 meters (3,500 feet) since the mid-1960s. Extinct, but formerly, it was concentrated in the uppermost regions of the Alakaʻi Wilderness Preserve. Historically was found in moist forests near sea level on northern Kauaʻi as well as upland, interior mountain forests.



ABUNDANCE: Probably extinct. The Hawaiian Forest Bird Survey (1981), estimated the population at 24 ± 30 (SE) individuals. The last kāmaʻo was observed in 1989, and was not observed during the 2000, 2008, 2018, or 2023 Kauaʻi Forest Bird Surveys. Historically, the kāmaʻo was extremely common.

LOCATION AND CONDITION OF KEY HABITAT: Most recent sightings were in open canopy forests of ʻōhiʻa (*Metrosideros polymorpha*) and ʻōlapa (*Cheirodendron* spp.). Based on the diet and life history of the ʻōmaʻo, a diverse understory including epiphytes, tree ferns, and fruiting plants such as ʻieʻie, ʻōhā wai (*Clermontia* spp.), and ʻōhelo (*Vaccinium* spp.) would likely be high-quality habitat. Because ʻieʻie, an important food plant, does not do well in high-elevation forests, if the species persists it may be restricted to marginal habitat. The area where the species was last observed is managed by the State of Hawaiʻi as a Wilderness Preserve.

THREATS: Kāmaʻo are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For kāmaʻo, the following are of particular concern:

- Disease. Mosquito-borne disease is probably the most important factor in the decline of the kāmaʻo. Pox lesions were noted on this species in mid-19th century.
- Habitat degradation. The presence of native forest with abundant fruit-bearing plants below the species current range demonstrates that habitat degradation cannot entirely explain the species extirpation from lowland areas. However, several invasive plants and feral pigs (*Sus scrofa*) have degraded the understory of many native forests.
- Competition. Non-native birds, especially ecologically similar species (e.g., white-rumped shama [*Copsychus malabaricus*]), may have contributed to the species' decline.
- Predation. If kāmaʻo, like many solitaires, are cavity or low platform nesters, their nests would be very susceptible to rats (*Rattus* spp.).
- Non-native arthropods. Recently introduced non-native insects, especially yellow jackets (*Vespula pensylvanica*) and Argentine ants (*Linepithema humile*), may compete with the kāmaʻo's native arthropod prey or disrupt the pollination of the species' food plants. Introduced herbivorous insects also could reduce the abundance of food plants.

CONSERVATION ACTIONS: If the species persists, it likely benefits from efforts to conserve other endangered forest birds on Kauaʻi, including the establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, habitat monitoring, studies of disease and disease vectors, and public education efforts featuring Kauai's endangered forest birds. In addition to these efforts, future management specific to the recovery of the kāmaʻo may include:

- Aggressively control ungulates to improve the quality of kāmaʻo habitat and facilitate the recovery of degraded, but potential, habitat. Control of non-native plants should be part of forest restoration efforts.
- Conduct eradication of rats and feral cats from the Alakaʻi Wilderness Preserve.
- Prevent introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other possible predators.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to

control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to kāmaʻo.

References:

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Wakelee KM, Fancy SG. 1999. ʻOmaʻo (*Myadestes obscurus*), kamaʻo (*Myadestes myadestinus*), olomaʻo (*Myadestes lanaiensis*), and ʻamaui (*Myadestes woahensis*). *In* The Birds of North America, No. 460 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kauaʻi ʻakialoa

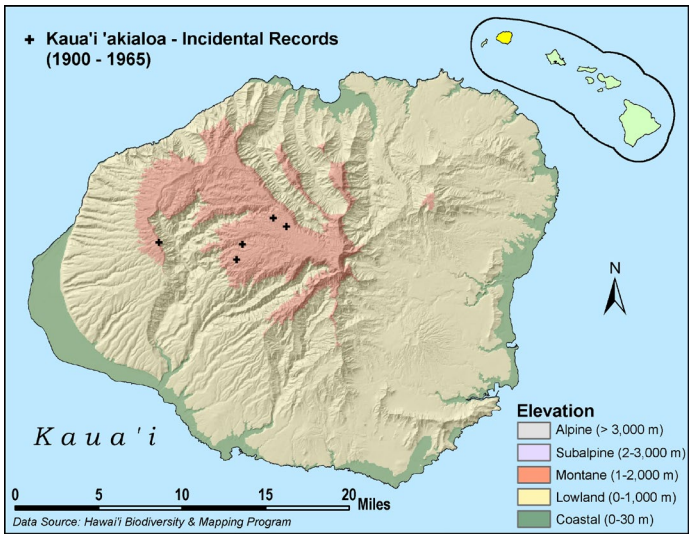
Akialoa procerus

Jeremy Snell Courtesy of Bernice Pauahi Bishop Museum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank GX—Presumed Extinct
IUCN Red List Ranking—Extinct
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Kauaʻi ʻakialoa is perhaps the most morphologically specialized of the Hawaiian honeycreepers (Family: Fringillidae) having a decurved bill that is up to half the length of their body. Both sexes are mostly olive-green; males being somewhat brighter, slightly larger, and have a longer bill. The life history of the Kauaʻi ʻakialoa is poorly known and mostly based on observations from the turn of the last century. The species principally foraged for arthropods on the trunks and branches of ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees, and hāpuʻu tree ferns (*Cibotium* spp.) by using its bill to probe bark cervices, decaying wood, epiphytes, and organic matter; observed to insert its entire bill into crevices. Foraging behavior has been described as being similar to that of a woodpecker or creeper. They also took nectar from ʻōhiʻa and lobelia (Campanulaceae) flowers. Nothing is known about its breeding biology. ʻAkialoa also occurred on the islands of Hawaiʻi, Oʻahu, and Lānaʻinone have been observed for at least 60 years.

DISTRIBUTION: Unknown. Probably extinct. The Kauaʻi ʻakialoa was last seen in the Alakaʻi wilderness preserve. Original range likely included all forested regions of Kauaʻi.



ABUNDANCE: Unknown. Last observed in 1969, and is probably extinct. Extensive surveys in 1989, 1994, 1996, 2000, 2005, 2006, 2008, 2018, and 2023 did not detect the species. Historically, the species was reported to be fairly common.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. In the late

1800s, the Kauaʻi ʻakialoa occurred in most forests on Kauaʻi from between 200 and 1,500 meters (650 – 4,875 feet) elevation. The species was last observed in the Alakaʻi Wilderness Preserve.

THREATS: Causes of the decline of this species are unknown. However, ʻakialoa likely were susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For Kauaʻi ʻakialoa populations, the following likely was of particular concern:

- Disease. Avian pox lesions are noted in historic accounts and occur on museum specimens. Perkins (1903) noted Kauaʻi ʻakialoa was "grievously affected by…swelling on the legs and feet, as well as on the head at the base of the bill, and on the skin around the eyes."
- Predation. Following the introduction of non-native mammals, particularly black rats, to Kauaʻi in the late 1800s or early 1900s this species and most other Kauaʻi endemics precipitously declined. Similar patterns of extinction and population decline were observed on Oʻahu, Hawaiʻi, Maui, Molokaʻi, and Lānaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: If the species persists, it likely benefits from actions to conserve other endangered forest birds on Kauaʻi, including the establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, habitat monitoring, studies of disease and disease vectors, control of feral ungulates through public hunting, and public education efforts featuring Kauai's endangered forest birds. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to Kauaʻi ʻakialoa.

References:

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

0Atkinson I. A. E. 1977. A Reassessment of Factors, Particularly *Rattus rattus*., That Influenced the Decline of Endemic Forest Birds in the Hawaiian Islands. Pacific Science.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK, Johnston SM. 2000. Greater ‘akialoa (*Hemignathus ellisianus*) and lesser ‘akialoa (*Hemignathus obscurus*). *In* The Birds of North America, No. 512 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Perkins RC. 1903. Verebrata. Pp. 365-466 *In* Fauna Hawaiiensis. Volume 1, Part IV (Sharp D, editor). Cambridge, UK: University Press.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Forest Birds

Kaua‘i ‘amakihi

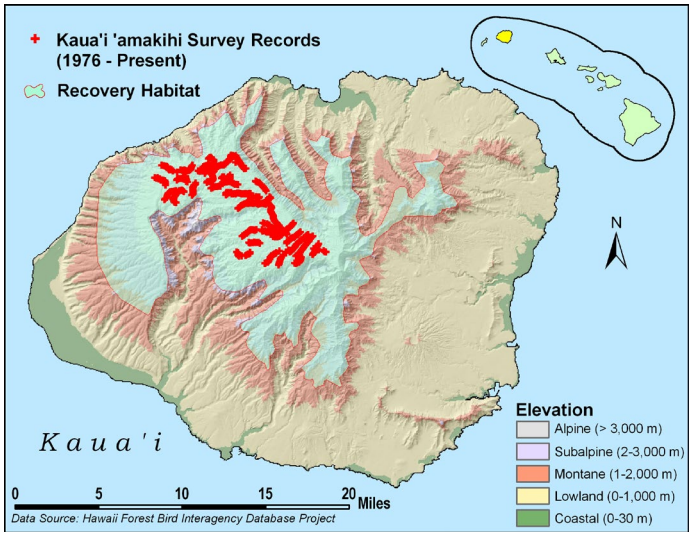
Chlorodrepanis kauaiensis

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Endangered

SPECIES INFORMATION: The Kaua‘i ‘amakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Kaua‘i. Until 1995, the Kaua‘i ‘amakihi, Hawai‘i (*H. virens*), and O‘ahu ‘amakihi (*H. falvus*) were considered a single species: common amakihi (*H. virens*). The plumage of all species is similar; males are yellow-green to olive with black lores. Females are generally similar, but duller. All have decurved bills. The Kaua‘i ‘amakihi is the dullest of the three species, is larger and has a longer, heavier and more decurved bill than the other species. They glean arthropods from branches and trunks as well as leaves, often hanging upside down to examine the underside of branches. Also probes bark crevices for food items, pierces the bases of ‘ōhi‘a (*Metrosideros polymorpha*) flowers for nectar, and feeds on the fruit of native and non-native plants. Males display (i.e., rapidly move around the female and sing), chase, and feed females prior to breeding. Both sexes build the nest, typically in a non-blooming ‘ōhi‘a tree, although the female does most of the construction while the male sings in adjacent trees. Kaua‘i ‘elepaio nests are lower than most other forest bird species on Kaua’i at 5.1 $\pm$ 2.0 m, (n = 40, range 1.3–8.4 m; Hammond et al. 2015). Females incubate a clutch of three eggs and brood nestlings at night and during inclement weather. Both parents feed nestlings. The mean incubation period of Kaua‘i ‘elepaio is 19.7 $\pm$ 1.5 d (n = 23, range = 17–23 and the mean nestling period is 15.0 $\pm$ 1.2 d (n = 24, range = 13–17 d, for a otal nesting period of 35 d (Hammond et al. 2015). Fledglings are accomplished fliers. No information on post-fledgling behavior or parental dependency. Although weather has been implicated in nest failure, nest survival probability is high (0.63 $\pm$ 0.08), but of nests that fail, predation is the cause in 60% of cases (Hammond et al. 2015).

DISTRIBUTION: Occurs above 600 meters (2,000 feet) in the forests of Waimea Canyon, Nā Pali Plateau, the Alaka‘i Swamp, and Makaleha Mountains. Original range likely included all forested areas of Kaua‘i

ABUNDANCE: In the early 1970s the population was estimated at 10,743 ± 970 (SE) birds. A survey in the late 1980s estimated 15,000 to 20,000 birds. The Kaua‘i Forest Bird Survey (2000) estimated the population in the Alaka‘i Swamp and Kōke‘e State Park area at greater than 40,000 birds and reported a significant population increase between 1981 and 2000. However, data from the Alakai Plateau suggest a general decline and possible range constriction since 2008, and in 2023 the population was estimated to be 9,307 (95% CI: 6,852-11,588; DOFAW, unpublished data).



LOCATION AND CONDITION OF KEY HABITAT: Wet and mesic montane forests above 600 meters (2,000 feet) dominated by ‘ōhi‘a, koa (*Acacia koa*), ‘ōlapa (*Cheirodendron trigynum*), and lapalapa (*C. platyphyllum*). At lower elevations where the species historically occurred, native habitats are severely degraded. Although public hunting reduces the number of feral ungulates in accessible areas of the species’ range, it is not effective in preventing habitat degradation. Occupied habitats above Waimea Canyon, in and west of the Alaka‘i Swamp, are managed by the State of Hawai‘i.

THREATS: Kaua‘i ‘amakihi are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. Although many Kaua’i ‘elepaio tolerate malaria well enough to be captured post-infection, positive malaria status is negatively associated with body condition and the species sometimes shows pox lesios (KFBRP, unpubl. data).

CONSERVATION ACTIONS: Kaua‘i ‘amakihi likely benefit from actions to conserve other endangered forest birds including establishment of the Alaka‘i Wilderness Preserve, regular surveys of forest bird populations, habitat monitoring, studies of disease and disease vectors, control of feral ungulates through public hunting control of feral ungulates through public hunting and fencing, suppression of rats on two A24 trapping grids over approximately 150 ha (470 ac), and education about Kauai’s endangered forest birds. Future management specific to the Kaua‘i ‘amakihi may include the following:

- Aggressively control ungulates to improve habitat quality.
- Control non-native plants that degrade native habitat.
- Reduce breeding habitat for mosquitoes on the Alaka’i Plateau
- Suppress mosquito populations through releases of incompatible or sterile mosquitoes.
- Investigate options to eradicate mosquitoes, including use of genetic manipulations.

- Prevent the spread of Rapid Ohia Death on the Alaka'i Plateau
- Suppress/control rats (*Rattus* spp.), feral cats (*Felis catus*), and barn owls (*Tyto alba*) from the Alakaʻi Wilderness Preserve and Koke'e Region.
- Prevent the introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other non-native predators.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquitoes. Research priorities specific to the Kauaʻi ʻamakihi include the following:

- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology, and success of this poorly known species.
- Conduct studies to investigate the apparent population fluctuations in this species
- Determine the species' susceptibility to avian malaria and avian pox.
- Investigate the impact of rat predation on food resources (e.g., flowers, invertebrates) for ʻamakihi.
- Investigate sub-lethal impacts disease (malaria, pox) on ʻamakihi fecundity
- Determine sources of mosquitoes and investigate methods of mosquito control.
- Determine the effects of recently established non-native insects on native arthropods, especially those that are part of the species' diet.Determine the status of populations outside of the greater Alakaʻi Swamp region.
- Conduct phylogenetic analyses to determine the relationship to other ʻamakihi species.

References:

Camp, RJ and PM Gorresen. 2011. Design of forest bird monitoring for strategic habitat conservation on Kauaʻi Island, Hawaiʻi. Hawaiʻi Cooperative Studies Unit Technical Report HCSU-022. University of Hawaiʻi at Hilo.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lindsey GD, VanderWerf EA, Baker H, Baker PE. 1998. Hawaiʻi (*Hemignathus virens*), Kauaʻi (*Hemignathus kauaiensis*), Oʻahu (*Hemignathus chloris*) and greater ʻamakihi (*Hemignathus sagittirostris*). *In* The Birds of North America, No. 360 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

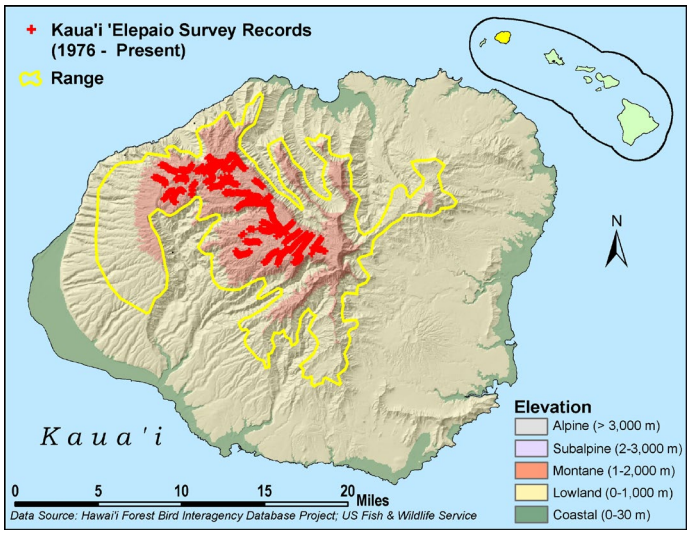
Forest Birds

Kaua‘i ‘elepaio

Chasiempis sclateri

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G2—Imperiled
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The Kaua‘i ‘elepaio is a small, adaptable monarch flycatcher (Family: Monarchiade) endemic to the island of Kaua‘i. ‘Elepaio also occur on the islands of Hawai‘i (*C. sandwichensis*) and O‘ahu (*C. ibidis*); the latter is federally listed as endangered. Adults have a dark grayish brown crown and back and white underparts with a rusty wash on the upper breast. The bird’s name is derived from its primary song which is a shrill whistle given only by males. Like other ‘elepaio on Hawai‘i and O‘ahu, Kaua’i ’elepaio use virtually all available substrates for foraging, including the ground, logs, rock crevices, snags, and all parts of trees. Equally diverse in the use of foraging maneuvers, ‘elepaio capture a wide range of arthropod prey by flycatching, gleaning while perched or hovering, and direct pursuit; foraging maneuvers vary depending on plant species from which prey is being captured and habitat type. For Kaua‘i, there is little information on plant species used, although ‘ōhi‘a (*Metrodiseros polymorpha*) is likely and nests in ‘alani (*Melicope* spp.) are common. On the island of Hawai‘i, pairs remain together throughout the year and long-term pair bonds are common. Unlike Hawaiian honeycreepers, both males and females participate almost equally in all aspects of rearing. Finely woven, cup nests are built in a variety of native and non-native trees. Clutch size is usually two and second nests are attempted, often while fledglings from first are still being fed. Young are fed by parents for at least a month, but remain on their natal territory for up to ten months, which may allow young birds to hone their foraging skills.



DISTRIBUTION: Widely distributed above 600 meters (2,000 feet) elevation, but most common above 1,100 meters (3,600 feet) elevation on the Alaka‘i Plateau. Original range likely included all forested regions of Kaua‘i.

ABUNDANCE: In 1984, the island-wide population was estimated at 40,000 birds. The 2000 Kauaʻi Forest Bird Survey estimated the population in the Alakaʻi and Kōkeʻe region at nearly 25,000 birds, with no change in the population since 1973. In 2018, the estimated population size was 51,903 birds (95% CI: 29,203-76,403, Paxton et al. 2020). In 2023, the population was estimated around 36,255 (95% CI: 29,894-43,463; U.S. Geological Survey, unpublished data). Unlike other Kaua'i forest bird species, which have experienced steep overall population declines over the last 40 years, reduced Kaua'i 'elepaio densities in Kōkeʻe have been compensated by increased densities in the Alaka'i Wilderness Area during the same time period (DOFAW, unpubl., Paxton et al. 2020). Densities peak in 'ōhiʻa forest between 1,100 and 1,300 meters (3,600 - 4,500 feet).

LOCATION AND CONDITION OF KEY HABITAT: Most common in dense wet 'ōhiʻa forests above 1,100 meters (3,600 feet) elevation; uncommon in the drier forests of Waimea Canyon, the Nā Pali coast, and the wet bogs of Waiʻaleʻale. 'Elepaio are found in some low elevation valleys with a mix of native and non-native tree species. Common non-native trees in this habitat include Java plum (*Syzygium cumini*), coffee (*Coffea arabica*), kukui (*Aleurites moluccana*), and *Albizia lebbeck.* Habitat quality varies considerably. The core of their range, the Alakaʻi Plateau and Kōkeʻe State Park, is managed by the State of Hawaiʻi as Forest Reserve, Wilderness Preserve, and State Park lands.

THREATS: Kauaʻi 'elepaio are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For Kauaʻi 'elepaio, the following are of particular concern:

- Disease. Avian pox is known to reduce both nesting success and adult survival. On O'ahu, annual survival and reproductive success of birds with active pox lesions are lower compared to healthy birds; no information on the effect of avian malaria.
- Predation. On Oʻahu, predation by black rats (*Rattus rattus*) have been implicated in the loss of nests and death of adult females and on Hawai'i and Kaua'i, the loss of nests (Banko et al. 2019, Hammond et al. 2015). Rat control in these populations resulted in large increases in nest success and in the survival of adult females. Other predators, including cats (*Felis catus*), Hawaiian short-eared owls (*Asio flammeus sandwichensis*), and barn owls (*Tyto alba*) occur throughout the forests of Kaua'i.

CONSERVATION ACTIONS: Given the increased population densities in the interior of Kaua'i, where most management occurs**,** Kauaʻi 'elepaio likely benefited from management actions to conserve other endangered forest birds including establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, monitoring of habitat conditions, eradication of ungulates within ungulate-proof fences, suppression of rats on A24 trapping grids, studies of disease and disease vectors, and public education efforts featuring Kauai's endangered forest birds. In addition to these efforts, future management specific to the Kauaʻi 'elepaio may include the following:

- Eradicate or control rats, feral cats, and barn owls in the Alakaʻi Wilderness Preserve.
- Prevent the introduction of the small Indian mongoose and other possible predators.
- Prevent the spread of Rapid 'ōhiʻa Death on the Alaka'i Plateau

- Suppress mosquito populations through releases of incompatible or sterile mosquitoes
- Investigate options to eradicate mosquitoes, including use of genetic manipulation.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquitos. Research priorities specific to the Kauaʻi ʻelepaio include life history studies to quantify population structure, dispersal patterns, survivorship, nesting phenology, and success of this poorly known subspecies.

- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps).
- Assess the impact of introduced rodents on food sources important to 'elepaio
- Investigate sub-lethal impacts disease (malaria, pox) on ʻelepaio fecundity

References:

Banko, Paul & Jaenecke, Kelly & Peck, Robert & Brinck, Kevin. (2019). Increased nesting success of Hawaii

Elepaio in response to the removal of invasive black rats. The Condor. 121. duz003. 10.1093/condor/duz003.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

Hammond RL, Crampton LH, Foster JT. 2015. Nesting success of native and introduced forest birds on the island of Kauai. Journal of Avian Biology 47: 252-262.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

Paxton ER, Brinck KW, Crampton LH, Hite J, Constantini M. 2020. 2018 Kauaʻi forest bird population estimates and trends. Technical Report Hawai'i Cooperative Studies Unit. University of Hawai'i at Hilo.

VanderWerf EA. 1998. ʻElepaio (*Chasiempis sandwichensis*). *In* The Birds of North America, No. 344 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kauaʻi nukupuʻu

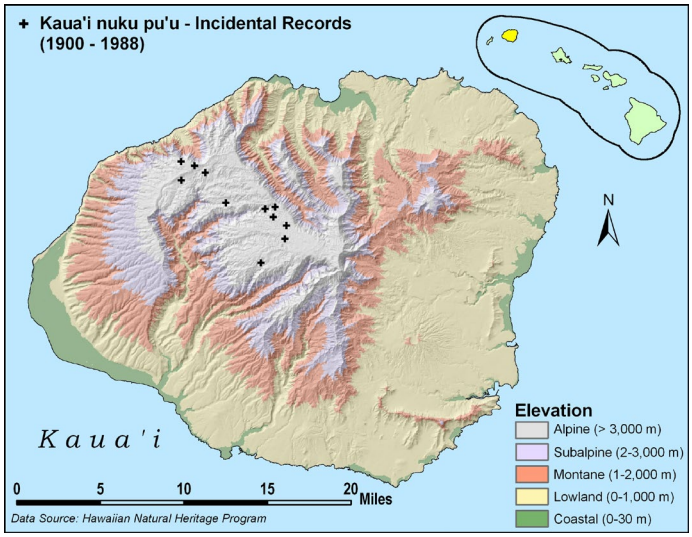
Hemignathus hanapepe

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank G1T1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
(Potentially Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Kauaʻi nuku puʻu is a medium, short-tailed Hawaiian honeycreeper (Family: Fringillidae) with a long, thin decurved bill; the lower mandible is half the length of the upper mandible. Nukupuʻu also are known from Oʻahu (*H. lucidus*) and Maui (*H. affinis*); the Oʻahu and Maui species are certainly extinct. Adult males are olive green with a yellow head, throat, and breast and have a small black mask; females are grayish green above and whitish below. Little is known about the species' life history. Often joins mixed species foraging flocks, especially those with ʻakikiki (*Oreomystis bairdi*). Apparently would creep along tree trunks, especially those of ōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees, searching the bark and dead wood for arthropod prey; also may have taken nectar. Accounts vary regarding bill use. Either hammered surfaces, similar to its congener the ʻakiapōlāʻau (*H. munroi*), or used its upper mandible to fish out prey from crevices, catching them with its tongue and lower mandible. No information on the species' breeding biology, but likely is similar to the ʻakiapōlāʻau.

DISTRIBUTION: Unknown. Probably extinct. All recent Kauaʻi nukupuʻu sightings are from a small area of southwestern Kauaʻi between 610 and 1,220 meters (2,000–4,000 feet) elevation. The species' historic range also appeared very restricted.

ABUNDANCE: Unknown. Probably extinct. There are fewer than a dozen historical records of the Kauaʻi nukupuʻu. Extensive surveys in 1989, 1994, 1996, 2000, 2005, 2008, 2018, and 2023 did not detect the species.



LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet montane forests. Habitat conditions of the species' historic range vary and all presumably support *Culex* mosquitoes. Areas where Kauaʻi nukupuʻu were most recently been observed are managed by the State of Hawaiʻi.

THREATS: Unknown. However, the Kauaʻi nukupuʻu likely was susceptible to the same factors that threaten other native Hawaiian forest birds including habitat loss and degradation, predation by introduced mammals, and disease. For Kauaʻi nukupuʻu, the following likely was of particular concern:

- Disease. The precipitous decline of all nukupuʻu taxa suggests that mosquito-borne diseases played an important role in the species' demise.
- Predation. Following the introduction of non-native mammals, particularly black rats, to Kauaʻi in the late 1800s or early 1900s this species and most other Kauaʻi endemics precipitously declined. Similar patterns of extinction and population decline were observed on Oʻahu, Hawaiʻi, Maui, Molokaʻi, and Lānaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: If the species persists, it likely benefits from management activities to conserve other endangered forest birds on Kauaʻi, including the establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, monitoring of habitat conditions, studies of disease and disease vectors, control of feral ungulates through public hunting, and public education efforts featuring Kauai's endangered forest birds. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in

native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to Kauaʻi nukupuʻu.

- If mosquitoes can be sufficiently controlled, explore introducing ʻAkiapōlāʻau to Kauaʻi to fill the vacant niche.

References:

Atkinson I. A. E. 1977. A Reassessment of Factors, Particularly *Rattus rattus*., That Influenced the Decline of Endemic Forest Birds in the Hawaiian Islands. Pacific Science.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Pratt TK, Fancy SG, Ralph CJ. 2001 ʻAkiapolaʻau (*Hemignathus munroi*) and nukupuʻu (*Hemignathus lucidus*). *In* The Birds of North America, No. 600 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Mark Collins

Forest Birds

ʻŌʻōʻāʻā

Moho braccatus

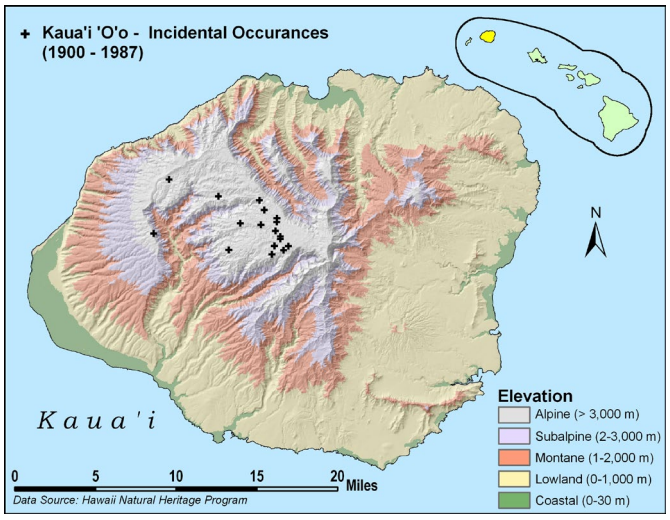
SPECIES STATUS:
Federally Listed as Extinct

Photo: Robert Shallenberger

State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank GH—Possibly Extinct
IUCN Red List Ranking—Extinct
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: Endemic to its namesake, the Kauaʻi ʻōʻō is the smallest of the five known species of Hawaiian honeyeaters (Family: Meliphagidae), and has the least gaudy plumage of the four Hawaiian species of *Moho*. ʻŌʻō eat a variety of arthropods, snails, ʻōlapa (*Cheirodendron* spp.) fruits, and nectar from the flowers of ʻōhiʻa (*Metrosideros polymorpha*), lobelia, as well as other species. Early naturalists reported the species extensively feeding on the flower bracts of ʻieʻie (*Freycinetia arborea*), a species abundant in lowland forests, but not in upper elevation forests. Little is known about the species' breeding biology. The only known nests were in cavities in large ʻōhiʻa snags.

DISTRIBUTION: Unknown. Possibly extinct. Was last observed in stream valleys of the central Alakaʻi Wilderness Preserve. Historically, the Kauaʻi ʻōʻō occurred in forest habitat throughout the island.



ABUNDANCE: Was last observed in 1987, and may be extinct. Extensive surveys in 1989, 1994, 1996, 2000, 2008, 2018, and 2023 did not detect the species. Was very common up to the end of 19th century.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. The last sightings were in dense ʻōhiʻa forests of the Alakaʻi swamp. Ironically, this habitat may have been low-quality or marginal habitat. ʻIeʻie, an important food plant, common in the lower elevation forests

previously occupied by ʻōʻō, is not found in the upper elevations forests where the species was last observed. Extensive damage to forests by hurricanes in 1982 and 1992 may have further reduced the suitability of high-elevation forests, especially given the species' apparent dependence on large snags for nest sites. The area where the species was last observed is managed by the State of Hawaiʻi as a Wilderness Preserve.

THREATS: Unknown. However, the species was likely susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For Kauaʻi ʻōʻō, the following likely were of particular concern:

- Disease. The precipitous decline of all Hawaiian *Moho* species suggests that disease played a role in this species' decline.
- Predation. Following the introduction of non-native mammals, particularly black rats, to Kauaʻi in the late 1800s or early 1900s this species and most other Kauaʻi endemics precipitously declined. Similar patterns of extinction and population decline were observed on Oʻahu, Hawaiʻi, Maui, Molokaʻi, and Lānaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: If the species persists, it likely benefits from management activities to conserve other endangered forest birds on Kauaʻi, including the establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, monitoring of habitat conditions, studies of disease and disease vectors, control of feral ungulates through public hunting, and public education efforts featuring Kauai's endangered forest birds. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the USFWS *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring on all islands.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct there are no research priorities specific to Kauaʻi ʻōʻō.

References:

Atkinson I. A. E. 1977. A Reassessment of Factors, Particularly *Rattus rattus*., That Influenced the Decline of Endemic Forest Birds in the Hawaiian Islands. Pacific Science.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Sykes PW, Kepler AK, Kepler CB, Scott JM. 2000. Kauaʻi oʻo (*Moho braccatus*), Oʻahu ʻoʻo (*Moho apicalis*), Bishop's ʻoʻo (*Moho bishopi*), Hawaiʻi ʻoʻo (*Moho nobilis*), and kioea (*Chaetoptila angustipluma*). *In* The Birds of North America, No. 535 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Portland, (OR): U.S. Fish and Wildlife Service.

Jeremy Snell Courtesy of Bernice Pauahi Bishop Museum

Maui ʻākepa

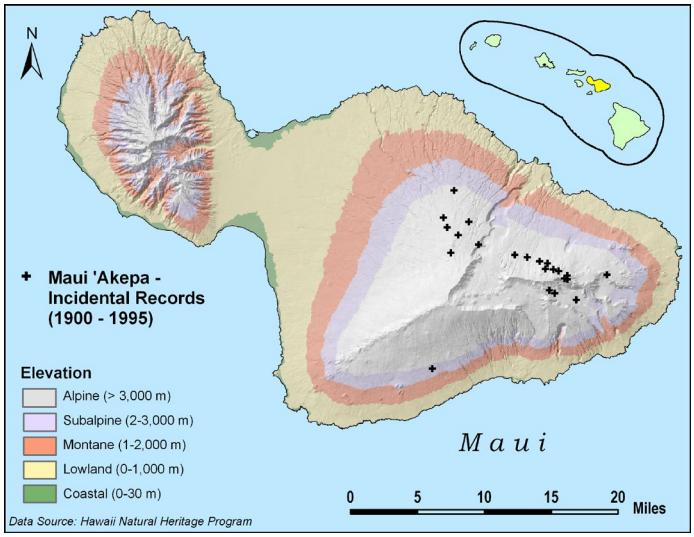
Loxops ochraceus

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank G1/TH— Presumed Extinct
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Maui ʻākepa is a small, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Maui. ʻĀkepa also are known from the island of Hawaiʻi (*L. coccineus*) and Oʻahu (*L. rufus*); the latter subspecies is certainly extinct. Adults are less colorful compared to the Hawaiʻi ʻākepa, and adult males have two color morphs bright florescent orange and yellow. There is no information on the plumage sequence of the Maui species, however the adult males on Hawaiʻi take 3-4 years to reach their definitive plumage. The lower mandible of the ʻākepa is slightly bent to one side which results in the mandible tips being offset; a characteristic shared with the ʻakekeʻe (*L. caeruleirostris*) and the other ʻākepa. Although almost nothing is known about its life history, the Maui ʻākepa likely forages in a similar manner to the Hawaiʻi ʻākepa, and was most often observed in ʻōhiʻa (*Metrosideros polymorpha*) forests. Although based on a single observation, in stark contrast to the Hawaiʻi ʻākepa, the Maui subspecies apparently builds an open-cup nest in the terminal foliage of ʻōhiʻa trees. Declared extinct by U.S. Fish & Wildlife Service in 2023.

DISTRIBUTION: Unknown. Probably extinct. Last sightings occurred on the northeastern slopes of Haleakalā between 1,700 and 2,000 meters (5,500 – 7,000 feet) elevation. Historical distribution is poorly known, but like many Hawaiian forest birds the original range likely included all forested regions of the island.

ABUNDANCE: The Hawaiian Forest Bird Survey (1980), estimated the population at 230 ± 290 (95% confidence interval) individuals, but reliance on auditory detections may have biased this estimate. No ʻākepa were found during the Hawaiʻi Rare Bird Search (1995 - 1999). The last reliable sightings occurred in 1970, and the species has not been detected in subsequent surveys.



LOCATION AND CONDITION OF KEY HABITAT: Virtually all sightings of the Maui ʻākepa in this century were in wet montane ʻōhiʻa forests on the northeastern slopes of Haleakalā. These forests vary from intact to degraded. Areas where the Maui ʻākepa have most recently been observed are managed by the State of Hawaiʻi or by the National Park Service.

THREATS: Unknown. However, the Maui ʻākepa was likely susceptible to the same factors that threaten other native Hawaiian forest birds including loss and degradation of habitat, predation by introduced mammals, and disease. For Maui ʻākepa, the following was likely of particular concern:

- Disease. The precipitous decline of the Maui and Oʻahu subspecies and the restriction of the Hawaiʻi ʻākepa to high-elevation forests suggests that disease played an important role in the demise of Maui ʻākepa.
- Predation. Following the introduction of non-native mammals, particularly black rats, to Maui in the early to late 1800s this species and most other Maui endemics precipitously declined. Similar patterns of extinction and population decline were observed on Oʻahu, Hawaiʻi, Maui, Molokaʻi, Lānaʻi, and Kauaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions. If this species nested in cavities, it may have also been particularly susceptible to predators.

CONSERVATION ACTIONS: If the species persists, it likely benefits from actions to conserve other endangered forest birds on northeastern Haleakalā. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring and studies of disease and disease vectors. Should this species be rediscovered, the Rare Bird Recovery Protocol contained in the U.S. Fish and Wildlife Service (USFWS) *Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to the Maui ʻākepa.

- Explore introducing Hawaiʻi ʻākepa to Maui to fill the now vacant niche left by this speceis.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK, Freed LA. 1997. ʻAkepa (*Loxops coccineus*). *In* The Birds of North America, No. 294 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Brooks Rownd

Forest Birds

Maui ‘alauahio

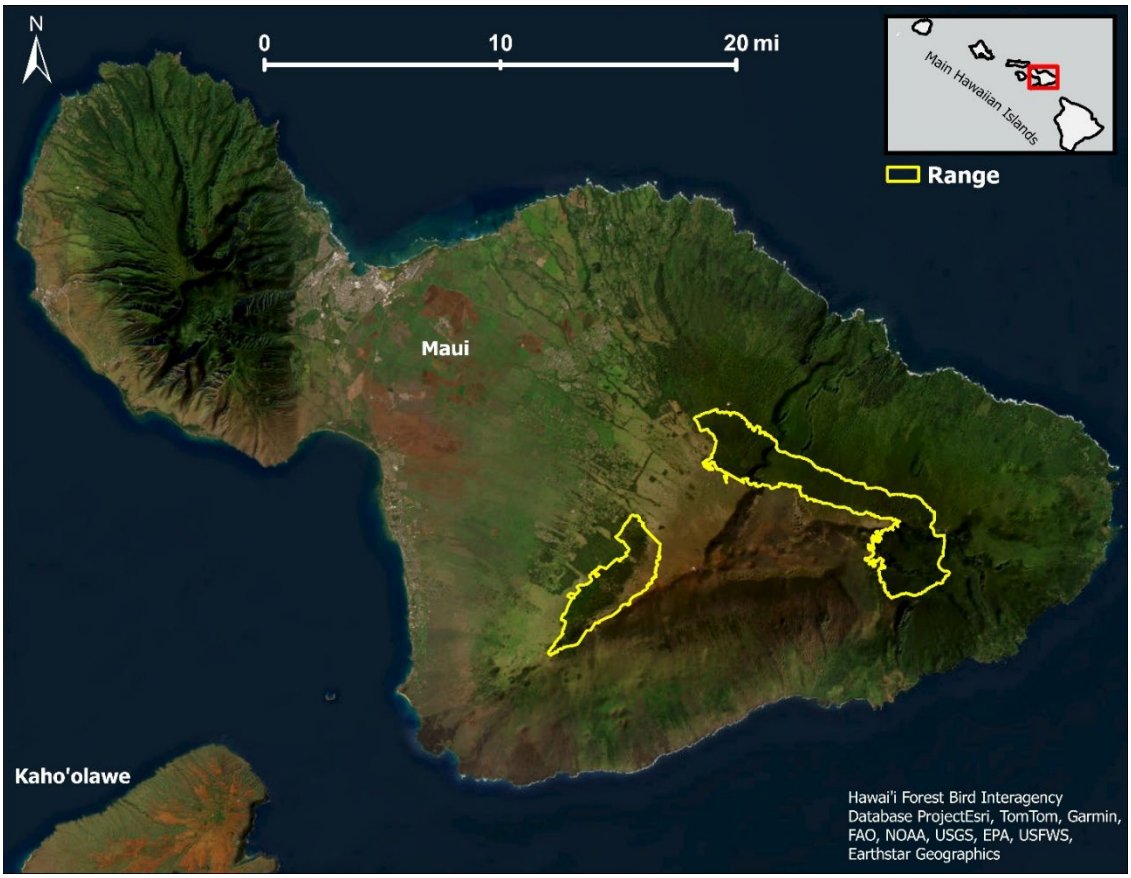
Paroreomyza montana

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G4—Apparently Secure
IUCN Red List Ranking—Endangered

SPECIES INFORMATION: The Maui ‘alauahio, or Maui creeper, is a small insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to Maui. A subspecies also occurred on Lāna‘i but was last seen in 1937 and is presumed extinct. Adult males are predominantly olive-green above and have a bright yellow face, throat, and belly; the amount and intensity of yellow varies among individuals. Adult females are similar, but generally not as bright; both have short, fine straight bills. Adult plumage is not attained for several years. The Maui ‘alauahio gleans invertebrates from woody and leafy parts of a variety of plants. Adults defend an approximately 1-hectare (2.5 acre) home range against conspecifics year-round and will chase other birds and predators from the vicinity of their nests. They are socially monogamous and pair for life, although extra-pair copulations have been confirmed through genetic analysis. Females choose the nest site and build open-cup nests. Clutch size is two, and birds will renest after a failure, although double brooding has not been documented. Only females incubate eggs and brood nestlings. They do not breed until their third year, and young birds (i.e., helpers) associate with breeding pairs. Helpers are usually offspring from the previous year and feed the female, nestlings, and fledglings. Family groups can be as many as six individuals. Fledglings are fed for two to three months, and young remain with their parents in family groups for 18 - 20 months. They will make alarm calls when predators are in the area.

DISTRIBUTION: Broadly distributed in native and non-native forest on the slopes of Haleakalā at elevations ranging from 1200 to 2300 meters (3,900- 7,500 feet). . Historically common in West Maui and on Lāna‘i; these populations are now extirpated. Fossil evidence suggests they were common across the south side of East Maui and in lowland forests, but they no longer exist in these locations today. Range is estimated to be 107 square kilometers (41 square miles).

ABUNDANCE: The Hawai’i Forest Bird Survey from 2022 estimated the population at 99,060 ± 9510 individuals (95% confidence interval); however surveys did not include all inhabited areas, so the population is likely higher. This estimate represents a 41% decrease since 1992.



LOCATION AND CONDITION OF KEY HABITAT: Primarily wet and mesic montane forests dominated by ʻōhiʻa (*Metrosideros polymorpha*), although they also occur in subalpine māmane schrubland (*Sophora chrysophylla*), and in dry and mesic forests dominated by pine (*Pinus* spp.) and eucalyptus (*Eucalyptus* spp.) (e.g., Polipoli State Park and Hosmer Grove); all populations occur above 1200 meters (3,900 feet) elevation. Habitat conditions vary greatly across the species' range. The species' range is managed by the State of Hawaiʻi, (i.e., Forest Reserve and Natural Area Reserve), the National Park Service, and private landowners including The Nature Conservancy. All entities are current members of the East Maui Watershed Partnership. Management efforts vary.

THREATS:

- Predation. Rats (*Rattus* spp.) and mongooses (*Herpestes auropunctatus*) have been observed depredating nests and females. Female behavior of begging near nests may make them particularly susceptible to rats. Additionally, their nests occur lower in the canopy than other honeycreeper species.
- Disease. Susceptibility to avian malaria has been documented, and likely prevents the establishment of populations in lowland areas.
- Habitat degradation. Current fencing around protected areas is not effective in excluding axis deer (*Axis axis*). Currently, deer populations on Maui are growing and threaten to further degrade forests occupied by the ʻalauahio.

CONSERVATION ACTIONS: Maui ʻalauahio likely have benefited from actions to conserve endangered forest birds on northeastern Haleakalā including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies on disease and disease vectors. In addition, ongoing fencing, ungulate control, and habitat restoration on Department of Hawaiian Homelands at Kahikinui could possibly allow for the re-establishment of a population there in the future. In general, actions should include continued protection and management of wildlife sanctuaries and refuges. Mosquito control implementation will benefit populations and could likely add to an increase in range and population and allow for reintroductions to areas where they used to be found. A possible reintroduction to West Maui, or Lānaʻi and traslocations to Oʻahu and Molokaʻi could allow for an expansion of range as well as being a safeguard for the species.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for Hawaiian forest birds include improving methods for controlling rats, mongooses, and feral cats (*Felis silvestris*) in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquitoes. Research priorities specific to Maui ʻalauahio include development of a translocation protocol to facilitate reintroduction into restored forests. Diet studies to determine overlap with non-native species as well as determining targeted invertebrate recovery.

References:

Baker H, Baker PE. 2000. Maui ʻalauahio (*Paroreomyza montana*). *In* The Birds of North America, No. 504 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

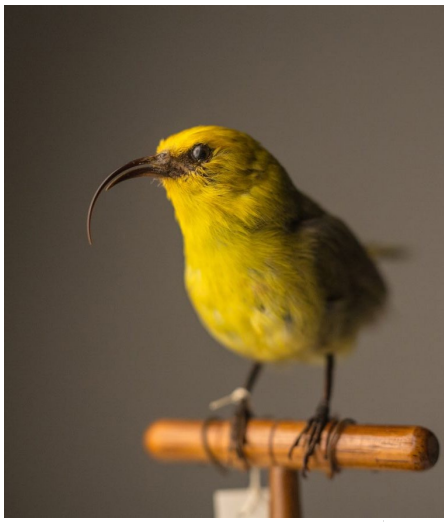
Judge SW, Camp RJ, Warren CC, Berthold LK, Mounce HL, Hart PJ, Monello RJ. 2019. Pacific island landbird monitoring annual report, Haleakalā National Park and East Maui Island, 2017. Natural Resource Report. NPS/PACN/NRR—2019/1949. National Park Service. Fort Collins, Colorado.

Judge, SW, Camp RJ, Warren CW, Berthold LK, Mounce HL, Hart PJ, and Monello RJ. 2021. Population Estimates and Trends of Three Maui Island-endemic Hawaiian Honeycreepers. Journal of Field Ornithology.

Peck RW, Banko PC, Cappadonna J, Steele C, Leonard DL, Mounce HL, Becker CD, Swinnerton KJ. 2015. An assessment of arthropod prey resources at Nakula Natural Area Reserve, a potential site of reintroduction for Kiwikiu (Pseudonestor xanthophrys) and Maui ʻAlauahio (Paroreomyza montana). Hawai'i Cooperative Studies Unit, University of Hawai'i at Hilo. Technical Report HCSU-059.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Warren CC, Motyka PJ, Mounce HL. 2015. Home range sizes of two Hawaiian honeycreepers: implications for proposed translocation efforts. Journal of Field Ornithology 86(4):305–316.



Jeremy Snell Courtesy of Bernice

Forest Birds

Maui nukupu‘u

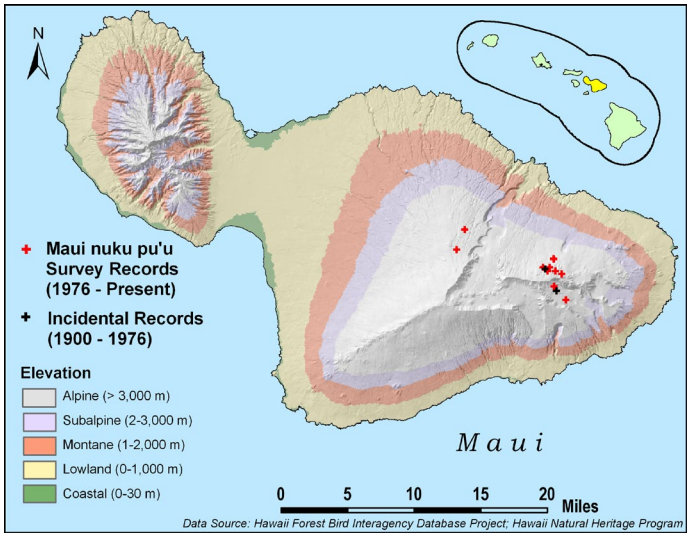
Hemignathus affinis

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank G1T1—Presumed Extinct
IUCN Red List Ranking—Critically Endangered (Possibly Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Maui nukupu‘u is a large, short-tailed Hawaiian honeycreeper (Family: Fringillidae) with a long, thin decurved bill; the lower mandible is half the length of the upper mandible. Nukupu‘u also are known from O‘ahu (*H. lucidus*) and Kaua‘i (*H. hanapepe*); all three species are certainly extinct. Adult males are olive green with a yellow head, throat, and breast and have a small black mask; females are olive green above and variable yellow-gray below. Little is known about the species’ life history. Often joins mixed species foraging flocks. Apparently would creep along large ‘ōhi‘a (*Metrosideros polymorpha*) limbs searching epiphytes, moss, bark, and dead wood for arthropod prey; may also have taken nectar. Hammered bark with lower mandible, similar to its congener the ‘akiapōlā‘au (*H. munroi*), and used its upper mandible to fish out prey from excavations. No information on the species’ reproduction, but is likely similar to ‘akiapōlā‘au. Declared extinct by U.S. Fish & Wildlife Service in 2023.

DISTRIBUTION: Poorly known. Probably extinct. Most recent sightings between 1,100 and 2,100 meters (3,600–6,900 feet) elevation in the Kīpahulu Valley and the northeastern slope of Haleakalā. Historic range apparently very restricted, although subfossil evidence suggests the species may have occurred in dry forests.

ABUNDANCE: Unknown. Probably extinct. Based on a single sighting, the Hawaiian Forest Bird Survey (1980), estimated the population at 28 ± 56 (95% confidence interval) individuals. More recent surveys have failed to detect the Maui nukupu‘u. Historically considered uncommon.



LOCATION AND CONDITION OF KEY HABITAT: Mixed ‘ōhi‘a/koa (*Koa acacia*) forests and mixed shrub montane wet forests between 1,100 and 2,100 meters (3,600–6,900 feet). Historic and fossil evidence indicates that its range was much broader and remnant populations may have been surviving in marginal habitat. Habitat conditions of the species’ former range vary. Areas where nukupu‘u were most recently sighted are managed as a Forest Reserve by the State of Hawai‘i or by the National Park Service.

THREATS: Unknown. However, the Maui nukupu‘u was likely susceptible to the same factors that threaten other native Hawaiian forest birds including loss and degradation of habitat, predation by introduced mammals, and disease. For Maui nukupu‘u, the following was likely of particular concern:

- Disease. The precipitous decline of all nukupu‘u taxa suggests that disease played an important role in the species’ decline.
  -
  - Predation. Following the introduction of non-native mammals, particularly black rats, to Maui in the early to late 1800s this species and most other Maui endemics precipitously declined. Similar patterns of extinction and population decline were observed on O‘ahu, Hawai‘i, Maui, Moloka‘i, Lāna‘i, and Kaua‘i. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: If the species persists, it likely benefits from actions to conserve other endangered forest birds on northeastern Haleakalā. These efforts include the establishment of the 3,000 hectares (7,500 acres) Hanawī Natural Area Reserve in 1986, the formation of the East Maui Watershed Partnership, fencing, ungulate and small mammal control, forest restoration, habitat monitoring and studies of disease and disease vectors. Should this species be rediscovered, the Rare Bird Recovery Protocol in the U.S. Fish and Wildlife Service (USFWS) *Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to Maui nukupuʻu.

- Explore the translocation of ʻAkiapōlāʻau to Maui to fill the vacant niche left by this species.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Pratt TK, Fancy SG, Ralph CJ. 2001 ʻAkiapolaʻau (*Hemignathus munroi*) and nukupuʻu (*Hemignathus lucidus*). *In* The Birds of North America, No. 600 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

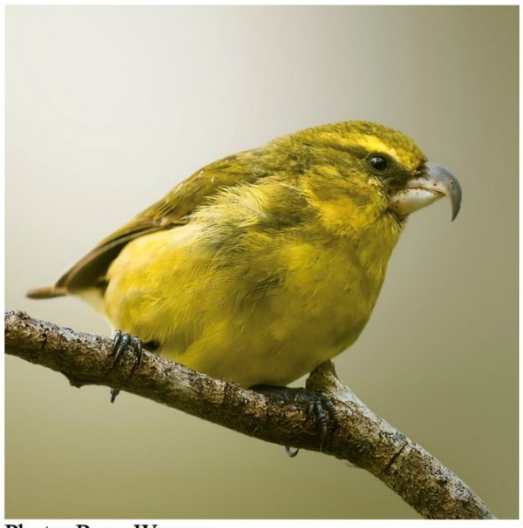


Photo: Ryan Wagner

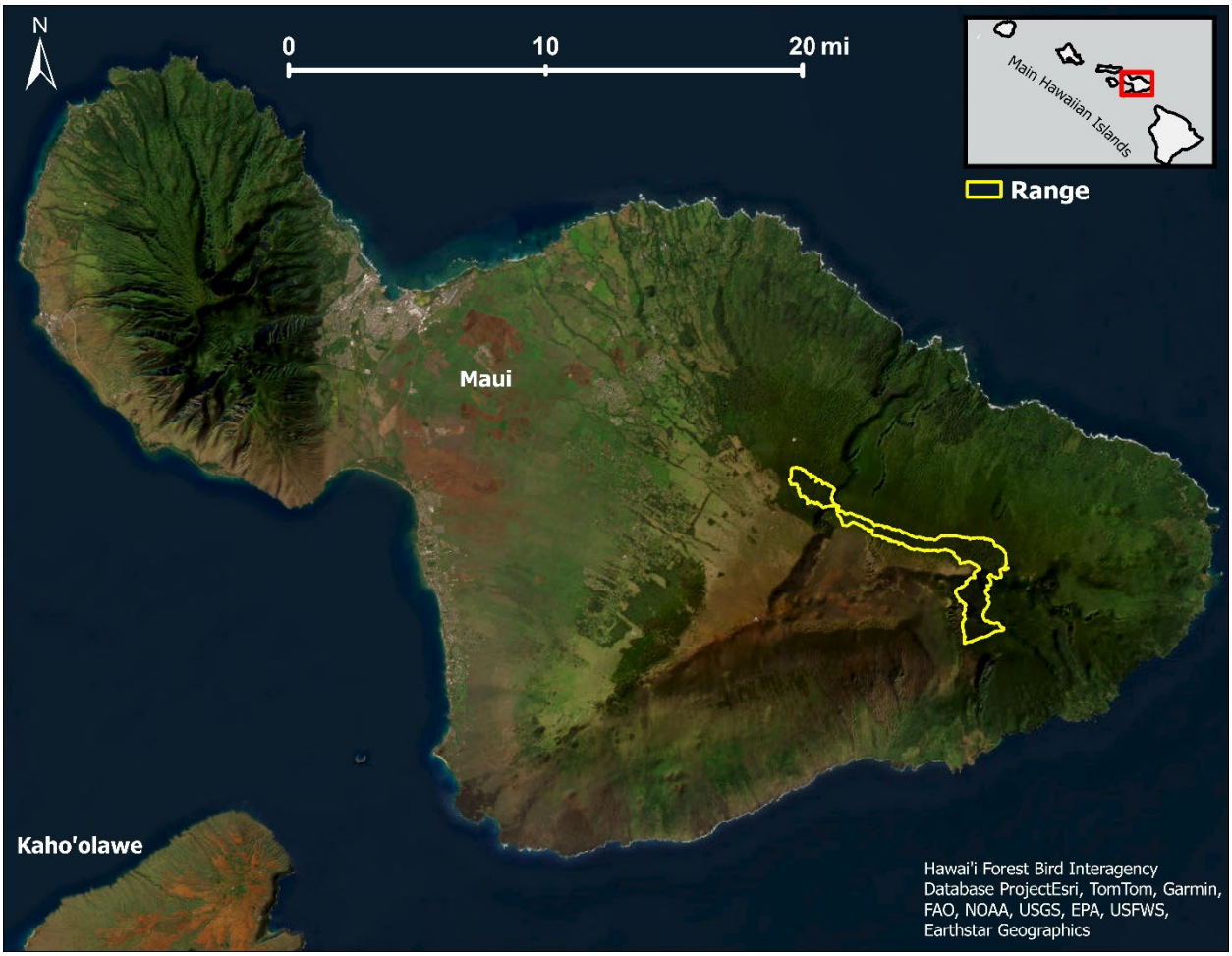
Forest Birds

Kiwikiu

Pseudonestor xanthophrys

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking— Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The kiwikiu or Maui parrotbill is a Hawaiian honeycreeper endemic to Maui, with a short tail and a relatively large, parrot-like bill. Adults are mostly olive-green above with a yellow breast, belly and cheeks, and a bright yellow line above their eyes (i.e., supercilium). Males are typically brighter than females, although individuals vary. Males are larger than females in size and bill. They feed on a variety of shrubs and small trees, especially ʻākala (*Rubus hawaiensis*), kanawao (*Broussaisia arguta*), ʻōhiʻa (*Metrosideros polymorpha*), ʻkōlea (*Myrsine* species), pilo (*Coprosma* species) and hoi kuahiwi (Smilax melastomifolia). They use their large parrot-like bills to glean prey from moss-covered branches or chisel, crack, crush, dig, and tear bark and softer wood in search of beetle and Lepidoptera larvae and pupae. They also open fruit in search of insects. Pairs defend relatively large 11.8-to-14.5-hectare year-round home ranges. Females build nests, incubate eggs, and brood young. Clutch size is usually one, and females feed nestlings with food delivered by males. Males feed the fledglings. They will renest after a nest failure but are not known to attempt another nest during the breeding season if the first is successful. Development of bill and acquisition of foraging techniques is prolonged and young remain with parents for 5 to 18 months. Because of this long period of dependency, kiwikiu are often seen in small groups and males can be seen provisioning juveniles from current and previous years. Pairs are typically monogamous and invidious can live longer than 16 years.



DISTRIBUTION: Restricted to a ~30 square kilometer (11.5 square mile) on the northeastern slopes of Haleakalā between 1,600 and 2,200 meters (5,200 – 7,200 feet). Subfossils indicate they once occurred island-wide including at low elevations and leeward (southeastern) forests and on the island of Molokaʻi.

ABUNDANCE: The Hawaiʻi Forest Bird Survey from 2022 estimated the population at 157 ± 67 (95% confidence interval) birds, a 71% decline in population since 2001

LOCATION AND CONDITION OF KEY HABITAT: Mid-to-upper-elevation montane wet forests dominated by ʻōhiʻa, and in a few mesic areas dominated by ʻōhiʻa and koa (*Acacia koa*), with a dense, diverse native understory and subcanopy of ferns, sedges, epiphytes, shrubs, and small to medium trees. Most of the range is managed by the National Park Service, State of Hawaiʻi, The Nature Conservancy (TNC). Their range exists within the East Maui Watershed Partnership.

THREATS:

- Low reproduction. Unlike many Hawaiian honeycreepers, kiwikiu have low annual fledgling production. This results from a low reproductive potential (one fledgling per

year) coupled with low reproductive success due to habitat limitations and weather. This life history characteristic may be related to their very specialized foraging strategy. Regardless, the species is susceptible to factors that reduce population size.

- Disease. Despite the availability of seemingly suitable habitat below 1,600 meters (5,200 feet), kiwikiu are not found in these areas, suggesting that disease may be restricting populations to higher elevations. Furthermore, nearly all of the kiwikiu died of avian malaria during the 2019 translocation to the southeast slope of Haleakalā, even though the kiwikiu had come from and were taken to mid-to high elevation forest, which was typically known for lower disease rates, suggesting that disease in these forests is higher than previously thought.
- Predation. Predation on adults and nests by rats (*Rattus* spp.), cats (*Felis silvestris*), the small Indian mongoose (*Herpestes auropunctatus*), and owls (*Asio flammeus sandwichensis, Tyto alba*) may limit the species. High rat densities have been reported in the Hanawī area, which also supports a large proportion of the kiwikiu population.
- Habitat loss. Historical accounts suggest that kiwikiu favored koa for foraging. Logging and ranching have resulted in the loss of large areas of mesic koa forest, and their current range is restricted to wet forests where koa density is relatively low and wet weather can lead to nest failure. Thus like many endangered Hawaiian forest birds, kiwikiu may be restricted to suboptimal habitat.
- Habitat degradation. Damage to understory vegetation by feral pigs (*Sus scrofa*) likely reduces habitat suitability and may contribute to reduced food availability and low reproductive success. Habitat degradation also may increase exposure of nests to inclement weather.
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former is usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.

CONSERVATION ACTIONS: The kiwikiu benefits from management efforts to conserve other endangered forest birds on northeastern Haleakalā, such as the establishment of the 3,000 hectare (7,500 acre) Hanawī Natural Area Reserve in 1986, the formation of East Maui Watershed Partnership and Maui Forest Bird Recovery Project, fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. Future actions specific to the recovery of the kiwikiu may include the following:

- Develop and deploy mosquito control techniques as soon as possible to reduce the mosquito vector of avian disease.
- Capture enough birds with a suitable age structure and sex ratio to establish a viable captive population. Continue to evaluate and adaptively manage captive care to maintain wild behaviors and encourage parental breeding behaviors. If/when mosquito control is deployed on Maui and meets efficacy success criteria, release worthy candidates back on Maui. In 1997, a captive breeding program was initiated. As of 2024, 8 kiwikiu are in captive care at the Maui Bird Conservation Center and efforts are ongoing to continue bringing suitable individuals into holding to prevent outright extinction in the wild from avian disease.

- Explore translocating birds to Hawai‘i Island to establish a 2nd population and reduce the species risk of extinction.
- Protect and restore habitat in high-elevation disease-free areas.
- Implement fencing and ungulate control in low-elevation habitat from the Hanawī Natural Area Reserve to TNC's Waikamoi Preserve, to facilitate the recovery of the understory and subcanopy vegetation and eventually result in high-quality kiwikiu habitat. Once mosquito control has been implemented, this could be a possible location for kiwikiu to reestablish a population.
- Establish a continuous corridor of suitable habitat around Haleakalā by connecting conservation lands on the southern and western parts of the mountain. Restoration of koa forests to this area would be a key element to this effort.
- Restore, fence, and eradicate ungulates from the remnant mesic koa forests on the State Forest Reserve and Department of Hawaiian Home Lands in the Kahikinui region of southern Haleakalā. Restoration of this area would be a cost-effective starting point to providing the kiwikiu with high-quality habitat for future reintroductions.
- Conduct public outreach and education about the importance of invasive species control and forest restoration. Incorporate Hawaiian knowledge and practices in conservation strategies
- Continue protection and management of wildlife sanctuaries and refuges.
- Develop and deploy new tools and evaluate above approaches.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats, mongooses, and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquitoes. Research priorities specific to the kiwikiu include the following:

- Evaluate the effect of predator control on reproduction and survival of kiwikiu.
- Further refine captive breeding techniques and evaluate experimental reintroduction sites. Evaluation should include mosquito surveys and determination of disease prevalence in lower elevation sites and possible sites on other islands.
- Investigate invertebrate communities where kiwikiu do not currently inhabit to design and implement large-scale restoration. Diet studies to determine overlap with non-native species as well as determining targeted invertebrate recovery.

References:

Brinck KW, Camp RJ, Gorresen PM, Leonard DL, Mounce HL, Iknayan KJ, Paxton EH. 2012. 2011 Kiwikiu (Maui Parrotbill) and Maui Alauahio abundance estimates and the effect of sampling effort on power to detect a trend. Hawaii Cooperative Studies Unit, University of Hawaii at Hilo. Technical Report HCSU-035.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Judge, S.W., R.J. Camp, C.W. Warren, L.K. Berthold, H.L. Mounce, P.J. Hart, and R.J. Monello. 2021. Population Estimates and Trends of Three Maui Island-endemic Hawaiian Honeycreepers. Journal of Field Ornithology.

Peck RW, Banko PC, Cappadonna J, Steele C, Leonard DL, Mounce HL, Becker CD, Swinnerton KJ. 2015. An assessment of arthropod prey resources at Nakula Natural Area Reserve, a potential site of reintroduction for Kiwikiu (Pseudonestor xanthophrys) and Maui ‘Alauahio (Paroreomyza montana). Hawai’i Cooperative Studies Unit, University of Hawai’i at Hilo. Technical Report HCSU-059.

Mounce HL, Leonard DL, Swinnerton KJ, Becker CD, Berthold LK, Iknayan KJ, Groombridge JJ. 2013. Determining productivity of Maui Parrotbills, an endangered Hawaiian honeycreeper. Journal of Field Ornithology 84(1):32-39.

Mounce, HL, Iknayan, KJ, Leonard, DL, Swinnerton, KJ, and Groombridge, JJ. 2014. Management implications derived from long term re-sight data: annual survival of the Maui Parrotbill *Pseudonestor xanthophrys*. Bird Conservation International 24:316-326

Mounce HL, Raisin C, Leonard DL, Wickenden H, Swinnerton KJ, Groombridge JJ. 2015. Spatial genetic architecture of the critically-endangered Maui Parrotbill (*Psuedonestor xanthophrys*): management considerations for reintroduction strategies. Conservation Genetics Volume 16, Issue 1: Page 71-84.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Simon JC, Baker PE, Baker H. 1997. Maui parrotbill (*Pseudonestor xanthophrys*). *In* The Birds of North America, No. 311 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Warren CC, Motyka PJ, Mounce HL. 2015. Home range sizes of two Hawaiian honeycreepers: implications for proposed translocation efforts. Journal of Field Ornithology 86(4):305–316.

Warren CC, Berthold LK, Mounce HL Luscomb P, Masuda B, Berry L. 2021. 2019 Kiwikiu Conservation Translocation Report. Pacific Cooperative Studies Unit Technical Report #203. University of Hawai‘i at Mānoa. Honolulu, HI. 103 pages.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Forest Birds

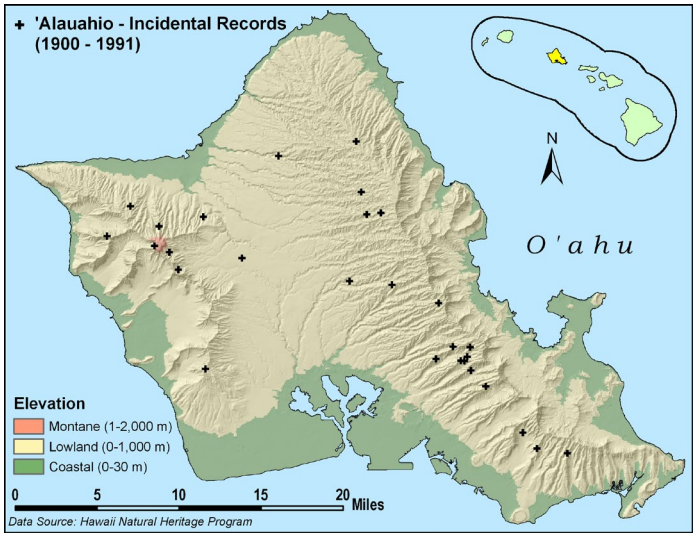
O‘ahu ‘alauahio

Paroreomyza maculata

SPECIES STATUS:
Federally Listed as Endangered
States Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank GH—Possibly Extinct
IUCN Red List Ranking—Critically Endangered (Possibly Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The O‘ahu ‘alauahio is a small, sexually dichromatic, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to O‘ahu. Males are olive-green above with bright yellow underparts and forehead, females are grayish-green above and yellowish-white below. The plumage of this species is very similar to that of the O‘ahu ‘amakihi (*Hemignathus flavus*). The song of the O‘ahu ‘alauahio has never been described. The O‘ahu ‘alauahio is insectivorous and forages by methodically searching and probing the bark of large branches and tree trunks. Like other Hawaiian creepers, ‘alauahio joins foraging flocks during non-breeding seasons. Little is known about the life history or breeding biology of the species, but it is likely similar to that of the Maui species (*P. montana*).

DISTRIBUTION: Unknown. Probably extinct. Historical range is poorly known as it was likely declining when first discovered, but it historically occurred in both the Ko‘olau and Wai‘anae ranges.



ABUNDANCE: Unknown. Probably extinct. The last well-documented sighting was of two birds in 1985. O‘ahu was not included in the Hawai‘i Rare Bird Search in the late 1990s, so it is possible that the O‘ahu ‘alauahio still exists in remote valleys.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Once occupied mid-elevation forests of ‘ōhi‘a (*Metrosideros polymorpha*) and koa (*Acacia koa*). Historically, it was reported to prefer large koa trees, but they also were reported in areas without koa. All recent observations occurred in mixed

koa/ʻōhiʻa forest between 300 and 600 meters (1,000 – 2,000 feet). Forests where the Oʻahu ʻalauahio historically occurred are largely managed by the State of Hawaiʻi, the U.S. Fish and Wildlife Service (USFWS), or the U.S. Military.

THREATS: Unknown. However, the Oʻahu ʻalauahio likely were susceptible to the same factors that threaten other native Hawaiian forest birds including habitat loss and degradation, predation by introduced mammals, and disease. For Oʻahu ʻalauahio, the following was likely of particular concern:

- Disease. The fact that no habitat above 1,250 meters (4,100 feet) occurs on Oʻahu, and that historical accounts report the species only above 350 meters (1,500 feet) suggests that disease played an important role in the species' decline.
- Predation. Following the introduction of non-native mammals, particularly black rats, to Oʻahu in the early 1800s this species and most other endemics precipitously declined. Similar patterns of extinction and population decline were observed on Maui, Hawaiʻi, Molokaʻi, Lānaʻi, and Kauaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: Unfortunately, few forest birds remain on Oʻahu, and little if any, specific management is directed at forest birds other than the Oʻahu ʻelepaio (*Chasiempis sandwichensis ibidis*). The Oʻahu Forest National Wildlife Refuge in the Koʻolau Range is near some of the most recent sightings, but whether the species still exists in the area is unknown. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the USFWS *Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Initiate regular forest bird surveys and habitat monitoring on Oʻahu.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats (*Rattus* spp.) and feral cats (*Felis silvestris*) in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is likely extinct, there are no research priorities specific to Oʻahu ʻalauahio.

References:

Baker PE, Baker H. 2000. Kākāwahie (*Paroreomyza flammea*) and O'ahu alauahio (*Paroreomyza maculata*). *In* The Birds of North America, No. 503 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Bryan Shirota

Oʻahu ʻamakihi

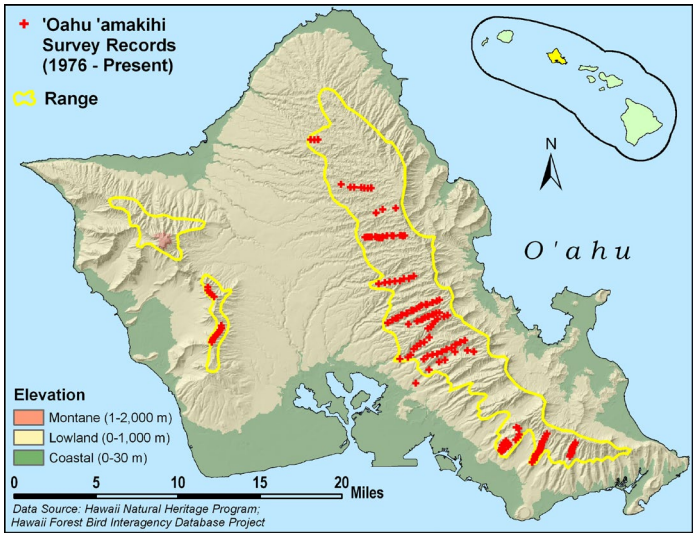
Hemignathus flavus

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The Oʻahu ʻamakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Oʻahu. Until 1995, the Oʻahu ʻamakihi, and the Hawaiʻi (*H. virens*) and Kauaʻi amakihi (*H. kauaiensis*), were considered a single species: the common ʻamakihi (*H. virens*). Plumage of all species is similar; males are yellow-green to olive with black lores. Females are similar, but duller. All have decurved bills. The plumage of some male Oʻahu amakihi is variable in having yellow above eyes and more yellow breasts, and compared to the other species, female Oʻahu ʻamakihi have two dull wing bars. The Oʻahu ʻamakihi is brighter and smaller than the Kauaʻi ʻamakihi but nearly identicle to the Hawaiʻi species. Oʻahu ʻamakihi are generalized foragers that take arthropods from a variety of trees and substrates. The species often gleans arthropods from leaves and twigs, less frequently from larger branches and trucks. Feeds on nectar and fruit from a variety of native and non-native plants and has been observed eating sap from koa (*Acacia koa*) trees. Only three nests have been found; thus, the species' reproductive biology is poorly known, but is likely similar to Hawaiʻi ʻamakihi.

DISTRIBUTION: Occurs in two disjunct populations between 50 and 300 meters (180 – 1,000 feet), although is most numerous above 200 meters (650 feet). In recent years, range has increased to include some residential areas. Original range likely included all forested regions of Oʻahu. Especially in areas where homeowners are planting native trees.

ABUNDANCE: A 1991 survey conducted by the State of Hawai‘i Division of Forestry and Wildlife estimated the O‘ahu ‘amakihi population at between 20,000 and 60,000 individuals. Audubon Christmas bird counts from 1958 to 1985 documented a decrease in detections. Despite this, populations may be increasing in some areas. The population was estimated at 49,500 birds in the Ko‘olau range, and 2,300 in Wai‘anae in 2009.



LOCATION AND CONDITION OF KEY HABITAT: Occurs in a variety of habitats from very wet forests in the Ko‘olau Mountains to dry forests in the Wai‘anae Mountains. They are more common in sheltered forests in valleys at middle elevations. Unlike other Hawaiian passerines, the range of the O‘ahu ‘amakihi extends to low-elevation forest dominated by non-native plant species. Among introduced forests, ‘amakihi are most abundant in areas dominated by guava (*Psidium guajava*) or kukui (*Aleurites moluccana*). Most of the species’ range is managed by the U.S. Fish and Wildlife Service, U.S. Army, and the State of Hawai‘i.

THREATS: Although O‘ahu ‘amakihi populations appear stable, they are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For O‘ahu ‘amakihi, the following is of particular concern:

- Fire. Non-native plants and military training activities often result in wildfires that threaten O‘ahu ‘amakihi habitat on military lands.

CONSERVATION ACTIONS: O‘ahu ‘amakihi likely have benefited from management activities to conserve other endangered forest birds including the establishment of the O‘ahu Forest National Wildlife Refuge in the Ko‘olau mountains, rat control directed at protecting nesting O‘ahu ‘elepaio (*Chasiempis sandwichensis ibidis*), fencing and ungulate control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the O‘ahu ‘amakihi may include the following:

- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Initiate regular forest bird surveys on O‘ahu and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to

control mosquito populations. Because the O‘ahu ‘amakihi appears to be surviving and possibly thriving in disturbed habitat and at elevations below the point where mosquitoes commonly occur, they provide potentially important research opportunities. Research priorities specific to the O‘ahu ‘amakihi include the following:

- Quantify the population structure, dispersal patterns, survivorship, nesting phenology, and success. Studies comparing life history characteristics between native and non-native habitats would be particularly useful.
- Identify and study disease-resistant populations, focusing on the genetic basis of resistance.
- Explore the impact of native plant reforestation and urban forestry on ‘amakihi populations.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lindsey GD, VanderWerf EA, Baker H, Baker PE. 1998. Hawai’i (*Hemignathus virens*), Kaua’i (*Hemignathus kauaiensis*), O’ahu (*Hemignathus chloris*) and greater ‘amakihi (*Hemignathus sagittirostris*). *In* The Birds of North America, No. 360 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Bryan Shirota

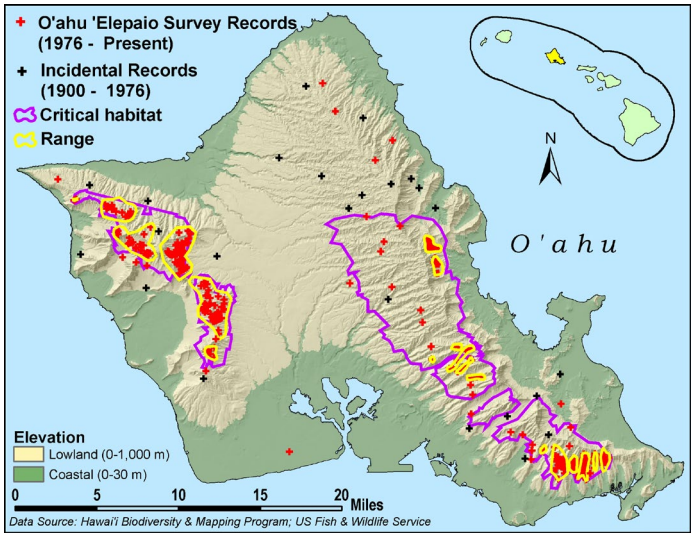
Forest Birds

O‘ahu ‘elepaio

Chasiempis ibidis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Endangered
Revised Recovery Plan for Hawaiian Forest Birds —USFWS 2006

SPECIES INFORMATION: The O‘ahu ‘elepaio is a small, adaptable monarch flycatcher (Family: Monarchiade) endemic to the island of O‘ahu. Other species of ‘Elepaio occur on Kaua‘i (*C. sclateri*) and the island of Hawai‘i (*C. sandwichensis*). Males and females are dark brown above and white below with variable light brown streaks on breast and conspicuous white wing bars, tail feather tips, and throat. Both sexes have variable amounts of blacking markings, but males tend to have more. The bird’s name is derived from its primary song which is a shrill whistle given only by males. On the island of Hawai‘i, ‘elepaio use virtually all available substrates for foraging including the ground, logs, rock crevices, snags, and all parts of tress. Equally diverse in the use of foraging maneuvers, ‘elepaio capture a wide range of arthropod prey by flycatching, gleaning while either perched or hovering, and direct pursuit; foraging maneuvers vary depending on plant species from which prey is being captured, and habitat. O‘ahu ‘elepaio use a variety of native and non-native trees for foraging. Pairs remain together throughout the year, and long-term pair bonds are common. Breeding season on O‘ahu is January through July compared to March through August on the island of Hawai‘i. Unlike Hawaiian honeycreepers, both males and females participate almost equally in all aspects of rearing. Finely woven cup nests are built in a variety of native and non-native trees. Clutch size is usually two and second and third nests are attempted after failures, but rarely is a second nest attempted if the first is successful. Fecundity is low even in areas where predators are controlled. Young are fed by parents for at least a month, but remain on their natal territory for up to ten months which may allow young birds to hone their foraging skills.



DISTRIBUTION: Occurs in the Koʻolau Range between 100 to 550 meters (325 – 1,800 feet) elevation, and in the Waiʻanae Range between 500 to 850 meters (1,625 – 2,775 feet) elevation. Dispersal between the ranges is unlikely. Each subpopulation consists of several populations; the amount of dispersal among these is likely low. Original distribution likely included all forested areas of Oʻahu.

ABUNDANCE: In 2013, the population was estimated at 1,261 (95% confidence interval = 1,205-1,317) birds. It had previously been estimated at 1,200 to 1,400 birds. Although Audubon Christmas bird counts from the 1960s through the 1980s provided strong evidence of a dramatic population decline, numbers are now so low that the rate of decline since the 1990s cannot be determined.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in a variety of forest types and across a range of elevations, primarily in valleys and particularly those with tall riparian vegetation, a continuous canopy, and dense understory. Common native plant species where ʻelepaio occur include papala kēpau (*Pisonia umbellifera*), lama (*Diospyros sandwicensis*), māmaki (*Pipturus albidus*), kaulu (*Sapindus oahuensis*) and ʻālaʻa (*Pouteria sandiwicensis*). Common introduced plants in ʻelepaio habitat include strawberry guava (*Psidium cattleianum*), common guava (*P. guajavai*), kukui (*Aleurites moluccana*), mango (*Mangifera indica*), and Christmas berry (*Schinus terebinthifolius*). Oʻahu ʻelepaio are not found in very wet forests, on windswept summits, or in very dry scrubland. Much of their current range is managed by the U.S. military or by the State of Hawaiʻi.

THREATS: Oʻahu ʻelepaio are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For Oʻahu ʻelepaio, the following threats are of particular concern:

- Predation. Predation by black rats (*Rattus rattus*) have been implicated in the loss of nests and death of adult females. Rat control in Oʻahu populations resulted in large increases in nest success and in survival of adult females.
- Low reproductive potential. The species' low annual productivity, even in quality habitat, makes it very susceptible to factors that reduce population size.
- Disease. Avian pox (*Poxvirus avium*) reduces both annual survival and reproductive success of birds with active pox lesions compared to healthy birds; no information on the effect of avian malaria (*Plasmodium relictum*).
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.
- Fire. Wildfires resulting from military activities threaten two populations.

CONSERVATION ACTIONS: Conservation efforts already undertaken to protect the Oʻahu ʻelepaio include the following: listing as an endangered species by both the U.S. Fish and

Wildlife Service (USFWS) and the State of Hawai‘i, the initiation of long term population and demographic surveys which have identified the most serious threats to its survival, and ongoing rat control at the Honolulu Forest Reserve (DOFAW), at Schofield Barracks West Range and Mākua Military Reservation (U.S. Army Environmental Division), in Honouliuli Preserve (DOFAW) and in Lualualei Valley (U.S. Navy and USDA). In addition, the O‘ahu ‘elepaio also benefits from management activities designed to conserve other endangered forest birds including the establishment of the O‘ahu Forest National Wildlife Refuge in the Ko‘olau Mountains, fencing and ungulate control, forest restoration, habitat monitoring and studies on disease and disease vectors. In addition to these efforts, future management specific to the O‘ahu ‘elepaio should include the following:

- Continue and expand rat control.
- Protect remaining forests on O‘ahu, including through fire prevention.
- Conduct public outreach about the importance and benefits of rodent control.
- Continue demographic studies, especially in the largest populations.
- Continue protection and management of wildlife sanctuaries and refuges.
- Explore translocations to suitable habitat in Maui Nui.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the O‘ahu ‘elepaio include the following:

- Identify disease resistance and transmission patterns. If resistant individuals are identified, translocation and/or captive propagation of these individuals may help recover populations.
- Determine genetic population structure.
- Identify areas most suitable for re-introduction of populations or for creation of habitat dispersal links between existing populations.
- Continue efforts to develop techniques for captive propagation using surrogate species (e.g., Hawai‘i ‘elepaio (*Chasiempis sandwichensis sandwichensis*)).

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

VanderWerf EA. 1998. ‘Elepaio (*Chasiempis sandwichensis*). *In* The Birds of North America, No. 344 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

VanderWerf EA, Rohrer JL, Smith DG, Burt MD. 2001. Current distribution and abundance of the O’ahu ‘elepaio. Wilson Bulletin 113:10-16.

VanderWerf EA, Lohr MT, Titmus AJ, Taylor PE, Burt MD. 2013. Current distribution and abundance of the O‘ahu Elepaio (*Chasiempis ibidis*). Wilson Journal of Ornithology 125:600-608.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Top – Moloka'i, bottom – Lāna'i. Bret Mossman courtesy of the Bernice Pauahi Bishop Museum.

Forest Birds

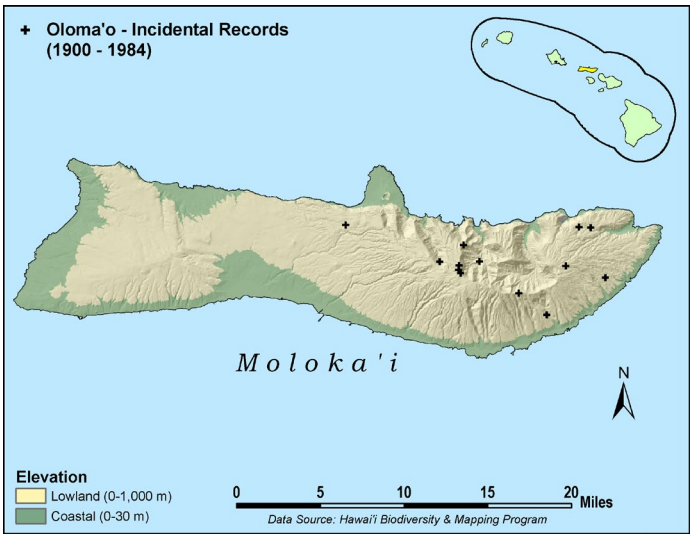
‘Oloma‘o

Myadestes lanaiensis

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank GH
—Known Only from Historical Occurrences
IUCN Red List Ranking—Critically Endangered
(Possibly Extinct)
Revised Recovery Plans for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ‘oloma‘o is one of five species of Hawaiian solitaires (family: Turdidae). All adult Hawaiian solitaires have olive-brown and gray plumage. ‘Oloma‘o are prolific singers often singing into the night, and the species engages in song flights. Their song, like that of many thrushes, is melodious. Similar to other Hawaiian solitaires, the species often trembles their wings when perched. ‘Oloma‘o are very philopatric, seldom leaving their small home range. The species feeds on a variety of small fruits and insects. Little is known about their breeding biology, but it is presumed to be similar to the ‘ōma‘o (*M. obscurus*).

DISTRIBUTION: Unknown. Probably extinct. The historic range included the native forests of eastern Moloka‘i and Lāna‘i. Historically the species also may have occurred on Maui, where subfossils of Hawaiian solitaires are abundant. Recent sightings (2023-2024) have been reported from Pelekunu and other remote valleys but not substantiated.



ABUNDANCE: Probably extinct. Since 1907, ‘oloma‘o have been observed on a dozen occasions, most recently in 1988. The Hawaiian Forest Bird Surveys (1979-1980) estimated the population at 19 ± 38 (SE) individuals. However, ‘oloma‘o were not detected during surveys in the late 1980s and 1990s or more recently. There is little information on historical abundance.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Historically occupied closed, wet and mesic ʻōhiʻa (*Metrosideros polymorpha*) forests across a broad elevation range. The areas where the species was last observed are managed by the State of Hawaiʻi as a Natural Area Reserve or by private conservation entities (e.g., The Nature Conservancy).

THREATS: Unknown. However, ʻoloma'o likely were susceptible to the same factors that threaten other native Hawaiian forest birds including loss and degradation of habitat, predation by introduced mammals, and disease. For ʻoloma'o, the following was likely of particular concern:

- Disease. The fact that no habitat above 1,250 meters (4,100 feet) occurs on Molokaʻi or Lānaʻi suggests disease may have played an important role in the species decline.
- Predation. Following the introduction of non-native mammals, particularly black rats, to Molokaʻi in the late 1800s and Lānaʻi in the early 1900s this species and most other endemics precipitously declined. Similar patterns of extinction and population decline were observed on Oʻahu, Maui, Hawaiʻi, and Kauaʻi. Within about a decade of the introduction of black rats to each respective island there were catastrophic population declines and multiple extinctions.

CONSERVATION ACTIONS: If the species persists, it likely benefits from management activities to conserve other endangered forest birds on eastern Molokaʻi, including the establishment and management of protected areas, regular surveys of forest bird populations, monitoring of habitat conditions, and studies of disease and disease vectors. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Revised Recovery Plan for Hawaiian Forest Birds* would be implemented, management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species is probably extinct there are no research priorities specific to oloma'o.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Wakelee KM, Fancy SG. 1999. ‘Oma’o (*Myadestes obscurus*), kama’o (*Myadestes myadestinus*), oloma’o (*Myadestes lanaiensis*), and ‘amaui (*Myadestes woahensis*). *In* The Birds of North America, No. 460 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

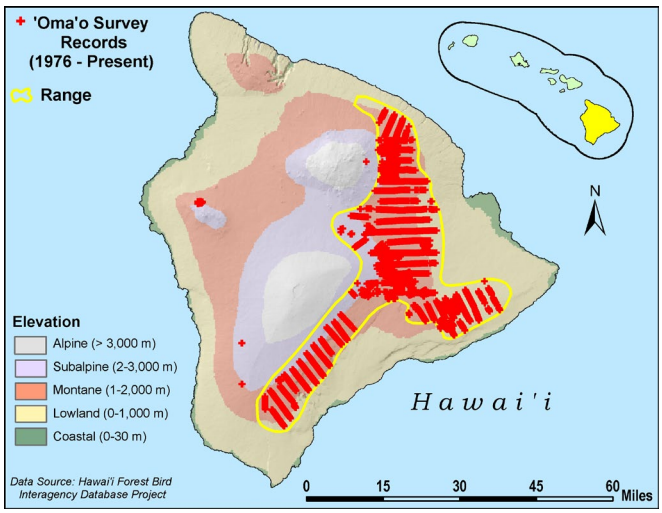
ʻŌmaʻo

Myadestes obscurus

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Ranking G3—Vulnerable
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: One of five species of Hawaiian solitaires (family: Turdidae), the ʻōmaʻo is endemic to the island of Hawaiʻi. They often perch silently for long periods and are usually detected by their song; however males perform a flight-song display known as "skylarking." Like all adult Hawaiian solitaires, ʻōmaʻo have drab olive-brown and gray plumage. Diet consists primarily of fruits of native and introduced understory plant species, although they also take koa (*Acacia koa*) flowers from the canopy and prey on invertebrates, including earthworms, snails, spiders, and insects. The life history is well-studied. Both sexes defend small nesting territories. Nests are built by females in a variety of locations (e.g., cavities, trunk forks); females also perform most incubation and brooding. Clutch size is one or two eggs, and double brooding occurs. The young remain in natal territories for four to six months after fledging. A male-biased sex-ratio exists, but its significance to populations is unknown.

DISTRIBUTION: Primarily occurs in two populations on the eastern and southern slopes of the island of Hawaiʻi at elevations greater than 1,000 meters (3,300 feet). A third, smaller population occurs in alpine scrub between 2,000 and 3,500 meters (6,500 – 11,500 feet). Currently occupies about 30 percent of their former range, which historically included habitats between 300 and 3,000 meters (1,000 – 9,750 feet).



ABUNDANCE: The Hawaiian Forest Bird Surveys (1976-79, 1983) estimated the population at 170,000 birds. Based on more recent surveys, populations appear stable and may be increasing below 1,200 meters (3,450 feet).

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet montane ʻōhiʻa (*Metrosideros polymorpha*) or mixed ʻōhiʻa and koa forests in the Hāmākua, Kaʻū, and Kīlauea districts. These forests support important food plants, including ʻōlapa (*Cheirodendron trigynum*), kōlea (*Myrsine lessertiana*), kāwaʻu (*Ilex anomala*), naio (*Myoporum sandwicense*), pilo (*Coprosma* spp.), pūkiawe (*Styphelia tameiameiae*), ʻōhelo (*Vaccinium* spp.), and ʻākala (*Rubus hawaiiensis*). In the small alpine scrub population on Mauna Loa, pūkiawe, ʻōhelo, kūkaenēnē (*Coprosma ernodeoides*), and ʻaʻaliʻi (*Dodonea viscosa*) are important food plants. Although most of the current range occurs on State and federal lands, habitat conditions vary considerably.

THREATS: ʻŌmaʻo are likely susceptible to the same factors that threaten other native Hawaiian forest birds, including loss and degradation of habitat, predation by introduced mammals, and disease. For ʻōmaʻo, the following are of particular concern:

- Disease. The prevalence of disease in areas tested is low and five ʻōmaʻo exposed to malaria recovered quickly, suggesting a greater disease resistance compared to other native forest birds. However, the species' disappearance from lower elevations is the pattern of decline noted in other Hawaiian birds susceptible to mosquito-borne diseases.
- Predation. Nests are very accessible and vulnerable to predation by rats (*Rattus* spp.). Predation by native raptors also is likely.
- Habitat degradation. ʻŌmaʻo occur at lower densities in degraded habitat. Pigs (*Sus scrofa*) and other ungulates likely destroy important food plants.

CONSERVATION ACTIONS: ʻŌmaʻo likely have benefited from management efforts designed to conserve other endangered forest birds and native habitat at Hakalau Forest National Wildlife Refuge, Hawaiʻi Volcanoes National Park, and the ʻŌlaʻa/Kīlauea Watershed Partnership. These efforts include fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future actions specific to the protection of ʻōmaʻo may include the following:

- Protect and restore native forests above 1,500 meters (4,500 feet), and eliminate feral ungulates and non-native plants.
- Conduct control or eradication of rats and feral cats in areas occupied by ʻōmaʻo.
- Conduct public education and outreach.
- Continue protection and management of wildlife sanctuaries and refuges.
- Restore ʻōmaʻo to former parts of their rage.
- Translocate birds to other islands such as Oʻahu and Maui Nui to fill the niche left vacent by those island's extinct thrush species.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to ʻōmaʻo include the following:

- Identify disease-resistant individuals.

- Develop improved techniques to control alien weed species.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Wakelee KM, Fancy SG. 1999. ‘Oma’o (*Myadestes obscurus*), kama’o (*Myadestes myadestinus*), oloma’o (*Myadestes lanaiensis*), and ‘amaui (*Myadestes woahensis*). *In* The Birds of North America, No. 460 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Mike Scott

Forest Birds

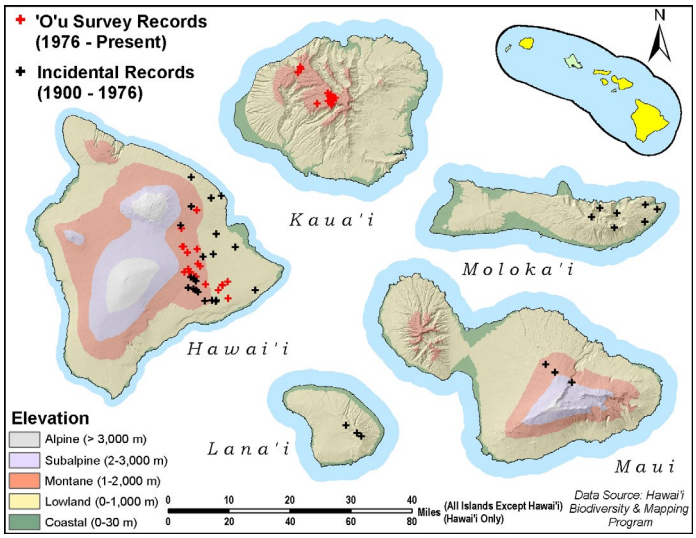
‘Ō‘ū

Psittirostra psittacea

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered (Possibly Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ‘ō‘ū is a heavy-bodied Hawaiian honeycreeper (family: Fringillidae) with a distinctive thick, pink, parrot-like bill. Adults are olive-green with whitish undertail coverts; males have a bright yellow head. Early naturalist noted that ‘ō‘ū had a strong musky odor, which is retained in museum specimens. Like several of Hawaii's nectivorous birds, ‘ō‘ū are strong fliers and ranged widely in search of fruit. ‘Ie‘ie (*Freycinetia arborea*) inflorescences apparently are an important part of the species’ diet, although ‘ō‘ū also feed on the fruits of *Clermontia* spp. as well as other native fruits. Geometrid caterpillars are an important food item during the breeding season. Little is known of the species life history and its nesting and breeding habits have not been described.

DISTRIBUTION: Possibly extinct. Occupied forests between 900 and 1,500 meter (3,000 and 5,000 feet, respectively) elevations on the islands of Kaua‘i and Hawai‘i. Historically widespread, ‘ō‘ū formerly occurred on all the Main Hawaiian Islands in low- to high-elevation forests. They are now presumed extirpated on every island except possibly on Kaua‘i and Hawai‘i.



ABUNDANCE: Almost certainly extinct. The Hawaiian Forest Bird Surveys (1976-1981) estimated the population at 400 ± 300 (95% confidence interval) birds on the island of Hawai‘i and nine or fewer individuals on Kaua‘i. ‘Ō‘ū

have not been detected during more recent surveys, although unconfirmed sightings are occasionally reported.

LOCATION AND CONDITION OF KEY HABITAT: Although known from a range of forest types, all recent observations have occurred in mid-elevation mesic to wet ʻōhiʻa (*Metrosideros polymorpha*) forests with an understory of ʻieʻie (*Freycinetia arborea*), tree ferns (*Cibotium* spp.), ʻōlapa (*Cheirodendron* spp.), kāwaʻu (*Ilex anomala*), kolea (*Myrsine* spp.), and pilo (*Coprosma* spp.). All recent sighting of ʻōʻū have occurred on lands managed by the State of Hawaiʻi.

THREATS:

- Habitat degradation. Pigs (*Sus scrofa*) degrade the understory of wet forest destroying food plants.
- Disease. ʻŌʻū primarily occurred in low- to mid-elevation forests where the effects of mosquito-borne diseases was most severe. The species' foraging movements may have increased their exposure to disease.
- Predation. In addition to potentially depredating nests, rats (*Rattus* spp.) may also compete with ʻōʻū by reducing the availability of fruits.
- Natural disasters. In 1984, a large portion of the Upper Waiākea Forest Reserve was inundated by a lava flow from Mauna Loa. This flow occurred in an area where the most recent observations of the species were noted and destroyed high quality ʻōʻū habitat. In 1982 and 1992, two strong hurricanes struck Kauaʻi, devastating native forest habitat. The ʻōʻū, has not been observed on Kauaʻi since 1992.

CONSERVATION ACTIONS: If the species persists, it likely benefits from management efforts to conserve other endangered forest birds on Hawaii and Kauaʻi. On Hawaiʻi, these activities have included fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. On Kauaʻi, these activities included the establishment of the Alakaʻi Wilderness Preserve, regular surveys of forest bird populations, monitoring of habitat conditions, studies of disease and disease vectors, and public education efforts featuring Kauai's endangered forest birds. Should this species be rediscovered, the Rare Bird Recovery Protocol outlined in the U.S. Fish and Wildlife Service (USFWS) *Recovery Plan for Hawaiian Forest Birds* would be implemented, and management in anticipation of that possibility should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring on Hawaiʻi and Kaua'i.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include developing improved methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Given that this species may be extinct, there are no research priorities specific to ʻōʻū.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Snetsinger TJ, Reynolds MH, Herrmann CM. 1998 ‘O’u (*Psittirostra psittacea*) and Lana’i hookbill (*Dysmorodrepanis munroi*). *In* The Birds of North America, No. 335-336 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

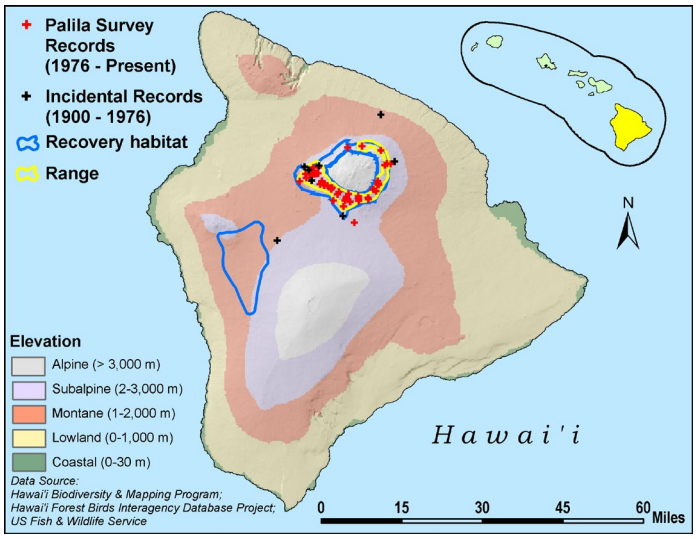
U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Palila

Loxioides bailleui

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds —USFWS 2006
Critical Habitat Designated 1977

SPECIES INFORMATION: The palila is a finch-billed Hawaiian honeycreeper (Family: Fringillidae) whose life history and survival is linked to māmane (*Sophora chrysophylla*), an endemic dry-forest tree in the legume family. Males and females are similar, with a yellow head and breast, greenish wings and tail, a gray back, and white underparts. Males have a black mask, and females have less yellow on the back of their heads and a gray mask. Approximately 90 percent of the palila's diet consists of immature māmane seeds; the remainder consists of māmane flowers, buds, leaves, and naio (*Myoporum sandwicense*) berries. Caterpillars and other insects comprise the diet of nestlings, but also are eaten by adults. Māmane seeds have been found to contain high levels of toxic alkaloids, and palila use particular trees for foraging, suggesting that levels of alkaloids may vary among trees. Individuals will move limited distances in response to the availability of māmane seeds. Palila form long-term pair bonds, and males perform low advertisement flights, sing, chase females, and engage in courtship feeding prior to breeding. Females build nests, usually in māmane trees, and males defend a small territory around the nest tree. Females mostly incubate eggs, brood nestlings and feed young with food delivered by male. First-year males sometimes help a pair by defending the nest and feeding the female and nestlings. Limited genetic testing found no evidence that helpers father the nestlings they were assisting, although more data are needed. Fledglings are dependent on their parents for three to four months, during this time they learn and practice foraging skills. The availability of green māmane seeds



strongly influences the number of nesting attempts in a given year. In poor years, not all pairs will attempt to nest.

DISTRIBUTION: Mostly restricted to the western slopes of Mauna Kea between 2,000 and 2,850 meters (6,500 – 9,250 feet) elevation. Historically, palila were common in all māmane forests. Currently, the species occupies approximately 10 percent of their historical range on the island of Hawai‘i. Subfossil evidence indicates palila also occurred in māmane forest on O‘ahu and Kaua‘i.

ABUNDANCE: Annual surveys between 1998 and 2005 yielded a mean population estimate of 3,268 ± 190 (SE) birds. In 2014, the estimate was 2,070 ± 209 birds. Populations have continued to decline and in 2024 was estimated to number 666 individuals. Population estimates are variable among years, which may be an artifact of survey techniques or timing.

LOCATION AND CONDITION OF KEY HABITAT: Restricted to māmane and māmane/naio forests. Densities are highest at 2,300 meters (7,550 feet) with large māmane trees and a high proportion of native shrubs. Up to 96 percent of the population and nearly all successful breeding occurs in a 30 square kilometer (11.5 square mile) area on the southwestern slope of Mauna Kea that has high quality habitat and steep terrain. The latter is important, especially during the breeding season because māmane at different elevations flower and fruit at different times, ensuring that māmane seeds are always available. Most habitat in the species' range is severely degraded by grazing ungulates, particularly mouflon sheep, and the spread of non-native plant species, especially fire-prone grasses. Most of the palila's current range occurs in the Mauna Kea Forest Reserve and is managed by the State of Hawai‘i.

THREATS:

- Feral ungulates. Historically, large numbers of sheep (*Ovis* spp.) grazed on Mauna Kea, reducing the density and productivity of māmane trees, limiting the regeneration of other native plants, and causing soil erosion. More recently the introduction of mouflon sheep has further degraded habitat.
- Invasive plants. Soil disturbance caused by sheep facilitated the spread of invasive plants. Fire-adapted grasses, such as fountain grass (*Pennisetum clandestinum*), are especially problematic in that they increase the risk of fire. Invasive plants also reduce the recruitment of native plants.
- Fire. A single large fire could severely limit food resources for the entire population.
- Predation. Predation by rats (*Rattus* spp.), feral cats (*Felis silvestris*), and the pueo (*Asio flammeus sandwichensis*) is an important factor limiting palila populations. In some areas, black rats (*R. rattus*) and feral cats may be responsible for up to 40 percent of nest failures, and feral cats have been documented preying on adults.
- Disease. Although palila are very susceptible to mosquito-borne diseases, mosquitoes do not occur at the elevations where palila currently occur. However, disease almost certainly contributed to the species' decline and likely prevents palila from recolonizing low-elevation habitat.

- Non-native insects. Yellow jackets and Argentine ants threaten the native caterpillars that nestlings depend on for food.
- Severe weather. The species' current range exposes them to severe weather that results in mortality in some years. Freezing temperatures, heavy rains, droughts, and high winds all can result in egg and nestling mortality.
- Population size. Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.

CONSERVATION ACTIONS: Several conservation efforts have been conducted to protect the māmane woodlands for the protection and recovery of the palila. In the first half of the 20th century, 46,000 sheep as well as smaller numbers of feral cattle (*Bos tarus*), goats (*Capra hircus*), and pigs (*Sus scrofa*) were removed from māmane forests. This allowed the regeneration of the māmane trees on which the palila depend. Beginning in the late 1970s, control measures to reduce mouflon sheep numbers were initiated. Considerable research has been conducted on palila, including estimating population size and determining their geographic range, documenting home range size, dispersal behavior, reproductive parameters, limiting factors, and habitat characteristics. Ongoing research mostly focuses on quantifying limiting factors, especially predation, food availability, and genetics, as well as refining māmane restoration techniques. Beginning in 1993, translocations were conducted on an experimental basis to determine if new breeding populations could be established. In 2004, 32 birds were translocated and in 2005, 75 birds were moved. Although most birds return to their natal territory, approximately 25 percent remained at translocation sites. In 1996, a captive propagation program was initiated and palila have successfully bred in captivity. Between 2003 and 2004, 15 captive-raised birds were released into the wild. A second attempt to establish palila on the north slope was initiated in 2019, but it was unsuccessful. Initial attempts at outplanting māmane have been successful in areas where competing non-native vegetation is sparse. In addition to the above efforts, palila likely have benefited from management activities to conserve other endangered forest birds in Mauna Kea Forest Reserve and elsewhere on the island of Hawai‘i, including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies of disease and disease vectors. In addition to these efforts, future management specific to the palila will likely include the following:

- Stabilize and increase at least one of the small populations using translocation or establish a new self-sustaining population while continuing to intensely manage the primary population. These efforts must include the restoration and regeneration of māmane forest as well as control of mammalian predators and parasitoid wasps that threaten food sources.
- Evaluate sites throughout the species' historical range for potential māmane restoration and re-introduction. These sites should have a range of elevation or rainfall gradients to ensure year-round food availability.
- Establish cat or predator proof fencing around key palila breeding areas and maintain and expand small mammal trapping.
- Develop a comprehensive fire management plan.

- Increase public education and involvement in palila recovery. Volunteer opportunities exist in habitat restoration efforts, monitoring weeds and predators, and education.
- Remove feral sheep and mouflon from palila habitat.
- Continue protection and management of wildlife sanctuaries and refuges.
- Establish a rear and release program for young palila.
- Develop supplemental feeding for wild palila.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the palila include the following:

- Refine survey methods.
- Further refine techniques to facilitate the establishment of new populations.
- Develop methods to control and eradicate the most harmful non-native plants and non-native insects that threaten native insect food sources.

References:

Banko PC, Johnson L, Lindsey GD, Fancy SG, Pratt TK, Jacobi JD, Banko WE. 2002. Palila (*Loxioides bailleui*). *In* The Birds of North America, No. 679 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Camp RJ, Brinck KW, Banko PC. 2014. Palila abundance estimates and trend. HCSU Technical Report HCSU-053. 18 pp.

Hunt, N. J., C. K. Asing, L. Nietmann, P. C. Banko, and R. J. Camp. 2025. 2022–2024 Status and trend of the palila (*Loxioides bailleui*). Hawai‘i Cooperative Studies Unit Technical Report HCSU-115. University of Hawai‘i at Hilo. 22 pages.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: DOFAW

Forest Birds

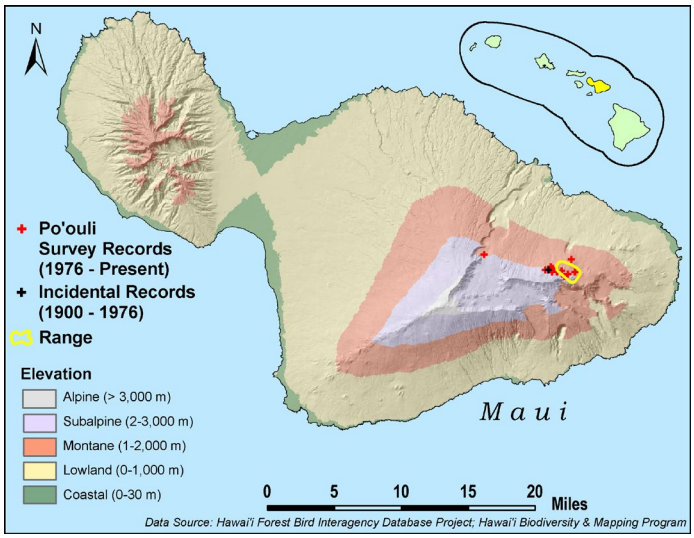
Po‘ouli

Melamprosops phaeosoma

SPECIES STATUS:
Federally Listed as Extinct
State Listed as Extinct
State Recognized as Endemic
NatureServe Heritage Rank: G1 – Presumed Extinct
IUCN Red List Ranking: Extinct
Revised Recovery Plan for Hawaiian Forest Birds - USFWS 2006

SPECIES INFORMATION: The po‘ouli is a stocky Hawaiian honeycreeper (Family: Fringillidae) endemic to Maui that was not discovered until 1973. Po‘ouli have short wings and tail, a finch-like bill, and distinctive plumage. Aptly named “black-faced” in Hawaiian, po‘ouli have a large black face mask, white cheeks, throat, and underparts and brown wings and back; no other Hawaiian forest bird is similarly colored. Although not well-studied, males and females are similar, although females have a grayish throat and breast. Little is known of the species’ life history. Po‘ouli often join mixed species foraging flocks. Forages primarily in the subcanopy and understory on tree branches of native shrubs and trees where they search moss, lichens, and bark for snails and arthropods. Breeding biology is based on observations from a single nesting pair and may be biased because of extremely low population density. For example, territorial behavior has not been observed. Nests are similar to those of other Hawaiian honeycreepers and are placed in ‘ōhi‘a (*Metrosideros polymorpha*) trees. Only the female incubates eggs and broods nestlings; male feeds the female on and off the nest. Last seen in the wild in 2004. Declared extinct by U.S. Fish & Wildlife Service in 2023.

DISTRIBUTION: In 2004, it was restricted to a 1,300 hectare (3,200 acre) area between 1,440 and 2,100 meters (4,750 – 7,000 feet) elevation on the northeastern slope of Haleakalā on Maui. No historical data on range, although fossil evidence indicates that poʻouli once occurred over a wider geographic range.



ABUNDANCE: The Hawai'i Forest Bird Survey in 1980 estimated the population at 140 ± 280 (95% confidence interval) individuals. As of 2003 there were three known individuals. One captured and brought into captivity in 2004 died in November of that year and the remaining two birds have not been seen since January 2004. The species' poor detectability has hampered attempts to locate additional individuals or estimate population size. The species has been declared extinct.

LOCATION AND CONDITION OF KEY HABITAT: Mixed shrub montane wet forest dominated by ʻōhiʻa, with an understory dominated by a diversity of small trees and shrubs, many of which are used as foraging substrates (e.g., kanawao [*Broussaissea arguta*], kawa'u [*Ilex anomala*]). Habitat conditions in areas occupied by poʻouli are variable, but improving. All known individuals occur (red) in the Hanawī Natural Area Reserve which is managed by the State of Hawaiʻi.

THREATS: Unknown. However, poʻouli is likely susceptible to the same factors that threaten other native Hawaiian forest birds, including habitat loss and degradation, predation by introduced mammals, and disease. For poʻouli, the following are likely of particular concern:

- Habitat degradation. The species appears to prefer areas with low levels of soil and vegetation disturbance and therefore may be particularly sensitive to understory and ground cover damage by feral pigs (*Sus scrofa*).
- Predation. Rats (*Rattus* spp.) are abundant in poʻouli habitat and may depredate adults and nests.
- Competition. In addition to direct predation on adults and nests, rats also may compete with po'ouli for food resources, especially snails. Also, the non-native garlic snail (*Oxychilus alliarius*) is abundant and preys on native snails.
- Disease: the last known individual that was brought in captivity and later died had chronic avian malaria. It is likely that disease spread from non-native mosquitoes contributed to their extinction.

CONSERVATION ACTIONS: Major efforts to conserve po'ouli include the establishment of the 3,000 hectares (7,500 acres) Hanawī Natural Area Reserve in 1986 to protect the species'

entire known range, and fencing and pig removal has facilitated recovery of the understory. In 1995, the Maui Forest Bird Recovery Project was created to research and protect native Hawaiian forest birds, including the poʻouli. Activities to date include small mammal control, research on optimizing rodent control methods, surveys for native land snails, and banding and collecting blood samples to monitor demography and disease prevalence. In 2002, the team successfully translocated a female poʻouli to the home range of the male, however, she quickly returned to her own home range. In September 2004, one poʻouli was captured in an attempt to establish a captive population but it died in November of the same year. The Hawaiʻi Department of Land and Natural Resources and the U.S. Geological Survey continue to search Hanawī and adjacent habitats for additional birds. In addition, poʻouli populations likely have benefited from management efforts to conserve other endangered forest birds on northeastern Haleakalā including fencing, ungulate and small mammal control, forest restoration, habitat monitoring, and studies on disease and disease vectors. In addition to these efforts, future management specific to the po'ouli may include the following**:**

- Continue pig and small mammal control efforts.
- Continue efforts to locate and capture the two known individuals and additional birds.
- Conduct public outreach about the importance of pig and rodent control to the remaining forest bird populations on Maui.
- Continue protection and management of wildlife sanctuaries and refuges.
- Implement mosquito control techniques to reduce non-native disease in forest bird populations.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining the ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. In addition to the ongoing research on poʻouli outlined above, additional priorities specific to po'ouli include the following:

- Determine the distribution and abundance of the species' prey base to determine if food resource is a limiting factor.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Pratt TK, Kepler CB, Casey TLC. 1997. Po'ouli (*Melamprosops phaesoma*). *In* The Birds of North America, No. 272 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 428 pp.

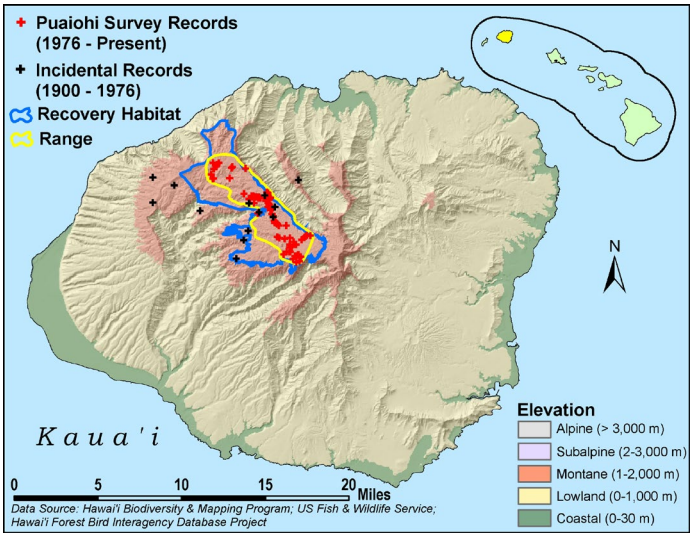
Forest Birds

Puaiohi

Myadestes palmeri

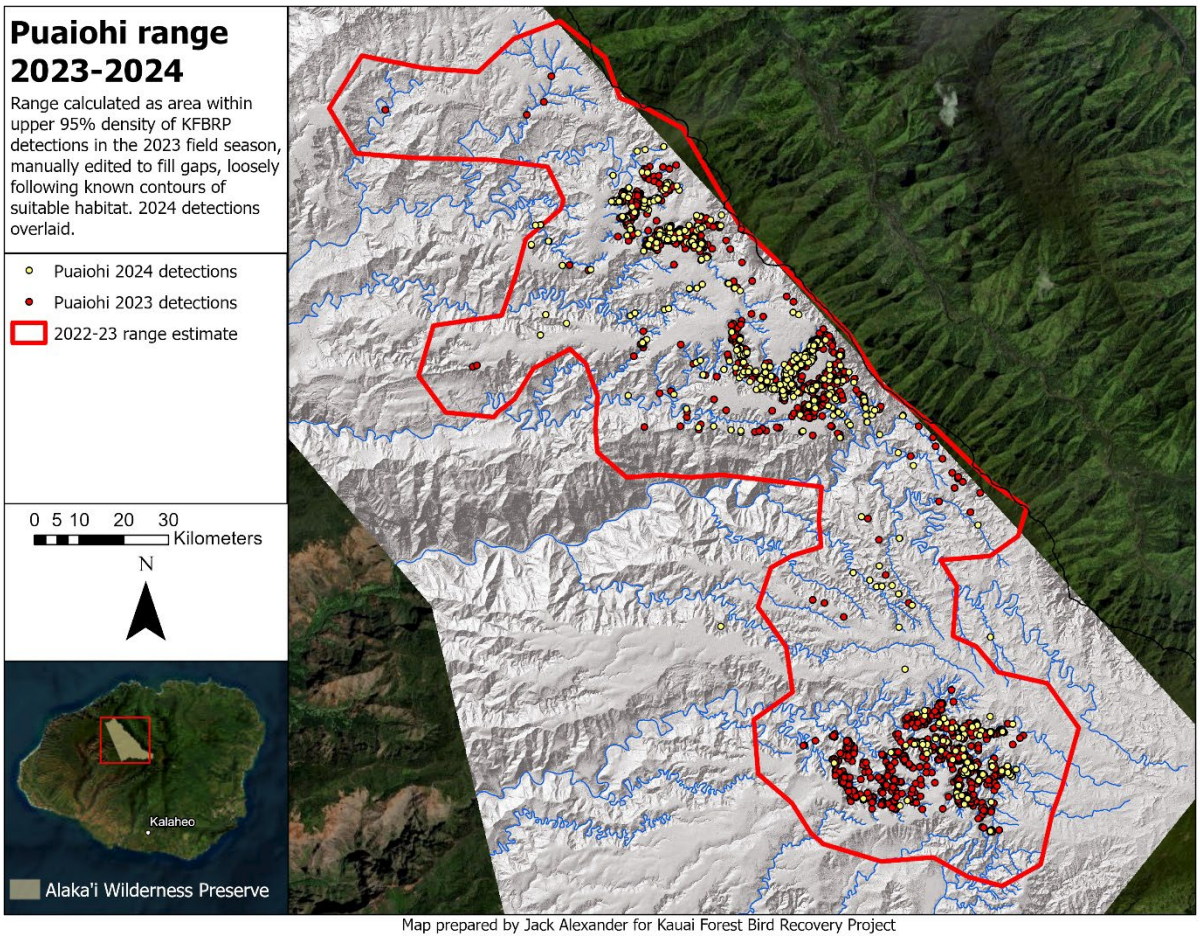
SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The puaiohi, or small Kaua‘i thrush, is the smaller of two solitaires (family: Turdidae) endemic to Kaua‘i, and was the last of the island’s avifauna to be discovered by western ornithologists. In the late 1800s, the puaiohi was considered exceedingly rare, but this assessment was likely due to its cryptic behavior and preference for remote, inaccessible ravines. Adult puaiohi are extremely sedentary and appear to have specific habitat requirements. Of the five Hawaiian solitaires, it is behaviorally, morphologically, and vocally the most divergent. Compared to the kāma‘o, or large Kaua‘i thrush (*M. myadestinus*), the puaiohi has a short tail, and a white eye-ring; in addition, it has a relatively simple song. The species life history is relatively well-known because of recent, intensive studies. Fruit dominates the non-breeding season diet; insects are important during the breeding season. Nests are built by the female in tree cavities or on cliff ledges, and only females incubate eggs and brood young. Breeding peaks from April to June, and re-nesting occurs after failed and successful nest attempts. This behavior, plus a high rate of nest success and a long breeding season, can result in high annual productivity. However, female and juvenile survival is low (0.46 $\pm$ 0.12 and 0.23 $\pm$ 0.06, respectively). Hatch-year and second-year birds (i.e., helpers) are known to assist in nest defense and feeding of related nestlings and fledglings at some sites. Young are very sedentary for two to four days after fledging.



DISTRIBUTION: Restricted to a < 20 square kilometer (7.6 square mile) area on the southern and central plateau of the Alaka‘i Wilderness Preserve. Currently occurs above 1,050 meters (3,450 feet), which is similar to its upper limit historically. It is more likely to occur in streams between 1,140 and 1,340 meters

with large numbers of tall, steep cliffs than in less incised streams. Prehistorically occurred at sea level.



Map prepared by Jack Alexander for Kauai Forest Bird Recovery Project

All known streams above 1,050 meters on the Alakai Plateau, Kauaʻi, which represents the best estimate of the entire puaiohi range.

ABUNDANCE: The most recent surveys in 2011-2013 and subsequent modeling estimated the population at 494 (95% confidence interval: 414-580, Crampton et al. 2017) individuals. Occupancy during these surveys ranged from 0.12 to 0.81 on 12 streams across the range, and has been relatively consistent since 2012 on four streams that were resurveyd in 2024 (KFBRP, unpubl. data) Densities peaked at 16 breeding pairs per square kilometer (0.62 square miles), but varied across streams. This species has been considered rare since the late 1800s.

LOCATION AND CONDITION OF KEY HABITAT: Puaiohi seem somewhat tolerant of avian malaria, so it is not clear what is restricting them to higher elevations—perhaps loss and degradation of habitat (see below). Occurs in deeply dissected, steep-walled ravines supporting wet montane forest dominated by ʻōhiʻa (*Metrosideros polymorpha*) and ʻōlapa (*Cheirodendron* spp.). Their former range included mesic areas dominated by ʻōhiʻa and koa (*Acacia koa*). These areas are now largely dominated by introduced plant species including fire tree (*Myrica faya*)

and strawberry guava (*Psidium cattleianum*). Densities are very low even in apparently suitable habitat. The entire known range of this species is within the Alakaʻi Wilderness Preserve and Na Pali Kona Forest Reserve, which are and is managed by the State of Hawai'i. However, models predict that low numbers of puaiohi occur on private lands adjacent to these areas, which is supported by opportunistic observations when traveling near property boundaries.

THREATS:

- Disease. In 1995-1997, seven puaiohi were tested for disease; none carried malarial (*Plasmodium relictum*) antibodies. Since 2011, 35/181 puaiohi have tested positive for malarial antibodies (KFBRP, unpubl. data).. Survival of puaiohi that tested positive was similar to that of puaiohi that tested negative, indicating a possible resistance to or tolerance of malaria.
- Predation. Two years of field data indicate that rats (*Rattus* spp.) were responsible for 14 to 22 percent of nest failures, as well as mortality of three adult females. Subsequent studies documented at least ten other instances of predation on adults at the nest, and the lower survival of females (0.46 ± 0.12) compared to males (0.71 ± 0.09) is indicative of predation on females at the nest. In 2020, cat (*Felis cattus)* predation of a puaiohi nest in a cliff alcove was documented. Fledglings typically spend their first days out of the nest within 2 meters (6.5 feet) of the ground, which makes them vulnerable to feral cats and rats. Cats have become more common in the Alaka'i in the last 10 years, following the new fence lines.Competition. Several non-native birds, including the introduced Warbling white-eyes (*Zosterops japonicus*), melodious laughing thrush (*Copsychus malabaricus*), and white-rumped shama (*Copsychus malabaricus*), occupy the same habitat and may compete with the puaiohi for food and nest resources. Shama have been observed nesting in nest boxes erected to promote puaiohi nesting on at least two occasions. Preliminary dissection of fecal samples indicate that Japanese white-eyes eat primarily small non-native fruits, whereas puaiohi eat native fruits almost exclusively. Fecal samples of shama and laughing thrush have not been obtained.
- Habitat degradation. Feral pigs (*Sus scrofa*) and goats (*Capra hircus*) have facilitated the invasion of non-native plants into puaiohi habitat. The establishment of these plants has altered the structure of these forests, especially the ground and shrub layer, and especially in the western part of the puaiohi's range where it is now exceedingly rare. Hurricanes in 1982 and 1992 further altered and degraded the forests of Kauaʻi, including those within the Alakaʻi Wilderness Preserve.
- Non-native arthropods. Recently introduced non-native insects, especially yellow jackets (*Vespula pensylvanica*) and Argentine ants (*Linepithema humile*), may compete with the puaiohi's native arthropod prey or disrupt the pollination of the species' food plants. Introduced herbivorous insects also could reduce the abundance of food plants.
- Natural disasters. Hurricanes in 1982 and 1992 likely caused the death of an unknown number of individuals.

CONSERVATION ACTIONS: In 1995, an intensive field ecology and behavior study was initiated. The results from this study are the basis for the current management actions for the species. Using captive propagation and re-introduction techniques developed using the ʻōmaʻo (*M. obscurus*), a captive breeding flock of puaiohi was established in 1996. Between 1999 and

2012, 222 captive-bred puaiohi were released into the wild on Kaua'i. Initially, the program was successful, with several captive-raised birds documented successfully breeding, but in later releases, survival and recruitment was lower. From 2005 to 2010, captive-bred birds released as hatch years had survival of 0.26 ± 0.21, and captive-bred birds released as adults had even lower survival (0.05 ± 0.06). Overall, only 20 released birds were observed paired up, nesting, and raising at least 24 chicks to fledging. Given these results, and the apparent stability of the wild population, this program was discontinued, and the remaining captive puaiohi were released at Halepa'akai in 2016 and 2017. PVA results published in 2018 (Fantle-Lepczyk et al.) indicates rat control would be the most effective management strategy to increase puaiohi abundance, primarily by increasing female and juvenile survival.

In addition, puaiohi likely have benefited from management activities to conserve other endangered forest birds including the establishment of the Alaka'i Wilderness Preserve, regular surveys of forest bird populations, monitoring of habitat conditions, control of feral ungulates through public hunting and fencing, suppression of rats on two A24 trapping grids over approximately 150 ha (470 ac), studies of disease and disease vectors, and public education efforts featuring Kauai's endangered forest birds. In addition to these efforts, future management specific to the recovery of puaiohi will likely include the following:

- Systematically control rats using registered rodenticides or traps in puaiohi nesting habitat over a larger area than currently under protection.
- Aggressively control ungulates to improve habitat quality and facilitate recovery of degraded, but potential, habitat.
- Control non-native plants as part of forest restoration efforts.
- Suppress rats,feral cats and barn owls (*Tyto alba*) in the Alaka'i Wilderness Preserve and Kokee Region.
- Reduce breeding habitat for mosquitoes on the Alaka'i Plateau,
- Suppress mosquito populations through releases of incompatible or sterile mosquitoes.
- Investigate options to eradicate mosquitoes, including use of genetic manipulations.
- Prevent the spread of Rapid Ohia Death on the Alaka'i Plateau
- Prevent the introduction of the small Indian mongoose and other possible predators.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.
- Translocate to other islands with appropriate habitat.

MONITORING: Continue puaiohi specific occupancy surveys, nest monitoring, and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for most Hawaiian forest birds include improving methods for controlling rats and feral cats in native forests, determining ecological requirements of *Culex* mosquitoes at mid- and high-elevation forests, and developing methods to control mosquito populations. Research priorities specific to the puaiohi include the following:

- Investigate immediate impacts of acute disease (malaria, pox) on puaiohi survival and sub-lethal impacts on fecundity
- Conduct captive-breeding of disease-resistant birds to establish disease-resistant populations at lower elevations.

- Continue field studies to document survival and dispersal, habitat use, and causes of high female and juvenile mortality.
- Investigate efficacy of other methods of controlling invasive rodents (e.g., different methods of applying rodenticide, snap traps).
- Assess the impact of introduced rodents on food sources important to puaiohi, including fruits and invertebrates.

References:

Atkinson, CT, RB Utzurrum, DA LaPointe, RJ Camp, LH Crampton, JT Foster, and TW Giambelluca. 2014. Changing Climate and the Altitudinal Range of Avian Malaria in the Hawaiian Islands - an Ongoing Conservation Crisis on the Island of Kaua‘i. Global Change Biology 20, 2426–2436, doi: 10.1111/gcb.12535.

Crampton LH, Brinck KW, Pias KE, Heindl BAP, Savre T, Diegmann JS, Paxton EH. 2017. Linking occupancy surveys with habitat characteristics to estimate abundance and distribution in an endangered cryptic bird. Biodiversity and Conservation 26: 1525-1539.

Fantle-Lepczyk J, Taylor A, Duffy DC, Crampton LH, Conant S. 2018. Using population viability analysis to evaluate management activities for an endangered Hawaiian endemic, the Puaiohi (*Myadestes palmeri*) Plos one 13: e0198952.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alaka’i swamp, Kaua’i. Conservation Biology 18:716-725.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Switzer R., Lieberman A, Nelson J, Crampton LH. 2013. Augmentation of the Puaiohi population through captive propagation and release on the Alakai Plateau, Kauai, Hawaii, USA. Reintroduction Specialist Group Book, IUCN.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service..

Vanderwerf, EA, LH Crampton, PK Roberts, JS Diegmann, and DL Leonard. 2014. Survival estimates of wild and captive-released Puaiohi, an endangered Hawaiian thrush. Condor 116: 609–618. DOI: 10.1650/CONDOR-14-18.1

Wakelee KM, Fancy SG. 1999. ‘Oma’o (*Myadestes obscurus*), kama’o (*Myadestes myadestinus*), oloma’o (*Myadestes lanaiensis*), and ‘amaui (*Myadestes woahensis*). *In* The Birds of North America, No. 460 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Jack Jeffery

Raptors

ʻIo

Buteo solitarius

SPECIES STATUS:

State Listed as Endangered
State Recognized as Endemic NatureServe Heritage Rank G2—Imperiled IUCN Red List Ranking—Near Threatened, Hawaiian Hawk Recovery Plan—USFWS 1984
Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The ʻio, or Hawaiian hawk, is the only broad-winged hawk (Family: Accipitridae) in Hawaiʻi. ʻIo are considered ʻaumākua, or family gods, by Native Hawaiians. Similar to many birds of prey, females are larger than males, and often weigh approximately 25 percent more than males. Also similar to many *Buteos*, two color morphs, light and dark, occur in ʻio populations. Prior to the arrival of Polynesians, ʻio may have exclusively preyed on birds, including now extinct flightless ibis, and rails. Its diet now includes non-native insects, birds and rodents, as well as native insects and birds. ʻIo form monogamous long-term pair-bonds and defend territories year-round. Nest construction is protracted, beginning up to two months before the first egg is laid, and continuing into the nestling period. Egg-laying generally occurs from March to June, and fledging from July to September. Both sexes contribute to nest-building. Clutch size is nearly always one, although historically clutches of two and three were reported. Both sexes incubate, although females perform most of the brooding of nestlings; males provide most of the food to chicks and female. Both adults feed fledglings, which are dependent on adults for up nine months. The ʻio was delisted from the Federal Endangered Species Act in 2019 but remains classified as an endangered species under the State of Hawaii.

DISTRIBUTION: Occurs throughout the island of Hawaiʻi from 300 to 2,600 meters (1,000 to 8,530 feet). Based on fossil evidence, they once occurred on Kauaʻi, Molokaʻi, and Oʻahu.

ABUNDANCE: Based on an island-wide survey in 2007**,** the population is estimated at 3,000 birds with a stable population trend over the past 20 years.

LOCATION AND CONDITION OF KEY HABITAT: Lowland non-native forests, urban areas, agricultural lands, pasturelands, and high-elevation native forests. Most nesting occurs in native ʻōhiʻa trees, although also occurs in non-native trees, including eucalyptus, ironwood, mango, coconut palm, and macadamia. In winter, they have been reported in subalpine māmane-naio forest, suggesting some seasonal movements.

THREATS:

- Habitat loss and degradation: Habitat is negatively affected by urbanization, land

conversion to unsuitable foraging habitat (e.g., pasture and cane fields to eucalyptus forest), increase in fire frequency that may eliminate nesting and perching habitat, and invasion of understory plants which can conceal prey and reduce foraging success.ʻIo nests occur in a variety of trees, but over 80% of nests observed in a 2003 study occurred on the native ʻōhiʻa tree (Klavitter et al. 2003). Threats to native forests on Hawaiʻi Island are current and rapid ʻōhiʻa death is changing the landscape level distribution of ʻōhiʻa trees with mortality rates as high as 90% being found in some areas.

- Volcanic activity: Forested areas have been lost either through direct lava inundation or increased levels of toxic sulphur dioxide fumes.

- Disease: ʻIo does not appear to be susceptible to the avian malaria and avian pox that have devastated other Hawaiian endemic forest birds. However, West Nile virus could affect the species if the disease reaches Hawaiʻi.

- Environmental contaminants and toxins: ʻIo are secondarily exposed to both first and second-generation anticoagulant rodenticides and likely face both lethal and sublethal effects from these toxicants. Increased use of urban, agricultural, and other human-altered environments puts ʻio at greater risk of encountering these environmental toxins.
- Shooting: Harassment of nesting birds and shooting was identified in the U.S. Fish and Wildlife Service's Hawaiian Hawk Recovery Plan (USFWS 1984) as a significant factor affecting the species. In 2018, four cases of ʻIo deaths were attributed to firearms and another two were reported in 2013 on Hawaiʻi Island.

CONSERVATION ACTIONS: ʻIo likely benefit from actions for other endangered birds, such as fencing, ungulate and small mammal control, and forest restoration. Actions specific to conservation of the ʻio should include the following:

- Protect and manage the species' foraging and nesting habitat.
- Minimize use of rodenticides and other environmental toxins within known ʻIo occupancy areas
- Concerted outreach for ʻIo to reduce and prevent harassment and shooting.

MONITORING: Conduct regular island-wide surveys to monitor population dynamics and abundance, distribution, and disease.

RESEARCH PRIORITIES: Research priorities specific to ʻIo include:

- Evaluate potential effects of land management and changes in fire frequency and intensity on the species.
- Continue regular population monitoring as outlined in the 2019 U.S. Fish and Wildlife Post-delisting Monitoring Plan for the Hawaiian Hawk or ʻIo, to assess the impacts of delisting the species from the federal ESA.

References:

Clarkson KE, Laniawe LP. 2000. Hawaiian hawk (*Buteo solitarius*). *In* The Birds of North America, No. 523 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American

Ornithologists' Union.

Hawai‘i Natural Heritage Program [Hawai‘i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai‘i, Center for Conservation Research and Training. Honolulu, HI.

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available at: http://explorer.natureserve.org. (Accessed May 2015).

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Sierts, S.R, S. E Volker, C.G Payne, R. T. Sugihara, C.E. Swift, J.T. Nelson, A.B. Shiels, and W.C. Pitt. 2019. Screening of Hawaiian bird and bat carcassess for rodenticide residues. Unpublished final report (QA-2240). USDA, APHIS, WS, NWRC. Hilo, HI.

U.S. Fish and Wildlife Service. 1984. Hawaiian Hawk Recovery Plan. Portland, Oregon.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; withdrawal of proposed reclassification of the Hawaiian hawk or io (*Buteo solitarius*) from endangered to threatened; proposed rule to remove the Hawaiian hawk from the federal list of endangered and threatened wildlife. Federal Register 73:45680–45689.

U.S. Fish and Wildlife Service. 2019. Post-delisting Monitoring Plan for the Hawaiian Hawk, or Io (Buteo solitarius). Endangered Species Division, Pacific Island Fish and Wildlife Office, Honolulu, HI.

Photo: NRCS

Raptors

Pueo or Hawaiian Short-eared Owl

Asio flammeus sandwichensis

SPECIES STATUS:

State listed as
Endangered on O‘ahu State recognized
as Endemic at the subspecies level
NatureServe Heritage Rank G5/T2 –
Species secure/Subspecies imperiled
Bird of Conservation Concern
- USFWS 2021

SPECIES INFORMATION: The Pueo, or Hawaiian Short-eared Owl, is an endemic subspecies of the nearly globally distributed Short-eared Owl (*Asio flammeus*; Family: Strigidae). Pueo are ‘aumakua (deified ancestors) that have the ability to restore life or save people from imminent death. The species is thought to have colonized the Hawaiian Islands sometime after the arrival of Polynesians.

Unlike most owls, Pueo are occasionally active during the day, however, they are most active during crepuscular (morning and evening) and nocturnal times (Wilhite et al. 2024). They are commonly seen hovering or soaring over open areas but they also occupy forested and developed habitats (Wilhite et al. 2024). Like Short-eared Owls in continental environments, those in Hawai‘i primarily consume small mammals, but unlike their continental counterparts Pueo will also hunt birds (including native seabirds) and invertebrates. Their relatively recent establishment on Hawai‘i may have been tied to the Pacific rats (*Rattus exulans*) that Polynesians brought to the islands. Little is known about the breeding biology of Pueo, but nests or recently fledged young have been found between November and July . Males perform aerial displays known as a sky dancing display to prospective females.
Nests are constructed by females and are simple scrapes in the ground occasionally lined with grasses and down feathers. Clutch sizes generally range between 2-7 eggs. Females perform all incubating and brooding. Males feed females and both sexes will defend nests. Chicks hatch asynchronously and are fed by the female with food delivered to her by the male. Young fledge from the nest on foot before they are able to fly, beginning at approximately 10 days old, but are flightless and remain on the ground in the vicinity of the nest until approximately 28 days old. After fledging, they depend on their parents for another month.

DISTRIBUTION: Found on all the Main Hawaiian Islands from sea level to 2,450 meters (8,000 feet). Individuals are documented to move between islands, such as from Kaho‘olawe to Maui, or from O‘ahu to Moloka‘i, although the frequency at which inter-island movements occur is still unknown.

ABUNDANCE: Unknown. Because of relatively few detections, the Hawaiian Forest Bird Survey did not estimate the population size of the Pueo. Pueo were widespread at the end of the 19th century and arethought to be declining, but recent analysis of eBird data indicates that Pueo occupancy rates across the Main Hawaiian Islands have remained low but stable from 2010-2020.However, focused surveys for the species will still be necessary to determine population size. However, focused surveys for the species will still be necessary to determine population size.

LOCATION AND CONDITION OF KEY HABITAT: Pueo occupy a variety of habitats, including wet and dry forests, suburban and developed areas, and open habitats such as grasslands, shrublands, wetlands, and montane parklands, including those actively managed for conservation. Pueo are also documented to breed in wet and dry native forests, grasslands, shrublands, wetlands, and coastal scrubland. Because of a lack of historical population data and the species' current, broad habitat use, key habitat variables are difficult to determine. Pueo occur in many areas that are managed by the State of Hawai‘i or Federal agencies.

THREATS: Pueo are likely susceptible to the same factors that threaten other native Hawaiian birds, including: loss and degradation of habitat, predation by introduced mammals, exposure to anthropogenic threats such as rodenticides and collisions with vehicles and structures, and disease. However, their persistence in lowland, non-native and rangeland habitats suggests that they may be less vulnerable to extinction than other native birds, especially because they may be resistant to avian malaria (*Plasmodium relictum*) and avian pox (*Poxvirus avium*).
Despite this, for Pueo populations, the following are of particular concern:

- Predation: Because Pueo nest on the ground, eggs, young, and even adult birds are vulnerable to predation by rats (*Rattus* spp.), feral cats (*Felis silvestris*), feral dogs (Canis lupus familiaris) and the small Indian mongoose (*Herpestes auropunctatus*).
- Habitat loss: Though Pueo are found in a variety of habitat types Pueo use of heavily altered landscapes such as agricultural and urban areas may increase their exposure to anthropogenic risks such as contaminants and human interactions (see below). May be particularly important for O‘ahu Pueo populations.
- Contaminants or toxins: Because Pueo are top predators, they are likely secondarily exposed to both first and second-generation anticoagulant rodenticides and face both lethal and sublethal effects from these toxicants. Increased use of urban, agricultural, and other human-altered environments puts pueo at greater risk of encountering these environmental toxins.
- Human interaction: Hunting behavior and habitat use predispose Pueo to collisions with infrastructure such as powerlines and vehicles,.

- Climate change: Pueo appear to be shifting their activity temporally and in elevation seasonally, potentially due to higher temperatures at low elevations.

CONSERVATION ACTIONS: Pueo likely have benefited from management activities designed to conserve other endangered birds, such as fencing, ungulate control, and invasive predator removal. They also may benefit from game bird management; high densities of Pueo occur on lands where game birds also are common. In addition to these efforts, future management specific to the Pueo may include the following:

- Determine population trends and abundance estimates through systematic surveys. Public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Regular island-wide population surveys are necessary to determine population trends for this species. This information is needed to assess the efficacy of habitat management efforts.

RESEARCH PRIORITIES: Research priorities specific to Pueo include the following:

- Analysis of population trends and changes in habitat occupancy, especially on O‘ahu.
- Analysis of habitat selection to better understand if certain habitat types are of greater value to Pueo and meet different life history needs (for example, increased breeding success in certain habitat types over others)
- Determine primary causes of mortality and its potential effect on populations.Quantify the number of infrastructure, powerline and vehicular collisions and determine the level of threat to populations.

References:

Berger AJ. 1981. Hawaiian birdlife. Honolulu: University of Hawai‘i Press. 260 pp.

Holt DW, Leasure SM. 1993. Short-eared owl (*Asio flammeus*). *In* The Birds of North America, No. 62 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Mostello, C.S. and Conant, S., 2018. Diets of native and introduced apex predators in Hawai'i. Pacific Conservation Biology, 24(1), pp.25-34.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence, (KS): Cooper Ornithological Society.

Sierts, S.R, S. E Volker, C.G Payne, R. T. Sugihara, C.E. Swift, J.T. Nelson, A.B. Shiels, and W.C. Pitt. 2019. Screening of Hawaiian bird and bat carcassess for rodenticide residues. Unpublished final report (QA-2240). USDA, APHIS, WS, NWRC. Hilo, HI.

Stormcrow, K., Kealiikanakaoleohaililani, K., Puniwai, N. Price, M.R., Vaughan, M.B. Winter, K.B. In Prep. ‘Ike ku‘una (Indigenous Knowledge) of Pueo (Hawaiian Short-eared Owl; Asio flammeus sandwichensis). Chapter in Owls in Myth and Culture. Springer? Johnson, D.H. (Editor).

Stormcrow, K., Winter, K.B., Puniwai, N., Risch, D., Price, M.R. In Prep. Factors influencing detectability of Pueo (Hawaiian Short-eared Owl; Asio flammeus sandwichensis).

Wang O, Garcia-Heras M-S., Wilhite CJ., Naguwa WH., Price MR. In Prep. Breeding ecology and management of Pueo (Hawaiian Short-eared Owl; Asio flammeus sandwichensis). Available at: https://scholarspace.manoa.hawaii.edu/items/9a442660-1f0e-4a0c-8cae-620e214af80d

Wilhite CJ, Cotin J, Wang O, Garcia-Heras M-S, Idle JL, Rípodas Melero AI, Price MR. 2024. Diurnal preference for wooded habitat hints at intraspecific niche expansion in the Pueo (Hawaiian Short-eared Owl; Asio flammeus sandwichensis). Avian Conservation and Ecology.

Waterbirds

Koloa maoli or Hawaiian duck

Anas wyvillian

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1 -
Critically Imperiled, IUCN Red List Ranking -
Endangered, Recovery Plan for Hawaiian Waterbirds – USFWS 2011

SPECIES INFORMATION: The koloa maoli, or Hawaiian duck, is one of two extant native duck species (Family: Anatidae) found in Hawai‘i and is closely related to the well-known mallard (*A. platyrhynchos*). Adult males and females are mottled brown overall. Males have darker heads and necks, olive bills and bright orange feet. The bills of females are more orange, their feet are dull orange, and they are smaller than males. Koloa maoli forage in a wide variety of freshwater habitats, including artificial wetlands. Movements between feeding and breeding habitats and between Kaua‘i and Ni‘ihau occur. The species typically forages in shallow water (less than 13 centimeters, or 5 inches, deep). Like mallards, koloa maoli are opportunistic and their diet includes snails, dragonfly larvae, earthworms, grass seeds, green algae, and seeds/leaf parts of wetland plants. They are usually found alone or in pairs and are wary, especially when nesting or molting, although during the winter they may gather in larger numbers to exploit abundant food resources. Nesting biology is poorly known. On Kauai, pairs nest in lowland habitats and upper elevation montane habitats. Nesting occurs year-round, but most activity occurs between January and May. Nests are usually on the ground near water, but few nests are found in areas frequented by humans or areas supporting populations of mammalian predators. Generally, eight to ten eggs are laid, and the precocial chicks hatch after an unknown incubation period, but likely less than 30 days. Hawaiian Ducks readily hybridize with Mallard ducks, with only the Kaua'i Island population considered genetically pure (Fowler et al. 2008; Wells et al. 2019), and hybridization is considered the largest threat to the species (USFWS 2011).

DISTRIBUTION: Currently, pure Koloa populations are found only on the island of Kauai where hybridization with feral mallard is not a significant threat. The remaining island populations are considered hybrids with varied levels of hybridization. Wetland habitats from sea level to 3,000 meters (9,900 feet) elevation are preferred by the species. On Kaua‘i, the majority of the koloa maoli population is found in Hanalei National Wildlife Refuge but they are also distributed in other wetlands and montane streams. On O‘ahu, hybrid populations occur at Kawainui, Hāmākua, Kaneohe Marine Corp Base and James Campbell National Wildlife Refuge. On the island of Hawai‘i, hybrid populations occur in Waimea. Other island populations are a mix of hybrids or predominantly mallard poulations. Historically, koloa maoli occurred on all the Main Hawaiian Islands except for Lāna‘i and Kaho‘olawe.

ABUNDANCE: Based on state-wide biannual (summer and winter) waterbird counts conducted by the Division of Forestry and Wildlife and partners between 2019-2023, the population is estimated at 673 (CI 516-854) birds where the only populations of pure Koloa are thought to exist (Gorresen, et al., 2024). The long-term population appears to be increasing, but short-term population trends on Kauai over the last 5 years appear to be declining. Historically, koloa maoli were fairly common in natural and agricultural wetland habitats. By 1949, only about 530 individuals remained, with 30 on Oʻahu and the remainder on Kauaʻi.

LOCATION AND CONDITION OF KEY HABITAT: Koloa maoli occurs in a wide variety of natural and artificial wetland habitats, including freshwater marshes, flooded grasslands, coastal ponds, streams, montane pools, forest swamplands, taro, lotus, shrimp, and fish ponds, irrigation ditches, reservoirs, and mouths of larger streams. Some important habitats are located in National Wildlife Refuges or on State lands that receive management attention, but others remain unprotected, such as wetlands facing development or those used for agriculture or aquaculture. Examples include playa lakes on Niʻihau; Opaekaʻa marsh; Lumahaʻi wetlands on Kauaʻi; Amorient prawn farms; Lāʻie wetlands; Uko, Punahoʻolapa, and Waiheʻe marshes; Waialua lotus fields; Waipiʻo Peninsula ponds on Oʻahu; Paialoa and ʻŌʻōʻia playa fishponds on Molokaʻi; and Opaeʻula and Waiākea-Loko Waka ponds on the island of Hawaiʻi.

THREATS: Historically, hunting pressure likely reduced populations. Like the rest of Hawaiian native waterbirds, koloa maoli are threatened by:

- Hybridization. Currently, the most important threat to koloa maoli is hybridization with nonnative mallards, especially on islands outside of Kauai, where most individuals are hybrids.
- Habitat loss and degradation. In the last 110 years, around 44% of coastal wetlands have been lost in Hawaiʻi (Burney et al., 2001; van Rees and Reed, 2014). The remainder are seriously affected by by non-native species, urban and tourist development, hydrological changes, sedimentation and sea level rise (US Fish and Wildlife Service (USFWS), 2011a; Jacobi and Stock, 2017). Feral pigs and other ungulates are reducing nesting habitat suitability for koloa maoli along montane streams.
- Introduced and native predators. Eggs and ducklings are especially vulnerable to predation by dogs (*Canis familiaris*), rats (*Rattus spp*.), feral cats (*Felis silvestris*), the small Indian mongoose (*Herpestes auropunctatus*), ʻaukuʻu or black-crowned night herons *(Nycticorax nycticorx hoactli*), cattle egrets (*Bulbulcus ibis*), barn owls (*Tyto alba*), bull frogs and non- native fish.
- Altered hydrology. Altering wetland habitats for flood control, agriculture or to serve as municipal water sources makes them generally unsuitable for koloa maoli. Climate change impacts are also expected to impact hydrology of wetlands.
- Nonnative invasive plants. Several species of invasive plants, including pickleweed (*Batis maritime*), water hyacinth (*Eichornia crassipes*), and mangrove (*Rhizophora mangle*), reduce open water, mudflats, and shallows.
- Avian diseases. Botulism outbreaks result in mortality. West Nile virus and avian flu may pose a risk to Hawaiian waterbirds if these diseases reach Hawaiʻi.
- Environmental contaminants. Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.
- Anthropogenic impacts: Powerline strikes, vehicle strikes and other man-made

infrastructure can cause mortality.

CONSERVATION ACTIONS: In order to establish new populations, 445 koloa maoli were released on the island of Hawai‘i from 1958 to 1979, 350 birds were released on O‘ahu from 1968 to 1982, and 12 birds were released on Maui in 1989. The State of Hawai‘i, the U.S. Fish and Wildlife Service (USFWS), and private organizations and landowners have protected 82 percent of the core wetlands for Hawaiian waterbirds and 17 percent of their supporting wetlands. Most of the populations outside of Kauai have some level of hybridization from feral ducks. Future reintroduction efforts will require management of mallard populations to protect and ensure pure koloa populations are established.

- Other actions specific to conservation of koloa maoli and other Hawaiian waterbirds should include the following:
- Continue to manage, restore, and protect core and supporting wetland habitats, including montane stream habitat.
- Eliminate or control feral mallards and mallard/koloa maoli hybrids.
- Eliminate or reduce populations of introduced predators.
- Conduct education and awareness programs regarding the mallard/koloa maoli interbreeding problem and the need for a feral and hybrid duck removal program.

MONITORING:

- Continue annual waterbird surveys of populations and habitat monitoring to detect changes in population trends.
- Monitor for the presence of hybrids in populations.
- Survey montane stream habitats to provide more accurate population estimates.

RESEARCH PRIORITIES:

- Determine the best methods to control and eliminate hybridization between mallards and koloa maoli.
- Analyze annual survey data for correlations, including use of specific wetlands, time of year, and state of wetlands, in order to improve management for koloa maoli.
- Conduct a population viability analysis to identify population numbers and time spans that can serve as predictors for the long-term recovery of koloa maoli.

References

Engilis A Jr., Uyehara KJ, Giffin, JG. 2002. Hawaiian duck (Anas wyvilliana). In The Birds of North America, No. 694 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

U.S. Fish and Wildlife Service. 2010. Koloa maoli or Hawaiian duck (Anas wyvilliana) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2011. Recovery plan for Hawaiian waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

Photo: NRCS

Waterbirds

ʻAlae ʻula or Hawaiian common gallinule

Gallinula chloropus sandvicensis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Indigenous
NatureServe Heritage Rank G5 - Secure
Recovery Plan for Hawaiian Waterbirds – USFWS 2011

SPECIES INFORMATION: The ʻalae ʻula or Hawaiian moorhen is a small, striking waterbird (Family: Rallidae) and is one of 12 recognized subspecies. ʻAlae ʻula is endemic to Hawaiʻi and is very similar to its North American relative in appearance; adults are black above and dark slate blue below, with a white stripe on their flanks and a prominent red shield over their red and yellow bill. Feet are lobed rather than webbed, and males are larger than females. In Hawaiian mythology, a moorhen brought fire to humans, which explains the red on its forehead, a symbol of the scorching from the fire. It uses a variety of freshwater and estuarine habitats and can be somewhat secretive, although it is often seen swimming across open water. ʻAlae ʻula are opportunistic feeders, and their diet likely varies with habitat, but includes algae, grass seeds, plant material, insects, and snails. Nesting habitat is restricted to areas with standing water less than 61 centimeters (24 inches) deep with dense emergent vegetation. Nesting occurs year-round, but mostly occurs between March and August. Nesting phenology is apparently tied to water levels and the presence of appropriately dense vegetation. Platform nests are constructed in dense vegetation over water. The particular species of emergent plant used for nest construction is not as important as stem density and vegetation height. Five to six eggs are laid and hatch after 22 days. Although chicks are precocial and can swim shortly after hatching, they remain in the nesting area for a few days after hatching and are dependent on their parents for several weeks.

DISTRIBUTION: Historically, ʻalae ʻula occurred on all the Main Hawaiian Islands except for Lānaʻi and Kahoʻolawe.ʻAlae ʻula generally occur in wetland habitats below 125 meters (410 feet) elevation on the islands of Kauaʻi and Oʻahu. Although there have been reports from Keʻanae Peninsula on Maui and from the island of Hawaiʻi, this species is now restricted to Kauai and Oahu. Reasons for the range restriction of the species is unknown, but are likely due to a combination of hunting, sparse and deteriorating breeding habitat, and predation from non-native mammals. On Kauaʻi, the largest populations occur in the Hanalei and Wailua river valleys, but they also occur in irrigation canals on the Mānā Plains of western Kauaʻi and in loi kalo (taro fields). On Oʻahu, the species is widely distributed with most birds found between Haleʻiwa and Waimanalo; small numbers occur at Pearl Harbor and the leeward coast at Lualualei Valley.

ABUNDANCE: ‘Alae ‘ula are quite secretive, and current survey methods are inadequate to accurately estimate population size. Based on state-wide biannual (summer and winter) waterbird counts between 2019-2023, the population is estimated at 712 (CI 573-876) birds with Kauai supporting a majority of the species with an estimated 485 (383-611) birds. ‘Alae ‘ula long-term trends over a 38 year period appear to be increasing, but short term trends on Kauai (11-year), appear to be decreasing (Gorresen, et al., 2024). The species was common at the turn of the twentieth century, but by the 1940s, its status was considered precarious.

LOCATION AND CONDITION OF KEY HABITAT: ‘Alae ‘ula are found in freshwater marshes, wetland agricultural areas (e.g., taro patches), reedy margins of water courses (e.g., streams, irrigation ditches), reservoirs, wet pastures, and, infrequently, brackish water habitats. Important breeding areas are found on the Hanalei National Wildlife Refuge on Kauaʻi and the State and Federal managed wetlands on Oʻahu. Key habitat features include dense stands of robust emergent vegetation near open water, floating or barely emergent mats of vegetation, and water depths less than 1 meter (3.3 feet). Some important habitats are located in National Wildlife Refuges or on State lands and receive management attention, but others remain unprotected, such as wetlands facing development or those used for agriculture or aquaculture. Examples include Opaekaʻa marsh; Lumahaʻi wetlands on Kauaʻi; Amorient prawn farms; Lāʻie wetlands; Uko, Punahoʻolapa, and Waiheʻe marshes; Waialua lotus fields; and Waipiʻo Peninsula ponds on Oʻahu.

THREATS: Like the rest of Hawaiian native waterbirds, ‘alae ‘ula are threatened by:

- Habitat loss: In the last 110 years, around 44% of coastal wetlands have been lost in Hawaiʻi (Burney et al., 2001; van Rees and Reed, 2014). The remainder are seriously affected by non-native species, urban and tourist development, hydrological changes, sedimentation and sea level rise (US Fish and Wildlife Service (USFWS), 2011a; Jacobi and Stock, 2017). A shift in wetland agriculture to other agriculture crops also has reduced the amount of wetland habitats.
- Introduced and native predators: Dogs (*Canis familiaris*), rats (*Rattus spp*.), feral cats (*Felis silvestris*), the small Indian mongoose (*Herpestes auropunctatus*), cattle egrets (*Bulbulcus ibis*), ‘Auku’u (*Black-crowned Night Herons*), barn owls (*Tyto alba*), and bullfrogs (*Rana catesbeiana*) all prey on adult or young ‘alae ‘ula. There have also been reports of predation by Red-eared Sliders and Mud Crabs.
- Altered hydrology: Altering wetland habitats for flood control, agriculture or to serve as municipal water sources makes them generally unsuitable for koloa maoli. Climate change impacts are also expected to impact hydrology of wetlands.
- Avian diseases: Botulism outbreaks result in mortality. West Nile virus and avian flu may pose a risk to Hawaiian waterbirds if these diseases reach Hawaiʻi.
- Environmental contaminants. Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.
- Climate change: Sea level rise due to climate change may result in a loss of coastal wetland habitats used by Hawaiian waterbirds. ‘Alae ‘ula depend on freshwater habitats and sea level rise is likely to make freshwater habitats saltier, reducing the suitable habitat for this species.
- Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.

CONSERVATION ACTIONS: In order to establish a new population, the U.S. Fish and Wildlife Service (USFWS) translocated six ʻalae ʻula to Molokaʻi in 1983; however this reintroduction was unsuccessful due to a number of reasons likely due to lack of management and potential poaching. The State of Hawaiʻi, USFWS, and private organizations and landowners have protected 82 percent of the core wetlands for Hawaiian waterbirds and 17 percent of their supporting wetlands. Other actions specific to conservation of ʻalae ʻula and other Hawaiian waterbirds should include the following:

- Continue to manage, restore, and protect core and supporting wetland habitats.
- Eliminate or reduce populations of introduced predators through predator management and predator fences.
- Reintroduce ʻalae ʻula to at least two additional islands (Maui, Molokaʻi, Lānaʻi, and/or Hawaiʻi), and monitor survival, dispersal, and reproduction.

MONITORING: Continue annual statewide surveys of populations and habitat monitoring to detect changes in population trends.

RESEARCH PRIORITIES:

- Refine survey techniques, potentially using playback calls of ʻalae ʻula to increase detections.
- Better monitoring for nest success and fledgling success. Understand fledgling survivorship and movements.
- Analyze annual survey data for correlations, including use of specific wetlands, time of year, and state of wetlands, in order to improve management for ʻalae ʻula.
- Use climate change models to predict sea-level rise, and assess key wetlands to protect/create in light of the analysis. Monitor current salinity levels and anticipate changes.
- Understand salinity thresholds and impacts to the ʻalae ʻula.
- Develop removal methods for invasive amphibians, reptiles, and invertebrates that prey on chicks.

References

Bannor BK, Kiviat E. 2002. Common moorhen (Gallinula chloropus). In The Birds of North America, No. 685 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. 2015. Available at: http://www.redlist.org. (Accessed May 2015).

U.S. Fish and Wildlife Service. 2010. Hawaiian moorhen or ʻalae ʻula (Gallinula chloropus sandvicensis) 5- year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawaiʻi.

U.S. Fish and Wildlife Service. 2011. Recovery plan for Hawaiian waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

Photo: DOFAW

Waterbirds

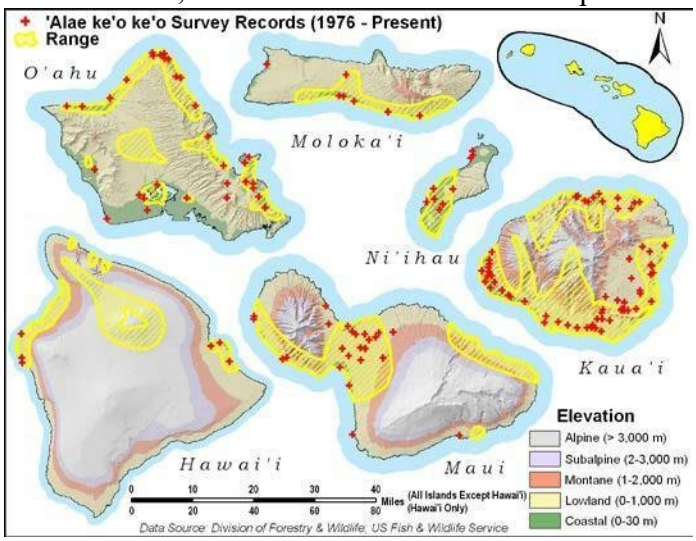
‘Alae ke‘oke‘o or Hawaiian coot

Fulica alai

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G2 - Imperiled
IUCN Red List Ranking - Vulnerable
Recovery Plan for Hawaiian Waterbirds - USFWS 2011

SPECIES INFORMATION: The ‘alae ke‘oke‘o or Hawaiian coot is a small waterbird (Family: Rallidae) endemic to Hawai‘i. Adult males and females have a black head, a slate gray body with white undertail feathers, and a prominent white frontal shield and bill; feet are lobed rather than webbed and are greenish gray. The Native Hawaiian considered ‘alae ke‘oke‘o to be a deity but also considered it good to eat. Life history and breeding biology are poorly known. The species is somewhat gregarious and uses freshwater and brackish wetlands, including agricultural (e.g., loi kalo or taro fields) wetlands and aquaculture ponds. ‘Alae ke‘oke‘o are generalists and feed on land, from the surface of the water, and underwater; also, they will graze on grass adjacent to wetlands. Food items include seeds and leaves, snails, crustaceans, insects, tadpoles, and small fish. The species will travel long distances, including between islands, when local food sources are depleted. Nesting habitat includes freshwater and brackish ponds, irrigation ditches, and taro fields. Floating nests are constructed of aquatic vegetation and found in open water or anchored to emergent vegetation. Open water nests are usually composed of mats of water hyssop (*Bacopa monniere*) and Hilo grass (*Paspalum conjugatum*). Nests in emergent vegetation are typically platforms constructed from buoyant stems of species such as bulrush. Nesting occurs year-round, but mostly between March and September. Nest initiation is tied to appropriate water levels from rainfall or water control systems as water levels are critical to nest success. Clutch size range from three to ten eggs, and precocial young hatch after a 25-day incubation period.

DISTRIBUTION: The ʻalae keʻokeʻo occurs in coastal plain wetlands usually below 400 meters (1,320 feet) elevation on all the Main Hawaiian Islands except for Kahoʻolawe; however, breeding is restricted to relatively few sites. About 80 percent of the population occurs on Kauaʻi Oʻahu and Maui. The remaining 20 percent of the population occurs in coastal ponds and playa wetlands, such as Paialoa Pond on Molokaʻi, the Lānaʻi City wastewater treatment ponds, ʻAimakapā and ʻŌpaeʻula ponds on the Kona Coast, and Waiākea and Loko Waka ponds on the island of Hawaiʻi.



ABUNDANCE: Based on state-wide biannual (summer and winter) waterbird counts conducted by the Division of Forestry and Wildlife and partners between 2019-2023, the population is estimated at 1,564 (1,306-1,858) birds with Kauai and Oahu supporting a majority of the species with an estimated 73% of birds. Population trends of the ʻAalae ʻkeokeo over the long-term(38 year period) appear to be stable or increasing except for Hawaii Island, but short term trends (11-year), appear to be decreasing (Gorresen, et al., 2024).

LOCATION AND CONDITION OF KEY HABITAT: The ʻalae keʻokeʻo uses lowland wetland habitats with suitable emergent plant growth interspersed with open water, especially freshwater wetlands and loi kalo (taro fields), but also freshwater reservoirs, sewage treatment ponds, brackish wetlands, and, rarely, saltwater habitats. On Kauaʻi, some birds are reported as having occured in plunge pools above 1,495 meters (4,900 feet) elevation, and on the island of Hawaiʻi, stock ponds up to 2,000 meters (6,600 feet) elevation. They typically forage in water less than 30 centimeters (12 inches) deep but will dive in water up to 120 centimeters (48 inches) deep. Compared to ʻalae ʻula (Hawaiian common gallinule), ʻalae keʻokeʻo forages in more open water. Logs, rafts of vegetation, narrow dikes, mud bars, and artificial islands are important for resting.

Ephemeral wetlands support large numbers during nonbreeding season and may provide a key habitat. Some important habitats are located in National Wildlife Refuges and State sanctuaries and receive management attention, but others remain unprotected, such as wetlands facing development or those used for agriculture or aquaculture. Examples include playa lakes on Niʻihau; Opaekaʻa marsh; Lumahaʻi wetlands on Kauaʻi; Amorient prawn farms; Lāʻie wetlands; Uko, Punahoʻolapa, and Waiheʻe marshes; Waialua lotus fields; Waipiʻo Peninsula ponds on Oʻahu; Paialoa and ʻŌʻōʻia playa fishponds on Molokaʻi; and Opaeʻula and Waiākea- Loko Waka ponds on the island of Hawaiʻi.

THREATS: Similar to the rest of Hawaiian native waterbirds, ʻalae keʻokeʻo are threatened by:

- Habitat loss: In the last 110 years, around 44% of coastal wetlands have been lost in Hawaiʻi (Burney et al., 2001; van Rees and Reed, 2014). The remainder are seriously

affected by non-native species, urban and tourist development, hydrological changes, sedimentation and sea level rise (US Fish and Wildlife Service (USFWS), 2011a; Jacobi and Stock, 2017). A shift from wetland agriculture to other types of crops has also reduced the amount of wetland habitats.

- Introduced and native predators: Dogs (*Canis familiaris*), rats (*Rattus spp*.), feral cats *(Felis silvestris*), the small Indian mongoose (*Herpestes auropunctatus*), cattle egrets (*Bulbulcus ibis*), barn owls (*Tyto alba*), and bullfrogs (*Rana catesb*eiana) all potentially prey on adults or young.
- Altered hydrology: Altering wetland habitats for flood control, agriculture or to serve as municipal water sources makes them generally unsuitable for koloa maoli. Climate change impacts are also expected to impact hydrology of wetlands.
- Nonnative invasive plants: Several species of invasive plants, including pickleweed (*Batis maritima*), water hyacinth (*Eichornia crassipes*), and mangrove (*Rhizophora mangle*) reduce open water, mudflats, or shallows.
- Avian diseases: Botulism outbreaks result in mortality. West Nile virus and avian flu may pose a risk to Hawaiian waterbirds if these diseases reach Hawai‘i.
- Environmental contaminants: Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.
- Climate change: Sea level rise due to climate change may result in a loss of coastal wetland habitats used by Hawaiian waterbirds.
- Anthropogenic impacts: Powerline strikes, vehicle strikes and other man-made infrastructure can cause mortality.

CONSERVATION ACTIONS: The State of Hawai‘i, the U.S. Fish and Wildlife Service (USFWS), and private organizations and landowners have protected 82 percent of the core wetlands for Hawaiian waterbirds and 17 percent of their supporting wetlands. Actions specific to conservation of ‘alae ke‘oke‘o and other Hawaiian waterbirds should include the following:

- Continue to manage, restore, and protect core and supporting wetland habitats.
- Eliminate or reduce populations of introduced predators.

MONITORING: Continue annual waterbird surveys and habitat monitoring on all islands to detect changes in population trends. Improve reporting of botulism outbreaks.

RESEARCH PRIORITIES:

- Analyze annual survey data for correlations, including use of specific wetlands, time of year, and state of wetlands, in order to improve management for ‘alae ke‘oke‘o.
- Conduct a population viability analysis to identify population numbers and time spans that can serve as predictors for the long-term recovery of the ‘alae ke‘oke‘o.
- Use climate change models to predict sea-level rise, and assess key wetlands to protect/create in light of the analysis.Develop removal methods for invasive amphibians, reptiles, and invertebrates that prey on chicks.
- Better monitoring for nest success and fledgling success. Understand fledgling survivorship and movements.

References

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).Pratt DH,

Brisbin IL. 2002. Hawaiian coot (Fulica alai). In The Birds of North America, No. 697 (Poole A, Gill F, editors). Philadelphia, (PA):
The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.U.S. Fish and Wildlife Service. 2010. Hawaiian coot or ʻalae keʻokeʻo (Fulica alai) 5-year review: summary and evaluation.

U.S. Fish and Wildlife Service, Honolulu, Hawaiʻi.U.S. Fish and Wildlife Service. 2011. Recovery plan for Hawaiian waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

Photo: Jack Jeffery

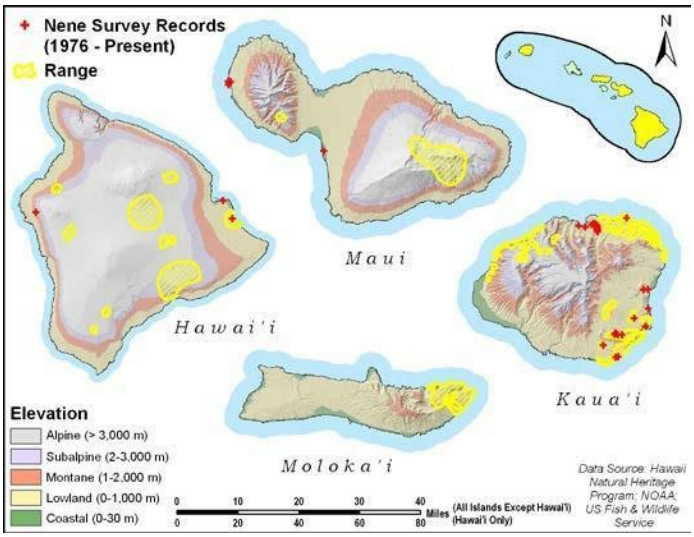
Waterbirds

Nēnē
or Hawaiian goose

Branta sandvicensis

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1 - Critically Imperiled
IUCN Red List Ranking - Vulnerable
Revised Recovery Plan for the Nēnē or Hawaiian Goose (Branta sandvicensis) – USFWS 2004

SPECIES INFORMATION: Historically, at least five species of geese (family: Anatidae) occurred in Hawai‘i; today, only the nēnē, or Hawaiian goose, survives. Adults are mostly dark brown or sepia with a black face and crown, cream-colored cheeks, and a buff neck with black streaks. Females are smaller than males. Compared to other geese, nēnē are more terrestrial and have longer legs and less webbing between their toes, which likely facilitates walking on lava flows. Nēnē graze and browse on the leaves, seeds, flowers, and fruits of at least 50 native and nonnative grasses, sedges, composites, and shrubs. Diet varies by location and habitat, and they may require a diverse suite of food plants. Currently, several species of nonnative grass are important in mid- and high-elevation habitats. Nēnē facilitate seed dispersal and play an important role in influencing the species composition of early successional plant communities. Historically, flocks moved between high-elevation feeding habitats and lowland nesting areas. Pairs mate for life and engage in relatively simple courtship displays in which the male attacks or threatens potential competitors, runs back to his mate, and calls loudly. Nēnē have an extended breeding season, and nesting may occur in all months except May, June, and July, although the majority of birds nest between October and March, and most clutches are laid between October and December. Nests consist of a shallow scrape lined with plant material and down. Breeding pairs usually return to the previous year’s nest site, typically in dense vegetation; when available, kīpuka may be preferred. Females lay two to five eggs, which hatch after 30 days. Young are precocial and not fed by their parents; however, they remain with their parents for up to a year.



DISTRIBUTION: Between sea level and 2,400 meters (7,800 feet) elevation on the island of Hawai‘i, Maui, Kaua‘i, and Moloka‘i, and a Kaua‘i translocated pair was reported and nested on O‘ahu in 2014. The only remaining member of the Oahu pair was a fledgling that was translocated to Hawai‘i Island therefore O‘ahu no longer has any nene on the island. Historically, the species was found on all Main Hawaiian Islands and was likely widespread.
ABUNDANCE: In 1951, the wild nēnē population was estimated at 30 individuals and information on historical abundance is limited. The 2023 population is estimated at about 3,797 birds, with 1,048 on the island of Hawai‘i, 429 on Maui, 2,314 on Kaua‘i and 6 on Moloka‘i. During 2005-2010, about 224 nēnē were removed from near the Kaua‘i Airport and released at remote relocation sites on that island to reduce the risk of bird-aircraft strikes. Between 2011 and 2016, the continued growth of the Kaua‘i nēnē population prompted the removal of an additional 655 nēnē from the vicinity of the Kaua‘i Airport and which were released into the wild on Hawai‘i and Maui.

LOCATION AND CONDITION OF KEY HABITAT: Nēnē historically occurred in lowland dry forest, shrubland, grassland, and montane dry forest, and shrubland. Current habitat preferences are likely biased by the location of release sites of captive-bred birds. They currently use a wide variety of habitats including coastal dune vegetation and nonnative grasslands (e.g., golf courses, pastures, rural areas), sparsely vegetated low- and high-elevation lava flows, mid-elevation native and nonnative shrubland, early successional cinderfall, cinder deserts, native alpine grasslands and shrublands, and open native and nonnative alpine shrubland-woodland community interfaces. Nesting occurs in a variety of habitats, including beach strand, shrubland, grassland, and lava rock, and at a range of elevations. On the islands of Hawai‘i and Maui, most nests are built under native vegetation, such as pūkiawe (Styphelia tameiameiae), ‘a‘ali‘i (*Dondonaea viscose*), and ‘ōhi‘a (*Metrosideros polymorpha*). On Kaua‘i, however, most nesting areas are dominated by nonnative species, and nēnē often nest under Christmas berry (*Schinus terebinthifolius*), shrub verbena (*Lantana camara*), and ironwood (Casuarina spp.). The condition of habitats occupied by nēnē varies considerably. Many of the areas managed for conservation by the State of Hawai‘i and the U.S. Fish and Wildlife Service (USFWS) are also used extensively by the species.

THREATS: Historical threats included habitat loss and degradation, hunting, and predation by rats (*Rattus spp.*), cats (*Felis silvestris*), dogs (*Canis familiaris*), and the small Indian mongoose (*Herpestes auropunctatus*). Current threats include predation by nonnative mammals; exposure to diseases that can be transmitted by introduced nonnative animals such as feral and domestic cats (e.g. toxoplasmosis); nutritional deficiencies due to paucity of quality habitat, exposure stress at high-elevation habitats; a lack of contiguous lowland habitat; human-caused disturbance and mortality (e.g., road mortality, disturbance by hikers, aircraft strikes, collisions with wind

turbines and powerlines); behavioral problems related to captive propagation; and inbreeding depression.

CONSERVATION ACTIONS: Past and current actions include captive propagation and release of captive-bred individuals into the wild, predator control, habitat enhancement, research and monitoring, private conservation efforts, formation of the Nēnē Recovery Action Group, and public education. Other actions specific to conservation of nēnē should include the following:

- Enhance and protect habitats used by nēnē, including foraging habitat, breeding grounds, and summer flocking areas.
- Increase predator control effort and effectiveness, including use of predator-proof fences. Increase efforts to detect and remove mongooses from Kauaʻi.
- Significantly increase efforts to minimize negative human-nēnē interactions through public education and outreach focused on communities or areas where the number of nēnē are known to be increasing; continue to promote avoidance and minimization measures that will reduce the risk of collisions with vehicles , aircraft, powerlines and wind turbines. Identification of key areas which could host nene and attract them away from hazards, followed by restoration, fencing etc of those sites could greatly reduce these impacts.
- Develop a statewide long-range management plan for nēnē that includes all of the distinct populations and anticipates changes resulting from climate change, management actions and human interaction.
- Continue the nēnē population reintroduction efforts and establish additional populations only where risks can be minimized and habitat quality can support recovery.
- Increase outreach about the negative impacts to feeding nene and any wildlife including cats.

MONITORING: Continue surveys to monitor abundance and distribution and annual productivity.

RESEARCH PRIORITIES:

- Standardize survey and monitoring protocols and develop a platform for data sharing.
- Conduct studies on diet and nutrition, particularly as it relates to forage quality of nonnative versus native vegetation, focusing on the needs of goslings and breeding females.
- Refine predator control and exclusion methods.
- Evaluate movement patterns and habitat use by nēnē.
- Evaluate and refine translocation and release methods that incorporates monitoring subsequent dispersal and movement patterns, survival, and reproduction.
- Investigate population genetics as a management tool to monitor the potential for inbreeding.
- Understand and evaluate mortality hotspots for vehicle strike mortality areas and powerline strike areas.

References

Banko PC, Black JM, Banko WE. 1999. Hawaiian goose (Branta sandvicensis). In The Birds of North America, No. 434 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

State of Hawai‘i, Department of Land and Natural Resources, Division of Forestry and Wildlife. 2014.

Kaua‘i Nēnē Relocation Project: December 2014 Project Update.U.S. Fish and Wildlife Service. 2004. Draft revised recovery plan for the Nene or Hawaiian Goose (Branta sandvicensis). U.S. Fish and Wildlife Service, Portland, OR. 148 + xi pp.

U.S. Fish and Wildlife Service. 2011. Nene or Hawaiian goose (Branta sandvicensis) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

VanderWerf, EA. 2012. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, HI.

Work, T., J. Dagenais, R. Rameyer, and R. Breeden. 2015. Mortality patters in endangered Hawaiian Geese (Nēnē, Branta sandvicensis). Journal of Wildlife Diseases. Vol. 51, Issue 3, pg(s) 688-695 doi: 10.7589/2014-11-256

Photo: Brett Mossman

Waterbirds

Aeʻo or Hawaiian stilt

Himantopus mexicanus knudseni

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered State
Recognized as Indigenous
NatureServe Heritage Rank G5 – Secure
Recovery Plan for Hawaiian Waterbirds - USFWS 201

SPECIES INFORMATION: The aeʻo or Hawaiian stilt is a slender, graceful waterbird (Family: Recurvirostridae) that is considered distinct from the North American subspecies, *H. m. mexicanus*. Adults are mostly black above and white below with a long, thin black bill and long, delicate pink legs. Foraging habitat consists of ephemeral freshwater, agriculture, brackish water, or saltwater habitats. They are opportunistic and prey on a variety of animals that inhabit shallow water or mudflats, including polychaete worms, small crabs, insects, and small fish. Aeʻo frequently move among wetland habitats in search of food. Breeding and foraging habitats differ, and individuals move between the two daily. Nesting occurs on freshly exposed mudflats with some low-growing vegetation; individuals also will nest on islands in freshwater and brackish water ponds or artificial floating nest structures. They aggressively defend their nests, calling and diving at intruders and performing broken-wing displays to attract potential predators away from their nests. Nesting occurs between March and August and peaks in May and June. Generally, three to four eggs are laid, and the precocial chicks hatch approximately 24 days later, leaving the nest once the last egg hatches. More eggs are laid and hatched when predator pressures decline. Both parents incubate eggs and brood young, and fledglings remain with their parents for several months. Some cooperative breeding activities may occur, including "helper-at-the-nest", extra-pair egg laying, and multi-parental care of multi-familial groups of chicks.

DISTRIBUTION: The aeʻo generally is found in wetland habitats below 200 meters (660 feet) elevation on all the Main Hawaiian Islands except for Kahoʻolawe.
On Oʻahu, most of the population can be found on the north and windward coast at Kahuku Point on the James Campbell National Wildlife Refuge, in Kahuku Point oyster ponds, in Amorient aquaculture ponds, and in Roland and Nuʻupia ponds in Kāneʻohe and Kailua wetlands. Smaller numbers use wetland habitats associated with Pearl Harbor and the leeward coast. On Kauaʻi, the aeʻo is found in large river valleys, including Hanalei, Wailua, and Lumahaʻi valleys; on the Mānā Plains; and at reservoirs and effluent ponds in Līhue and Waimea. Populations move annually between Kauaʻi and Niʻihau in response to water level changes in Niʻihau's ephemeral lakes. On Maui, most aeʻo use the coastal wetlands of Kanahā and Keālia; smaller numbers use reservoirs and aquaculture habitats. On Molokaʻi, the southern coastal wetlands and playa lakes are important habitats. On Lānaʻi, a few aeʻo are permanent residents at the Lānaʻi City wastewater treatment ponds. On the island of Hawaiʻi, the largest number of aeʻo are found on the Kona coast, especially in anchialine ponds, from Kawaihae Harbor south to

Kailua. Other habitats include Makalawena and Aimakapā ponds; Cyanotech Ponds; the Kona wastewater treatment ponds; wetlands along the Hāmākua Coast; and the Kohala River valleys of Waipiʻo, Waimanu, and Pololū. Historically, aeʻo occurred on Niʻihau, Kauaʻi, Oʻahu, Maui, and Molokaʻi; there are no documented records of the species on the island of Hawaiʻi prior to 1961. Interisland movements by aeʻo are suspected.

ABUNDANCE: Based on state-wide biannual (summer and winter) waterbird counts conducted by the Division of Forestry and Wildlife and partners between 2019-2023, the population is estimated at 1,511 (1,317-1,718) birds with Maui, Kauai and Oahu supporting a majority of the species with over 80% of the birds. Population trends of the ʻAe ʻo over the long-term (38-year period) appear to be increasing, but short-term trends (11-year), appear to be decreasing except for the island of Maui (Gorresen, et al., 2024).

LOCATION AND CONDITION OF KEY HABITAT: Aeʻo use a variety of wetland habitats but have specific habitat requirements. Water depth and vegetation density are important determinants of foraging habitat suitability, and the species prefers sites with a water depth of less than 24 centimeters (9 inches). Preferred foraging habitats are early successional marshlands with shallow water and perennial low-growing vegetation or exposed tidal flats; other wetland habitats with similar characteristics also are used. Examples include freshwater habitats (ephemeral lakes, reservoirs, settling basins, natural or manmade ponds, brackish water habitats (coastal ponds, fish ponds, loi kalo [taro fields]and estuaries), and saltwater habitats (inshore reefs, silted beach areas, and tidal flats). Ephemeral lakes on Molokaʻi, Maui, and Niʻihau provide important habitats for aeʻo as do prawn farms and anchialine pools. Preferred nesting habitats are low-relief islands in bodies of fresh, brackish, or salt water and sites adjacent to these areas. Examples include reservoirs, settling basins, natural or manmade ponds, marshes, taro patches, silted fish ponds, salt evaporation pans, and other wetlands. Loafing areas are usually open mudflats or open flooded pasturelands where visibility is good and predator populations are low. Some important habitats are located in National Wildlife Refuges or on State lands and receive management attention while others lack intensive invasive predator removal. These mostly include wetlands facing development or those used for agriculture or aquaculture, such as playa lakes on Niʻihau; Opaekaʻa marsh; Lumahaʻi wetlands on Kauaʻi; Amorient prawn farms; Lāʻie wetlands; Uko, Punahoʻolapa, and Waiheʻe marshes; Waialua lotus fields; Waipiʻo Peninsula ponds on Oʻahu; Paialoa and ʻŌʻōʻia playa fish ponds on Molokaʻi; and Opaeʻula and Waiākea-Loko Waka ponds on the island of Hawaiʻi. Newly restored loʻi attract Aeʻo and successful nesting has been documented in these expanding populations, particularly when predator control is implemented.

THREATS: Historically, the species was a popular game bird, and hunting contributed to population declines until its prohibition in 1939. Similar to the rest of the Hawaiian native waterbirds, aeʻo are threatened by:

- Habitat loss. In the last 110 years, approximately 31 percent of coastal plain wetlands have been lost. A shift in wetland agriculture to other agriculture crops also has reduced the amount of wetland habitats.
- Introduced and native predators. Adults and young are vulnerable to predation by dogs (*Canis familiaris*), rats (*Rattus spp*.), feral cats (*Felis silvestris*), the small Indian mongoose (*Herpestes auropunctatus*), cattle egrets *(Bulbulcus ibis*), barn owls (*Tyto*

alba), and bullfrogs (*Rana catesbeiana*). They also are vulnerable to predation by pueo or Hawaiian short- eared owl (*Asio flammeus sandwichensis*) and ʻaukuʻu or black-crowned night herons (*Nycticorax nycticorx hoactli*).

- Altered hydrology. Altering wetland habitats for flood control, agriculture or to serve as municipal water sources could make them unsuitable for ae'o. Climate change impacts are also expected to impact hydrology of wetlands.
- Nonnative invasive plants. Several species of invasive plants, including pickleweed (*Batis maritime*), water hyacinth (*Eichornia crassipes*), and mangrove (*Rhizophora mangle*) reduce open water, mudflats, or shallows.
- Avian diseases. Botulism outbreaks result in mortality. West Nile virus and avian flu may pose a risk to Hawaiian waterbirds if these diseases reach Hawaiʻi.
- Environmental contaminants. Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.
- Climate change. Sea level rise due to climate change may result in a loss of coastal wetland habitats used by Hawaiian waterbirds.
- Anthropogenic impacts: Powerline strikes, vehicle strikes and other man-made infrastructure can cause mortality.

CONSERVATION ACTIONS: The State of Hawaiʻi, the U.S. Fish and Wildlife Service (USFWS), and private organizations and landowners have protected 82 percent of the core wetlands for Hawaiian waterbirds and 17 percent of their supporting wetlands. Other actions specific to conservation of aeʻo and other Hawaiian waterbirds should include the following:

- Continue to manage, restore, and protect core and supporting wetland habitats.
- Eliminate or reduce populations of introduced predators including predator proof fencing.

MONITORING: Continue annual statewide surveys of populations and habitat monitoring to detect changes in population trends.

RESEARCH PRIORITIES:

- Analyze annual survey data for correlations, including use of specific wetlands, time of year, and state of wetlands, in order to improve management for aeʻo.
- Conduct a population viability analysis to identify population numbers and time spans that can serve as predictors for the long-term recovery of the aeʻo.
- Use climate change models that predict sea-level rise, and assess key wetlands to protect/create in light of the analysis.
- Develop removal methods for invasive amphibians, reptiles, and invertebrates that prey on chicks.
- Better monitoring for nest success and fledgling success. Understand fledgling survivorship and movements.

References

Robinson JA, Reed JM, Skorupa JP, Oring LW. 1999. Black-necked stilt (Himantopus mexicanus). In The Birds of North America, No. 449 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2010. Hawaiian stilt or Aeʻo (Himantopus mexicanus knudseni) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2011. Recovery plan for Hawaiian waterbirds, Second Revision. Portland, OR.

Photo: Richard Palmer

Waterbirds
ʻAukuʻu or Black-crowned Night Heron

Nycticorax nycticorax hoactli

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The ʻaukuʻu or black-crowned night heron (Family: Ardeidae) is a stocky cosmopolitan species that breeds on every continent except for Australia and Antarctica. Four subspecies are recognized and *N. n. hoactli* occurs in Hawaiʻi, as well as across North America and most of South America. Adult males and females have a black crown and upper back, with a white throat, cheeks, and a narrow band above the bill that extends over the eyes, gray wings, and whitish underparts; males are larger than females. Juveniles are overall brown with light spots. The species' stout bill is black; legs and feet are yellow, and the eyes are red. ʻAukuʻu (black-crowned night heron) are gregarious and unlike continental birds, those in Hawaiʻi can be diurnal. The species uses a variety of shallow wetlands for foraging and employs various techniques to capture a diversity of prey including insects, fish, frogs, mice, and the young of other native waterbirds. Information on breeding in Hawaiʻi is limited, but the species is a colonial nester, and in North America breeding occurs from December to August. Eggs are laid in a bulky stick nest usually placed low in vegetation or in trees.

DISTRIBUTION: ʻAukuʻu (black-crowned night heron) is widely distributed throughout the main Hawaiian Islands.

ABUNDANCE: Island-wide population numbers, based on semi-annual waterbird counts conducted by DOFAW and partners, indicate that the population is variable, but appears stable. Between 2013 and 2023 the average number of ʻaukuʻu (black-crowned night heron) counted has been just over 550 individuals. This number is certainly an under-estimate as all stream habitats are not surveyed.

LOCATION AND CONDITION OF KEY HABITAT: ʻAukuʻu (black-crowned night heron) occur in a wide-range of aquatic habitats including mountain streams, lowland ponds, agriculture and estuaries (wetlands and open water), aquaculture farms, and suburban/urban waterways (e.g., golf course ponds, concrete channels).

THREATS: Similar to the rest of Hawaiian native waterbirds, ʻaukuʻu (black-crowned night heron) are threatened by:

- Habitat loss: In the last 110 years, approximately 31 percent of coastal plain wetlands have been lost. A shift in wetland agriculture to other agriculture crops also has reduced

the amount of wetland habitats.

- Introduced predators: Dogs (Canis domisticus), rats (Rattus spp.), feral cats (Felis silvestris), the small Indian mongoose (Herpestes auropunctatus), cattle egrets (Bulbulcus ibis), and barn owls (Tyto alba) all potentially prey on adult or young ‘auku’u (black crowned night heron).
- Non-native invasive plants: Several species of invasive plants reduce open water, mudflats, or shallows.
- Avian diseases: The most important disease affecting Hawaiian waterbirds is botulism (*Clostridium botulinum*).
- Environmental contaminants: Fuel and oil spills, dumping and agricultural discharge in wetlands result in toxicity and habitat degradation.Anthropogenic impacts: Powerline strikes and other man-made infrastructure can cause mortality.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. The State of Hawai‘i and the USFWS have protected 23 percent of the State’s remaining coastal plain wetlands. Currently there are no conservation actions specifically directed at ‘auku‘u (black-crowned night heron); however, the species certainly benefits from actions taken for the protection of Hawaii’s endangered waterbirds including wetland protection and predator control efforts. In addition to common statewide and island conservation actions, specific actions directed at ‘auku‘u (black-crowned night heron) should include:

- Continue protection and management of wildlife sanctuaries and refuges.Better monitoring for abundance and distribution estimates.

MONITORING: Continue waterbird surveys and habitat monitoring on all islands. This information is needed to identify significant population declines.

RESEARCH PRIORITIES:

- Conduct studies to determine the effects on endangered waterbird populations by ‘auku‘u (black-crowned night heron) predation on the young of these species.
- Conduct life history studies to quantify the population structure, dispersal patterns, survivorship, nesting phenology and success of this poorly known species.

References:

Berger AJ. 1981. Hawaiian birdlife. Honolulu: University of Hawai‘i Press. 260 pp.Davis WE. 1993. Black-crowned night-heron (Nycticorax nycticorax). In The Birds of North America, No. 74 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington, D.C.: The American Ornithologists’ Union.

Pratt DH, Bruner PL, Berrett DG. 1987. Field guide to the birds of Hawai‘i and the tropical Pacific. Princeton, (NJ): Princeton University Press.

Harmon, Kristen C., Pawl A. Awo, and Melissa R. Price. "Foraging behavior of the Black-crowned Night-Heron (‘Auku ‘u; Nycticorax nycticorax hoactli) in wetlands on O ‘ahu, Hawai ‘i." The Wilson Journal of

Ornithology 134.3 (2022): 526-531.

Waterbirds

Koloa Pohaka
Laysan duck
Anas laysanensis

SPECIES STATUS:
Federally Listed as Endangered State Listed as Endangered State Recognized as Endemic
NatureServe Heritage Rank G1 - Critically Imperiled IUCN Red List Ranking - Critically Endangered
Revised Recovery Plan for the Laysan Duck (*Anas laysanensis*) - USFWS 2009

SPECIES INFORMATION: The Koloa Pohaka (Laysan duck) is a small dabbling duck (Family: Anatidae) endemic to Hawai‘i, and until recently was restricted to Kamole (Laysan Island) (370 hectares, or 911 acres) in the Northwestern Hawaiian Islands (NWHI). Even after recent successful translocation efforts to establish new populations on Kuaihelani (Midway) and Holaniku (Kure Atolls), the species still has one of the smallest geographic ranges of any duck. Adults are dark brown overall with a prominent white eye-ring and varying amounts of white feathers on the head and neck; the sexes are similar.
Unlike many other duck species, Laysan ducks have low fecundity and are nocturnal, very terrestrial, and highly secretive; the species also is relatively long-lived (about 12 years). During the day, ducks take cover under vegetation such as bunchgrass or shrub. On Kamole individuals forage mainly at night around and in a large hypersaline lake, feeding primarily on the larvae and pupae of Dipteran brine flies and adult Dipteran brine flies, the larvae and pupae of a noctuid moth, and brine shrimp. Seeds, leaves, algae, and other invertebrates also are eaten. In the most common method of foraging, the Laysan duck runs through swarms of adult brine flies while moving its head back and forth, snapping up flies. Moth larvae and pupae are taken by “filter feeding” in sand under low vegetation. The species also dabbles along the lake shore. Long-term pair bonds are not formed, and males do not participate in brood-rearing. Nesting occurs between February and November, although most eggs are laid between April and August. Nests are well concealed and typically are placed at the base of dense vegetation, especially bunch grass. Nests are shallow scrapes lined with dead grass and some down. Typically three to five eggs are laid, and they hatch after 28 days. Ducklings are precocial and are not fed by the female. Because the species evolved with avian predators, when surprised, individuals tend to walk away rather than fly and freeze rather than flush.
DISTRIBUTION: The Laysan duck currently occurs only on Laysan Island, Midway Atoll, and Kure Atoll in the NWHI; the population on Midway Atoll was a result of a successful translocation effort that occurred in 2004–2005. This success enabled 28 young adult birds to be relocated from Midway to Kure Atoll in 2014 which has greatly reduced the possibility of extinction. A second introduction of 24 individuals occurred in Feb 2023. Fossil and subfossil evidence indicates that Laysan ducks were widespread in the NWHI and Main Hawaiian Islands (MHI) prior to the arrival of Polynesians and occurred on the islands of Hawai‘i,

Moloka‘i, O‘ahu, Maui, and Kaua‘i. Laysan ducks were extant on Lisianski as late as 1844. **ABUNDANCE:** On Laysan island, the Laysan duck population is somewhat variable, but generally does not exceed 500 individuals; surveys in 2012 estimated the population at 339 individuals. On Midway Atoll, the population was estimated at 231–330 individuals in 2012 and the population at Kure Atoll in 2024 was 90 and is generally estimated to be between 70-80 birds.

LOCATION AND CONDITION OF KEY HABITAT: Two habitats are critical to the survival of Laysan duck: vegetated uplands and wetlands. Uplands supporting vegetation such as beach naupaka and bunch grass provide ducks with shelter and nesting habitat, and hypersaline lakes provide important foraging habitat. The importance of upland vegetation was demonstrated by the severe decline of ducks at the turn of the last century, when rabbits denuded Laysan, and by the species' subsequent recovery after the rabbit population was eradicated in the 1920s and the vegetation recovered. Similarly, the number of ducks varies considerably depending on lake water levels; in 1987, there was a total breeding failure due to a drought and a lack of brine flies.

THREATS: Historical threats included the introduction of rabbits, which subsequently denuded the island's vegetation (see above), sport hunting, and guano mining. The species' limited population size and geographic range exacerbates the risk of extinction from demographic and environmental stochasticity and catastrophes. These threats include:

- Nonnative species: Introduced plants have displaced native vegetation and degraded nesting habitat, and nonnative invertebrates may be altering habitat and affecting native species. The control of big-headed ants at Hoalniku beginning in 2014, significantly increased invertebrate and native plant populations. Potential future reintroductions of the Laysan duck to the MHI are complicated by the presence of nonnative predators, such as cats, dogs, pigs, mongooses, ants and rats.
- Habitat degradation: Devegetation caused by introduced rabbits has resulted in filling of Laysan's interior lake and freshwater seeps, which are an important habitat and food source for the duck.
- Disease: Avian botulism has occurred annually on Midway Atoll since 2008, resulting in high mortality and population declines. The bacterium *Erysipelothrix rhusiopathiae* poses a threat to species as two deadly outbreaks occurred at Holaniku in 2023 and 2024. Other diseases such as avian flu could also pose a threat to the species.
- Contaminants: Oil spills, pesticides, and other types of contaminants washing ashore are potentially a serious risk to the species. Migration of PCBs reburied at Holaniku could enter fresh water seeps.
- Climate change: Sea level rise due to climate change may result in loss or degradation of nesting habitat, food availability and increased frequency and severity of storms could reduce survival and nesting success.
- Catastrophes: The Laysan duck is vulnerable to environmental catastrophes, such as severe droughts, increased temperatures, major storms, and tsunamis. For example, on Midway Atoll, some of the freshwater wetlands created for the ducks were damaged and inundated with saltwater, Japanese green beetle larvae and dead fish by the Fukushima Japan tsunami in 2011.

CONSERVATION ACTIONS: Rabbits were eradicated from Laysan in the 1920s. In 1967, the U.S. Fish and Wildlife Service (USFWS) translocated 12 ducks to Pearl and Hermes Reef; however, this attempt was unsuccessful. USFWS has successfully controlled the nonnative grass*, Cenchrus echinatus*. Twenty ducks were translocated to Midway Atoll in 2004 and 22 in 2005, establishing a second population. Other actions specific to the conservation of Laysan ducks should include the following:

- Restore habitat with native plants, and continue to maintain existing habitat (e.g., by controlling harmful weeds and stabilizing dunes and planting vegetation to prevent sand from filling the lake at Kamole and eroding dune structures at Holaniku).
- Restore native invertebrates to increase food availability, and control and monitor nonnative invertebrates.
- Prevent the establishment of additional nonnative plants and animals.
- Continue efforts to translocate Laysan ducks, and establish additional populations in the MHI and NWHI. Continue to translocate 3-5 ducks every 10 years from Kamole to Holaniku to improve Microsatellite variation and rare alleles to prevent bottlenecking.
- Conduct disease screening and prevention to prevent botulism outbreaks and the introduction of new diseases on the NWHI.
- Prepare and implement emergency contingency plans to address the potential threat of catastrophes, such as hurricanes and tsunamis.
- Redesign guzzlers and seeps to prevent Botulism outbreaks caused by invertebrates infesting these fresh water sources.
- Keep supplies of Botulism antitoxin on hand and train field crews to respond to disease outbreaks.
- Develop a Botulism vaccine
- Continue to remediate the runway hard substrate at Holaniku to increase native plants diversity and abundance that provide food (seeds and invertebrates), nesting habitat and protection from frigatebird predation on ducklings.

MONITORING:

- Monitor population status and reproduction on Laysan to determine trends, identify limiting factors that can be addressed through management, and monitor numbers and condition of juvenile ducks in years when translocations are planned.
- Monitor survival and reproduction in the Midway Atoll and Holaniku populations (and any other populations initiated through translocation), and compare that population with the Laysan population to identify limiting factors that can be addressed through management.

RESEARCH PRIORITIES:

- Study the survival, reproduction, and other aspects of Laysan duck ecology on Midway Atoll (and any other translocation sites), compare the data with data from Laysan, and assess management requirements.
- Develop new tools to prevent botulism-related mortality on Laysan, Midway Atoll, Holaniku and any future reintroduction sites.

References

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).Moulton DW, Marshall AP. 1996. Laysan duck (Anas laysanensis). In The Birds of North America, No. 242 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.Reynolds MH. 2002. Habitat use and home range of the Laysan Teal on Laysan Island, Hawai'i.

Waterbirds 27:183-192U.S. Fish and Wildlife Service. 2009. Revised recovery plan for the Laysan Duck (Anas laysanensis). U.S. Fish and Wildlife Service, Portland, OR.U.S. Fish and Wildlife Service. 2012. Laysan duck (Anas laysanensis) 5-year review: short form summary.

U.S. Fish and Wildlife Service, Honolulu, HI.

Cooper, A., J. Rhymer, H. F. James, S. L. Olson, C. E. McIntosh, M. D. Sorenson, and R. C. Fleischer. 1996. Ancient DNA and island endemics. Nature 381:484

Department of Land and Natural Resources. 2020. Kure Atoll Monthly Field Report. May 2020.

Ely, C. A., and R. B. Clapp. 1973. The natural history of Laysan Island, Northwestern Hawaiian Islands. Pages 361 in Atoll Res. Bullet. Smithsonian Institution, Washington, D.C.

Jamieson, I. G. 2010. Founder effects, inbreeding, and loss of genetic diversity in four avian reintroduction programs. Conservation Biology: 25, No. 1, 115–123.

Kure Atoll Translocation Plan for Laysan ducks. 2014. (see Attached Supplementary Material.1)

Lavretsky P., E. Andrew, Peters J. L. 2014. Major histocompatibility I gene diversity in the critically endangered Laysan duck (Anas laysanensis). Pacific Conservation Biology 20, 86-93.

Papahānaumokuākea Marine National Monument Management Plan (PMNM MMP). 2008. Papahānaumokuākea Marine National Monument. Pg. i -595.

Olson SL and Ziegler AC. 1995. Remains of Land Birds from Lisianski Island, with Observations on the Terrestrial Avifauna of the Nortwester Hawaiian Islands. 1995. Pacific Science. Vol 49, no. 2: 111-125.

Reynolds MH, Veksay M, Klavitter J. 2004. Revised Draft Laysan Teal Re-introduction Plan: Part 1 Translocation to Midway Atoll Preparation, Transport, & Release. July 2004. USGS Report for the USFWS.

Reynolds MH, Berkowitz P, Klavitter JL, Courtot KN. 2017. Lessons from the Tōhoku tsunami: A model for island avifauna conservation prioritization. June 2017. Ecology and Evolution. Vol 7. Issue 15.

Reynolds MH, Hatfield JS, Courtot KN, Vanderlip C. In press. Survival of Laysan Teal Anas laysanensis differs among island populations: role of chronic avian botulism.

NCTC (Reynolds MH, McGowan C, Converse SJ, Mattsson B, Hatfield JS, McClung A, Mehrhoff L, Walters JR, and Uyehara K). 2010. Trading off short-term and long-term risk: minimizing the threat of Laysan Duck extinction from catastrophes and sea-level rise. A Case Study from the Structured Decision Making Workshop January 25–29, 2010. National Conservation Training Center, Shepherdstown, WV, USA. http://training.fws.gov/CSP/Resources/Decision_Analysis/SDM.htm

Reynolds, M. H. and J. L. Klavitter. 2006. Translocation of wild Laysan duck Anas laysanensis to establish a population at Midway Atoll National Wildlife Refuge, United States and US Pacific Possession. Conservation Evidence (2006) 3, 6-8.

Reynolds, M. H., N. E. Seavy, M.S. Vekasy, J. L. Klavitter & L. P. Laniawe. 2008. Translocation and early post-release demography of endangered Laysan teal. Animal Conservation 11(2):160-168.

Reynolds M. H., Weiser E, Jamieson I, and Hatfield JS. 2013. Demographic Variation, Reintroduction, and Persistence of an Island Duck (Anas laysanensis). The Journal of Wildlife Management 77(6):1094–1103.

Reynolds, M. H., J. M. Pearce, P. Lavretsky, P. P. Seixas, and K. N. Courtot. 2015. Microsatellite variation and rare alleles in a bottlenecked Hawaiian Islands endemic: implications for reintroductions. Endangered Species

Research 28:117–122

U.S. Geological Survey (USGS). 2004. Translocation of Endangered Laysan Ducks to Midway Atoll National Wildlife Refuge (2004-5). Fact Sheet U.S. Geological Survey Fact Sheet FS-2005-3128. July 2005.

VanderWerf, E.A. 2013. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, HI and U.S. Fish and Wildlife Service, Portland, OR.

Weiser, E., C. Grueber, and I. Jamieson. 2013. Simulating Retention of Rare Alleles in Small Populations to Assess Management Options for Species with Different Life Histories. Conservation Biology 27(2) 335-344.

Work, T.M., C.U. Meteyer, and R.A. Cole. 2004. Mortality in Laysan Ducks (Anas laysanensis) by Emaciation Complicated by Echinuria uncinata on Laysan Island, Hawaii, 1993. Journal of Wildlife Diseases: January 2004, 40 (1), 110-114.

Work, T. W., J. L. Klavitter, M. H. Reynolds, and D. Blehert. 2010. Avian Botulism: A Case Study in Translocated Endangered Laysan Ducks (Anas laysanensis) on Midway Atoll. Journal of Wildlife Diseases, 46(2), 499–506.

Photo: David Leonard, USFWS

Seabirds

Mōlī or Laysan albatross

Phoebastria immutabilis

SPECIES STATUS:
State Recognized as Indigenous, NatureServe Heritage Rank G3 – Vulnerable, IUCN Red List Ranking – Near Threatened, Regional Seabird Conservation Plan – USFWS 2005, Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The mōlī or Laysan albatross is a large, abundant seabird (Family: Diomedeidae) whose breeding range is centered in Hawai‘i. Adults are mostly white except for black wings and tail; upperwings entirely dark, underwings mostly white with variable amounts of black especially along leading and trailing edges. Bill is pink with gray, hooked tip; legs and feet are light pink. Like all albatrosses, mōlī are accomplished fliers using dynamic soaring to cover great distances. They mainly feed at night and often far from breeding colony (e.g., 1,770 kilometers [1,100 miles]). Mōlī often feed with conspecifics, but rarely with other species, and similar to other albatross, seizes prey from the surface while sitting on the water. Scavenges from carrion and follows fishing boats, but not as frequently as ka‘upu or black- footed albatross (*P. nigripes*). In Hawai‘i, diet consists primarily of squid, as well as deep-water crustaceans, fish and flyingfish eggs. Like most seabirds, mōlī nest in colonies, have long-term pair bonds and high site fidelity, lay only one egg per season, and both parents participate in all aspects of raising young. Pairs engage in long, noisy, ritualized courtship dances. They typically select nest site closer to vegetation than ka‘upu, and nest varies from a scrape to a ring-like structure comprising sand, vegetation, and debris. In Hawai‘i, eggs are laid between November and December and chicks fledge in July, and no post-fledgling care is provided by parents. Young birds do not return to land until their third year after fledging. These birds do not breed, but dance, build nests, and prospect for mates. Birds first breed between five and eight years of age, and the oldest known individual was at least 71 years old.

DISTRIBUTION: Nests throughout the Northwestern Hawaiian Islands (NWHI) and on the Main Hawaiian Islands (MHI) of Kaua‘i and O‘ahu and Lehua Island off Ni‘ihau. Outside of Hawai‘i, they nest on islands off Japan and Mexico. At sea, mōlī occur widely throughout the north Pacific Ocean.

ABUNDANCE: The worldwide population is estimated at 590,000 breeding pairs, and more than 99 percent of them nest in the NWHI; most are on Midway Atoll (441,000 pairs) and Laysan Island (145,000 pairs). Small numbers nest in the MHI (500 pairs), on islands near Japan (20 pairs), and off western Mexico (400 pairs).

LOCATION AND CONDITION OF KEY HABITAT: Most nesting occurs in flat open areas on

low-lying coral and sand islands, but they also nest in steep rocky areas on high volcanic island such as Nihoa and Lehua. A majority of the world's mōlī nest within the North WestHawaiian Islands and Midway Atoll National Wildlife Refuge (NWR). Two of the largest breeding colonies on the MHI occur in the Kīlauea Point NWR on Kauaʻi and the Kaʻena Point Natural Area Reserve on Oʻahu. Predators are controlled at both these sites. Nesting attempts are discouraged (e.g., eggs are removed) at several military bases in the MHI to reduce collisions with aircraft.At-sea, they occur over the open ocean.

THREATS:

- Human disturbance and conflict: Historically, hunters decimated populations for the millinery trade. Populations extirpated from Johnston, Wake, and Marcus islands by Japanese feather hunters at the turn of the last century are only recently being re-colonized. Occupation of Pacific islands by military during World War II also took a heavy toll on this species. For example, during the 1950s and 1960s tens of thousands were killed at Midway to reduce collisions with aircraft. In 1909, 300,000 birds were killed on Laysan Island. Currently, human disturbance to breeding colonies on Oʻahu and Kauaʻi are a threat, and eggs are removed each year at the U.S. Navy Pacific Missile Range Facility to reduce the risk of aircraft collisions.
- Fisheries bycatch: One of the most serious threats to albatross, thousands were killed annually as bycatch in drift net fisheries prior to their ban in 1993. U.S. longline fisheries once killed thousands annually, but this form of bycatch has been greatly reduced in the last 10-20 years. However, bycatch from Japanese and Taiwanese fleets that operate in the north Pacific Ocean remains a significant threat to the albatross.
- Introduced predators: Like all seabirds, adults and nests on the MHI are susceptible to predation by introduced mammals including pigs (*Sus scrofa*), rats (*Rattus* spp.), dogs (*Canis familiarus*), feral cats (*Felis silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*). At certain times mice have been documented predating incubating mōlī on Midway Atoll.
- Invasive species: Non-native plants, specifically golden crown-beard (*Verbesina encelioides*), degrades nesting habitat and may limit nesting density, reduce productivity, and provide habitat for mosquitoes that carry avian pox. Introduced big-headed ants (*Pheidole megacephala*) at Holaniku (Kure) may facilitate the destruction of native vegetation by a non-native scale insect.
- Contaminants: At Midway Island, lead contaminated paint chips and soil is ingested by chicks, which causes lead poisoning and mortality. Organochlorine and mercury contamination, and oil spills are also potential threats to this wide-ranging species.
- Marine pollution: Adults ingest plastic debris, then feed it to their chicks, resulting in harm or mortality of chicks.
- Collisions: At Midway, albatrosses collide with buildings, lights, antenna wires, and other human-made structures. In 1964 alone, 3,000 albatrosses were killed by colliding with communication antennas on Midway.
- Climate change: Nesting colonies on low-lying atolls are vulnerable to sea level rise, and increased storms and wave events associated with climate change.
- Disease: Diseases like avian influenza may impact albatross and other seabird species. Avian pox is also recorded in mōlī and has the potential to influence adult and chick

survival.

CONSERVATION ACTIONS: Actions specific to mōlī should include the following:

- Continue predator control and eradication at MHI colonies.
- Continue non-native vegetation control at Midway, Pearl and Hermes, and Kure Atoll.
- Continue lead remediation on contaminated soil and structures on Midway Island.
- Continue protection and management of wildlife sanctuaries and refuges.
- Continue egg swap project on Kaua‘i, in which eggs removed from the U.S. Navy Pacific Missile Range Facility are placed with foster parents (whose eggs are not viable) at other suitable locations. Continue efforts to reduce fisheries bycatch throughout the north Pacific Ocean.
- Conduct public education awareness programs about the hazards of plastics and other types of marine pollution, and their effects on seabirds and the ocean.
- Develop social attraction and potential translocation colonies on the higher MHI.
- Conduct outreach campaigns to increase the awareness of the general public on protecting the nesting albatrosses in residential areas from predation by cats, dogs, and other introduced species.

MONITORING: Continue annual censuses of breeding colonies and design and implement a population monitoring program that will allow the estimation of age-specific survival rates.

RESEARCH PRIORITIES:

- Continue monitoring all Hawaiian breeding colonies to collect demographic data, inform management decisions, and measure efficacy of conservation actions.
- Estimate annual mortality from albatross bycatch in U.S. and foreign fisheries and use demographic models to determine the effect of this mortality on population. Continue research and development of techniques and gear to minimize bycatch.
- Explore ways to reduce impacts of climate change and soil erosion on low-lying breeding colonies in the NWHI.
- Evaluate plastic loads in albatross chicks on Midway Island and other nesting locations. Understand the impacts of diseases such as avian pox and flu on the species

References:

Hawai’i Natural Heritage Program [Hawai‘i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai’i, Center for Conservation Research and Training. Honolulu, Hawai‘i.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015). NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland Oregon.

VanderWerf, EA. 2012. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, Hawai‘i.

Whittow GC. 1993. Laysan albatross (*Diomedea immutabilis*). *In* The Birds of North America, No. 66 (Poole A,

Gill F, editors.). Philadelphia: The Academy of Natural Sciences; Washington DC: The American Ornithologists' Union.

Seabirds

Ka‘upu or Black-footed albatross

Phoebastria nigripes

SPECIES STATUS:
State Recognized as Indigenous, NatureServe Heritage Rank G5 – Apparently Secure, IUCN Red List Ranking – Near Threatened, Regional Seabird Conservation Plan – USFWS 200 Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The ka‘upu or black-footed albatross is the smallest albatross (Family: Diomedeidae) in Hawai‘i. Adults are entirely black except for a narrow whitish area at the base of the bill and another under the eyes; 10 percent of the individuals also have a white rump and undertail coverts. Like all albatross, ka‘upu use dynamic soaring to cover great distances. They feed from the surface by seizing prey while sitting on the water, and will “tip-up” like ducks, using their well-developed olfactory sense to locate food. Ka‘upu form long-term pair bonds and exhibit high nest site fidelity, and do not breed every year. Nesting occurs in large colonies, and nests are placed in scooped out hollows on open, sandy beaches or dunes. Pairs engage in noisy, ritualized courtship dances. A single egg is laid in November and chicks fledge in June and July. Both male and female incubate egg, and brood and feed young. Young birds do not return to land until their third year after fledging. These birds do not breed, but dance, build nests, and prospect for mates. Age at first breeding is at least five years old. The oldest-known black-footed albatross was at least 43 years old.

DISTRIBUTION: Nests on all the Northwestern Hawaiian Islands (NWHI), and on Lehua Island off Ni‘ihau in the Main Hawaiian Islands (MHI). Between 2017-2021, a translocation project brought albatross chicks from the NWHI to the James Campbell National Wildlife Refuge on Oahu to create new protected breeding colonies safe from climate change. Outside of Hawai‘i, there are a few small nesting colonies off Japan and western Mexico. Historically, nesting occurred on several islands in the central and south Pacific, but no evidence of historical nesting on MHI. At sea, they occur widely throughout the north Pacific Ocean.

ABUNDANCE: The worldwide population is estimated at 60,000 pairs, more than 95 percent of which nest in the Hawaiian Islands. Majority of the Hawaiian population nests on Laysan (19,000 pairs) and Midway (25,000 pairs) Islands in the NWHI.

LOCATION AND CONDITION OF KEY HABITAT: Nesting colonies occur on low coral and sand islands. These birds use open sandy beaches or dunes for nest sites, or occasionally nest

among vegetation. At sea, they occur over the open ocean.

THREATS:

- Historical human disturbance: Hunters decimated populations for the millinery trade. Military activities at nesting islands also took a heavy toll on this species; for example, tens of thousands were killed at Midway Island during the 1950s and 1960s to reduce collisions with aircraft.
- Fishery bycatch: Bycatch is one of the most serious threats to albatross; thousands were killed annually as bycatch in drift net fisheries prior to their ban in 1993, and in U.S. longline fisheries: Bycatch has been greatly reduced in the last 10–20 years by U.S. fisheries; however, bycatch from Japanese and Taiwanese fleets in the north Pacific Ocean remains a significant threat.
- Invasive species: Non-native plants, specifically golden crown-beard, degrades nesting habitat and may limit nesting and reduce productivity.
- Marine pollution: Adults ingest plastic debris, then feed it to their chicks, resulting in harm or mortality of chicks.
- Contaminants: Organochlorine levels high enough to result in eggshell thinning and embryonic defects have been detected in ka‘upu. Oil spills are also a threat.
- Climate change: Nesting colonies on open sandy areas near the shoreline are vulnerable to sea level rise and increased storms and wave events associated with climate change.
- Disease: Diseases like avian influenza may impact albatross and other seabird species.

CONSERVATION ACTIONS: Actions specific to conservation of ka‘upu should include the following:

- Continue protection and management of nesting colonies.
- Control and eradicate non-native predators at nesting colonies.
- Reduce fisheries bycatch throughout the north Pacific Ocean.
- Conduct public education programs about the hazards of plastics and marine pollution for seabirds and the ocean.
- Establish new colonies on high islands that are less vulnerable to climate change.

MONITORING: Monitor all Hawaiian nesting colonies to collect demographic data, inform management decisions, and measure efficacy of conservation actions.

RESEARCH PRIORITIES:

- Estimate annual mortality from albatross bycatch in U.S. and foreign fisheries and model the effect of this mortality on population. Continue research and development of techniques and gear to minimize bycatch.
- Investigate methods to reduce impacts of climate change and soil erosion on low-lying colonies.
- Understand impacts of disease such as avian pox and flu on the species.

References:

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VI. Available at: http://explorer.natureserve.org. (Accessed May 2015).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

Whittow GC. 1993. Black-footed albatross (*Diomeda nigripes*). *In* The Birds of North America, No. 65 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

VanderWerf, EA. 2012. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, Hawai‘i.

Photo: Eric VanderWerf

Seabirds

Koa‘e kea or White-tailed Tropicbird

Phaethon lepturus

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Ranking G5 – Secure, North American Waterbird Conservation Plan – High concern, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The koa‘e kea or white-tailed tropicbird is a showy, white seabird (Family: Phaethontidae), related to boobies and frigatebirds. Six koa‘e kea (white-tailed tropicbird) subspecies are recognized; only one (*P. l. dorothea*) breeds in Hawai‘i. Adult male and females are mostly white, although sometimes with pale pinkish wash, except for a narrow black eye patch, black streak on upper wings, and black on the leading edge of the outer primaries; both sexes have long, narrow, white central tail feathers. Large yellow-green bill; legs and feet are very small. Flight is characterized by rapid wing beats, interspersed with brief periods of gliding. Koa‘e kea (white-tailed tropicbird) usually forage alone, but occasional with conspecifics, most often far from land; often will follow ships. Koa‘e kea (white-tailed tropicbird) captures prey by plunge diving from 15 to 20 meters (50 – 65 feet) above the water. Diet is poorly known, but includes flyingfish and is likely similar to koa‘e ula or red-tailed tropicbird (*P. rubricauda*). Koa‘e kea (white-tailed tropicbird) breed in colonies and pairs remain together for years. At the beginning of the breeding season, pairs engage in complex aerial displays. Nests are placed in hard to reach locations on cliffs as well as in caves and tree hollows; nests have little if any material. In Hawai‘i, breeding occurs March through October and a single egg is laid per season. Both parents incubate the egg, and brood and fed the chick. No post-fledging care is provided. Based on few data, age at first breeding is likely after fourth year; no data on longevity.

DISTRIBUTION: Koa‘e kea (white-tailed tropicbird) breed on Midway Atoll and in the MHI at the following locations: Waimea Canyon, Kīlauea Point National Wildlife Refuge, and the Nā Pali Coast on Kaua‘i; Pelekunu Valley, Waikolu, and windward sea cliffs on Moloka‘i; Kaholo Pali, Maunalei Gulch, Hauola Gulch on Lāna‘i; Alau Islet, Moku Mana, & gulch walls windward and leeward on Maui; Kīlauea Crater, Manukā, Kainaliu and windward coast on the island of Hawai‘i, and the offshore islet Mokoli‘i. A few pairs nest on southeastern O’ahu.
Outside of Hawai‘i, koa‘e kea (white-tailed tropicbird) breed on oceanic islands throughout the Atlantic, Indian, and Pacific oceans as well as the Caribbean. Outside the breeding season, adults are solitary and pelagic, and their range is poorly known.

ABUNDANCE: In Hawai‘i, population is estimated at 1,800 breeding pairs with most occurring in the MHI. The worldwide population is estimated at less than 200,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Koa‘e kea (white-tailed tropicbird) breeds mainly on oceanic islands. Frequently nests in inaccessible crevices or ledges on cliff walls, outside of Hawai‘i the species is known to nest in a variety of sites including caves, tree hollows, and in closed-canopy rain forests. **Marine:** Pelagic and nearshore.

THREATS:

- Introduced predators: Like all seabirds, adults and nests susceptible to predation by rats (*Rattus* spp.), mongoose (Herpestes auropunctatus) and feral cats (*Felis silvestris*).

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of koa‘e kea (white-tailed tropicbird) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Continued protection and management of existing wildlife sanctuaries and refuges.

MONITORING: Targeted surveys of population and distribution in known and likely habitats are needed.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to koa‘e kea (white-tailed tropicbird) include the following:

- Conduct long-term demographic studies to determine population trends, philopatry to nest colonies and nest sites, survival rates, and reproductive success.
- Develop and implement survey protocols to assess population abundance, status and monitor trends.
- Understand foraging and at-sea behaviors through telemetry studies.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

Lee DS, Walsh-McGehee M. 1998. White-tailed tropicbird (*Phaeton lepturus*). *In* The Birds of North America, No. 353 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service

Photo: DOFAW

Seabirds

Koaʻe ʻula or Red-tailed Tropicbird

Phaethon rubricauda

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Ranking G4/G5 –Apparently secure/Secure, North American Waterbird Conservation Plan -Moderate concern, Regional Seabird Conservation Plan - USFWS 2005 Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The koaʻe ʻula or red-tailed tropicbird is a showy, white seabird (Family: Phaethontidae) related to boobies and frigatebirds. Four koaʻe ʻula (red-tailed tropicbird) subspecies are recognized, and one (*P. r. roseotincta*) breeds in Hawaiʻi. Adult males and females are mostly white, although sometimes with pale pinkish wash, except for partial black eye ring and short eye line, black flanks, and black shafts of outer primaries; both sexes have long, narrow, tail feathers with red shafts. Large reddish orange bill with black tip; legs and feet are very small. Flight is characterized by strong flapping interspersed with gliding; koaʻe ʻula (red-tailed tropicbird) are capable of flying long distances. Koaʻe ʻula (red-tailed tropicbird) usually forage alone, but occasional with other species, most often far from land; often will follow ships. Koaʻe ʻula (red-tailed tropicbird) captures prey by plunge diving. In Hawaiʻi, diet is mainly comprised of flyingfish, but also takes squid, mackerel scads, dolphinfish, truncated sunfish, and ballonfish. Koaʻe ʻula (red-tailed tropicbird) breed in colonies and pairs remain together for years. At the beginning of the breeding season, pairs engage in complex aerial displays. Nests are placed on the ground, and generally are a simple scrape lined with some vegetation. In Hawaiʻi, breeding can occur throughout the year, but most nests are active between February and June. A single egg is laid per season, and both parents incubate the egg, and brood and feed the chick. No post-fledgling care is provided. Age at first breeding is between two and four years, and the oldest known individual was 23 years old.

DISTRIBUTION: Koaʻe ʻula (red-tailed tropicbird) breed throughout the NWHI and at a limited number of sites on MHI such as Molokai, Maui, Lānaʻi,Oʻahu and Hawaiʻi Island, mostly on coastal areas, offshore islets and sea cliffs, such as Lehua and Mokuʻaeʻae on Kauaʻi and sea cliffs, but possibly on Niʻihau, Kaʻula, and Kahoʻolawe. Outside of Hawaiʻi, koaʻe ʻula (red-tailed tropicbird) breed on oceanic islands in the Indian and Pacific oceans. Outside the breeding season, adults are solitary and pelagic, and their range is poorly known.

ABUNDANCE: In Hawai‘i, population iz estimated at between 9,000 and 12,000 breeding pairs, with the largest populations occurring on Midway Atoll and Laysan. The worldwide population is estimated at 17,000 to 21,000 breeding pairs, with the majority residing in the Pacific Ocean.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Koa‘e ‘ula (red-tailed tropicbird) breed mainly on oceanic islands and coral atolls with shrubs, including beach magnolia (*Scaevola sericea*) and beach heliotrope (*Tournefortia argentea*). Koa‘e ‘ula (red-tailed tropicbird) nest on the ground, generally in inconspicuous places such as under vegetation or in cliff crevices. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests susceptible to predation by rats (*Rattus* spp.), mongoose (Herpestes auropunctatus) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Breeding habitat loss: On Lehua, Koa‘e ‘ula mainly nests in shallow caves on rocky ledges, and the old known and currently unoccupied nest sites are apparently taken over by invasive grass species, forming thick cover in front of the nest. As the species is known to nest in vegetated islands, more research is needed to quantify the impact of introduced plants on nest occupancy and abundance.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of koa‘e ‘ula (red-tailed tropicbird) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Continued protection and management of existing wildlife sanctuaries and refuges.
- Eradication and control of introduced predators (and plants if impacting nesting sites) at current and potential breeding colonies.

MONITORING: Targeted surveys of population and distribution in known and likely habitats are needed.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to koa‘e ‘ula (red-tailed tropicbird) include the following:

- Conduct long-term demographic studies to determine population trends, survival rates, and reproductive success.
- Develop and implement survey protocols to assess population abundance, status and

monitor trends.

- Understand at-sea distribution and behavior through telemetry studies.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Schreiber EA, Schreiber RW. 1993. Red-tailed tropicbird (*Phaeton rubricauda*). *In* The Birds of North America, No. 43 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Seabirds

‘Ou or Bulwer’s Petrel

Bulweria bulwerii

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G4 -Apparently secure, North American Waterbird Conservation Plan - Moderate concern. Regional Seabird Conservation Plan - USFWS 2005, Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The ‘ou or Bulwer’s petrel is a highly pelagic, nocturnal gadfly petrel (Family: Procellariidae) with a pantropical distribution. Individuals have long pointed wings, a long-pointed tail, a black bill and pale short legs. Adult males and females are overall sooty brown, with a pale bar across the proximal half of upper wings. Flight is buoyant and erratic; individuals fly low over the water using short wing beats followed by glides. ‘Ou (Bulwer’s petrel) forage alone. Foraging behavior is poorly known as is diet. Likely takes prey at surface by dipping on the wing or seizing while sitting on the water. Diet includes fish and squid, but also crustaceans and sea-striders. ‘Ou (Bulwer’s petrel) form long-term pair bonds and breed in large colonies. Limited data suggests they return to their natal colonies to breed and pairs return to the same nest site year after year. Nest is placed in a variety of hollows or crevices. Nests have a strong musky odor and may be nothing more than the cavity floor or may be lined with feathers, vegetation, or rubble. In Hawai‘i, eggs are laid from mid-May to mid-June and most nestlings fledge by early October. Both parents incubate the egg, and brood and feed the chick. Age at first breeding is six years, and the oldest known individual was 24 years old.

DISTRIBUTION: ‘Ou (Bulwer’s petrel) breed throughout the NWHI and on offshore islets of the MHI, including Hulu, Kaeoi, Kāohikaipu, Kapapa, Ka‘ula, Lehua, Mānana, Moke‘ehia, Mōkōlea Rock, Moku Lua, Moku Manu, Mokuho‘oniki, Molokini, Mokapu, Moku‘ae‘ae and Popoi‘a. ‘Ou have laid eggs in artificial burrows in the seabird exclosures at Makamaka‘ole on Maui, and ‘ou have been documented calling at ~2500 feet on windward Maui at Honomanu. Every fall fledging chicks are recovered in the water at the base of the sea cliffs of leeward Lāna‘i. Outside of Hawai‘i, ‘ou (Bulwer’s petrel) breed on a limited number of islands in the North Atlantic, North and South Pacific, and Indian Ocean. Non-breeding season range is poorly known, but have been observed dispersing to the southeast after breeding.

ABUNDANCE: In Hawai‘i, the population is estimated at between 75,000 and 103,000 breeding pairs on the NWHI and between 500 and 1,000 pairs on MHI. Largest colony on Nihoa (75,000 to 100,000 pairs); which supports the world’s largest known breeding colony. Smaller colonies are found on Laysan (1,000 - 2,000 pairs), French Frigate Shoals (200 - 500 pairs), and Necker (250 - 500 pairs). Prior to the introduction of rats (*Rattus* spp.) to Midway, ‘ou (Bulwer’s petrel)

were abundant. The worldwide population is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ‘Ou (Bulwer’s petrel) breed on rocky islets and atolls, nesting in rock crevices, rock or coral rubble, under vegetation, and man-made nest structures. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests susceptible to predation by rats, mongoose (Herpestes auropunctatus) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats. Recent eradication of rats from Midway and Kure should allow re-establishment of breeding colonies. Barn Owls (Tyto furcata) are the main predator for the species on rat-free Lehua and Moku‘ae‘ae Islets. Although a native species, the Hawaiian Short-eared Owl (Asio flammeus sandwichensis) is also documented depredating ‘ou on Moku‘ae‘ae.
- Invasive species. Introduced big-headed ants (*Pheidole megacephala*) have been observed killing piping chicks.
- Catastrophic events: Given that a large portion of the world’s population breeds on Nihoa, a single catastrophic event (e.g., hurricane) could decimate the species.
- Collisions: Disorientation due to artificial lighting increases vulnerability to collisions with man-made structures.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re- establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ‘ou (Bulwer’s petrel) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Facilitate the re-colonization of islands in MHI to reduce the species’ vulnerability to catastrophes.
- Continued protection and management of existing wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ‘ou (Bulwer’s petrel) include the following:

- Baseline research on this species is needed as most aspects of its biology are poorly known.
- Determine effects of spectral content of night lighting on seabird distraction
- Design and implement survey protocols to understand the demography, trends,

and connectivity of ‘ou populations across the Hawaiian Islands

References:

Hawai’i Natural Heritage Program [Hawai‘i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai’i, Center for Conservation Research and Training. Honolulu, HI.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

Megyesi JL, O’Daniel DL. 1997. Bulwer’s petrel (*Bulweria bulwerii*). *In* The Birds of North America, No. 281 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Rachel Seabury, USFWS

Seabirds

Bonin Petrel

Pterodroma hypoleuca

SPECIES STATUS:

State recognized as Indigenous, North American Waterbird Conservation Plan –Moderate concern, Regional Seabird Conservation Plan - USFWS 2005
Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The Bonin petrel is a small, nocturnal gadfly petrel (Family: Procellariidae) which breeds further north than any of its Pacific relatives. Like many pelagic seabirds, Bonin petrels mostly have dark upper parts and light underparts and the sexes are similar in appearance. Flight is fast, and compared to other petrels, the species is very maneuverable. Bonin petrels generally forage far offshore, and feed by seizing prey while sitting on the water or while hovering. Usually forages alone, but may join mixed species flocks. Unlike most of its congeners, Bonin petrels feed mostly on fish, primarily lantern fishes (Myctophidae) and hatchetfishes (Sternoptychidae), although squid (Ommastrephidae) also are important. Bonin petrels are winter breeders, and interestingly, the only other gadfly petrel that breeds in Hawai‘i (i.e., ‘ua‘u or Hawaiian petrel [*P. phaeopygia*]) nests in the summer. Like most seabirds, Bonin petrels breed in their natal colonies, form long-term pair bonds, have high site fidelity, lay only one egg per season, and both parents participate in all aspects of raising young. Bonin petrels nest in burrows which they excavate in sandy soils. In Hawai‘i, eggs are laid in mid January and chicks fledge by June. Competes with larger ‘ua‘u kani (or wedge- tailed shearwater [*Puffinus pacificus*]) for burrows, and late fledging petrel chicks are sometimes killed by returning shearwaters. No information on age of first breeding. The oldest known Bonin petrel is 19 years old.

DISTRIBUTION: Bonin petrels breed on the NWHI from French Frigate Shoals to Kure. Historically bred on MHI. Between 2018-2021, a translocation project brought bonin chicks from the NWHI to the James Campbell National Wildlife Refuge on Oahu to create new protected breeding colonies safe from climate change. Outside of Hawai‘i, breeding populations are restricted to Bonin and Volcano islands off of Japan. Outside the breeding season a few individuals remain in the waters surrounding the Hawaiian Islands, but most disperse widely mainly between Hawai‘i and Japan.

ABUNDANCE: In the Hawaiian Archipelago, the population is estimated at between 270,000 and 395,000 breeding pairs, with the largest populations occurring on Lisianski (150,000 - 250,000 pairs), Laysan (50,000 - 75,000 pairs), and Midway Atoll (70,000 pairs). Prior to the introduction of rats (*Rattus* spp.) in the 1930s, an estimated 250,000 pairs nested on Midway. Worldwide population is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Bonin petrels breed on predator free islands. Sandy soils are necessary for nest burrow excavation. Currently all breeding colonies in Hawai‘i occur in the Hawaiian Islands National Wildlife Refuge or the Midway Atoll National Wildlife Refuge. **Marine**: Pelagic.

THREATS:

- Non-native mammals: Historically, mammalian introductions to islands supporting nesting colonies resulted in declines or extirpations. On Lisianski and Laysan, rabbits (*Oryctolagus cuniculus*) denuded the island resulting in erosion which destabilized burrows. On Midway and Kure, rats (*Rattus* spp.) resulted in declines of breeding populations. Over a 40 year period, the Midway population declined from 250,000 to 5,000 pairs. Rabbits and rats have been eradicated from all NWHI.
- Collisions: Disorientation due to artificial lighting increases vulnerability to collisions with man-made structures.
- Invasive species: Non-native plants, specifically golden crown-beard (*Vervesina encelioides*) and sandbur (*Cenchrus agrimonioides*), degrades nesting habitat by providing poor soil stabilization. Introduced big-headed ants (*Pheidole megacephala*) at Kure may cause nestling mortality, but also facilitate the destruction of native vegetation by a non-native scale insect.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protection, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of Bonin petrels should include the following:

- Eradicate golden crown-beard on Pearl and Hermes Reef and Midway, and prevent its establishment on other islands.
- Continue protection and management of wildlife sanctuaries and refuges.
- Expand translocations from the NWHI to MHI, above projected sea level rise in protected areas.

MONITORING: Continue surveys of population and distribution in known and likely habitats, and develop and implement a monitoring program to track recovering populations at Midway and Kure.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to the Bonin petrel include the following:

- Conduct long-term demographic studies to determine population trends, survival rates, and reproductive success.
- Determine the effect of non-native ants and scale insects on Bonin petrel populations

and develop methods to eradicate or control ants and scale.
- Determine effects of spectral content of night lighting on seabird distraction

References:

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Seto NWH, O'Daniel D. 1999. Bonin petrel (*Pterodroma hypoleuca*). *In* The Birds of North America, No. 385 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: C. S. N. Bailey, NPS

Seabirds

Ua‘u or Hawaiian petrel

Pterodroma sandwichensis

SPECIES STATUS:
Federally Listed as Endangered, State Listed as Endangered, State Recognized as Indigenous, NatureServe Heritage Ran G2/T2 – Species Globally Imperiled/Subspecies Locally Imperiled, IUCN Red List Ranking – Vulnerable, Regional Seabird Conservation Plan – USFWS 2005

SPECIES INFORMATION: The ‘ua‘u or Hawaiian petrel is a medium-sized, nocturnal gadfly petrel (Family: Procellariidae) endemic to Hawai‘i. The name is derived from a commonly uttered call, heard at colonies. Adults are uniformly dark grayish black above forming a partial collar which contrasts with white throat, forehead, and cheeks; entirely white below except for black tail and leading and trailing edges of underwings. Owing to darkness of back color, the ‘W-pattern’ across back and upper surface of wings is not visible except in worm plumage. Bill black, and legs and feet mostly pink. Even during the breeding season, ‘ua‘u often feed thousands of kilometers from their breeding colonies, usually foraging within mixed-species feeding flocks over schools of predatory fishes. They feed by seizing prey while sitting on the water or by dipping prey while flapping just above the ocean surface. In Hawai‘i, they feed primarily on squid, but also on fish, especially goatfish and lantern fish, and crustaceans. ‘Ua‘u nest in colonies, form long-term pair bonds, and return to the same nest site year after year.

Colonies are now typically in high-elevation, xeric habitats or wet, dense forests, although before the arrival of the Polynesians and their associated animals these birds nested in the lowlands, too. They nest in burrows, crevices, or cracks in lava tubes; nest chambers can be from 1 to 9 meters (3-30 feet) deep. Most eggs are laid in May and June and most birds fledge by December, although there are significant inter-island differences in breeding phenology; for example, the nesters that are earliest by more than a month reside at the summit of Haleakala Volcano. Both parents incubate the single egg, and brood and feed the chick. Birds first breed at five to six years of age.

DISTRIBUTION: Nests among the Main Hawaiian Islands (MHI) including Maui, Hawai‘i, Kaua‘i, Lāna‘i, and possibly small numbers on Moloka‘i and O‘ahu. Subfossil evidence indicates that prior to the arrival of Polynesians, ‘ua‘u was common throughout the MHI. At sea, they occur throughout the central tropical and subtropical Pacific Ocean. Fledged juveniles have been tracked to Lagonoy Gulf in the Philippines, the South China Sea and the waters off Taiwan, and 1 bird flew up to Japan before returning to the waters off the Philippines.

ABUNDANCE: In the early 1990s the population was estimated at 19,000 individuals with a breeding population of 4,500 to 5,000 pairs, although inaccessible nesting locations make accurate counts difficult. Analysis of at-sea counts indicate broad consistency with the island- based estimates. More recently (1998-2011) the global population was estimated at 52,000 birds, although due to differences in sampling methods it is unknown whether these higher numbers reflect a population increase or a difference in the proportion of the total population sampled. More than 1,800 individuals occur at Haleakalā National Park on Maui (a few hundred more nest in West Maui), around 150 pairs occur on Mauna Kea, Hawai‘i; around 1,600 pairs occur on Kaua‘i; several thousand birds occur on Lāna‘i.

LOCATION AND CONDITION OF KEY HABITAT: Nests in a variety of remote, inland habitats. On the islands of Hawai‘i and Maui, colonies are located above 2,500 meters (8,200 feet) in xeric habitats with very sparse vegetation, with most nests in existing crevices in the lava. On Kaua‘i and Lāna‘i, windward east Maui and West Maui colonies occur in lower-elevation forests dominated by ‘ōhi‘a (*Metrosideros polymorpha*) often with a dense understory of uluhe fern (*Dicranopteris linearis*). At sea, they are pelagic and occur over the open ocean.

THREATS:

- Historical hunting: Nestlings were considered a delicacy by Polynesians, and were harvested from nest burrows, including artificial ones constructed by the Polynesians. Adults were netted as they returned to colonies, and smoky fires were sometimes lit along flight corridors to disorient and ground birds.
- Introduced predators: Adults and chicks are susceptible to depredation by dogs, pigs, rats, barn owls, feral cats, and the small Indian mongoose. The presence of these destructive introduced animals, the main force behind population decline, has relegated the species now to nest only in remote interior areas, at very high altitude, or on islands that are predator-free. An emerging new threat is introduced feral honey bees, documented to take over the burrows on Kaua‘i, as well as causing mortality by killing adult birds (Raine et al., 2023).
- Feral ungulates: Feral goats (*Capra hircus*), mouflon sheep (*Ovis musimon*), and potentially axis deer (*Axis axis*) trample burrows and degrade nesting habitat.
- Artificial lighting: Street and resort lights, especially in coastal areas, disorient fledglings, causing them to eventually fall to the ground exhausted or increasing their chance of colliding with artificial structures (i.e., fallout) such as powerlines. Once on the ground, fledglings are killed by cars, cats, and dogs, or die of starvation or dehydration.
- Collisions: Adults and fledglings are susceptible to mortality from collisions with obstacles such as communication towers, utility lines, fences, and wind farm structures while commuting between inland nest sites and the ocean at night.
- Colony locations: The remoteness of colonies, as well as the habitat in which they occur (e.g., steep terrain or dense forest), complicates predator and ungulate eradication or control.
- Breeding habitat loss. Habitat-modifying introduced plants such as Kahili Ginger and Australian Tree Fern are causing a reduction in available breeding habitat to the species on Kaua‘i.

CONSERVATION ACTIONS: Past actions directed at ʻaʻo (Newell's shearwater [*Puffinus newelli*]) have often benefited ʻuaʻu populations. These actions include the rat and cat control in some of the large breeding colonies on Kauaʻi, rescue and rehabilitation of downed fledglings by the Save Our Shearwaters (SOS) program on Kauaʻi and Save Our Seabirds on Maui; and efforts to shade and curtail resort and event lighting and streetlights. Current and future conservation efforts should include efforts to reduce and shield lighting, control predators and invasive species at breeding colonies, conduct surveys to locate and characterize additional colonies, evaluate updated population estimates, and implement management actions appropriately. Actions being carried out in association with several Habitat Conservation Plans, along with State and federal recovery efforts are resulting in conservation benefits to ʻuaʻu on Maui, Lānaʻi, Hawaii and Kauaʻi; these include efforts to protect existing breeding populations and establish new colonies using predator-proof fencing, predator control, ungulate control, social attraction, and translocation work plans. In addition to these efforts, future management actions specific to ʻuaʻu populations should include the following:

- Continue predator and ungulate control at colonies on Hawaiʻi, Maui, Lānaʻi, and Kauaʻi, and potentially at offshore islets that contain suitable nesting habitat.
- Locate additional breeding colonies on Hawaiʻi, Maui, and Kauaʻi and perform surveys on Molokaʻi and Oahu, to assess ʻuaʻu presence.
- Continue to identify fallout areas and minimize effects of powerlines and artificial lights.
- Continue to support the SOS programs, particularly public outreach about light attraction and fallout, the rescue and rehabilitation program, and the establishment of similar programs on other islands where appropriate.
- Re-establish/expand breeding colonies by identifying suitable candidate locations for social attraction and/or translocation, and continue to refine translocation protocols.

MONITORING: Continue at-sea and terrestrial surveys in known and likely habitats to evaluate the population size and status, and to locate unidentified breeding colonies. Monitor breeding incidence, breeding density, reproductive success, causes of mortality, population trends, adult survivorship, return rates and effectiveness of management at breeding colonies. Assess the efficacy of predator control efforts.

RESEARCH PRIORITIES:

- Develop and implement standardized survey and monitoring protocols that can be used throughout Hawaiʻi to better estimate population parameters and changes.
- Expand and refine radar studies to monitor population trends.
- Conduct long-term demographic studies to evaluate reproductive success, breeding incidence, breeding density, colony boundaries, population trends, and survival rates.
- Develop, refine, and monitor the outcome of conservation actions and measures that are employed to avoid and minimize impacts from flight collision and other causes, and broaden adaptive management approaches.
- Determine effects of spectral content of night lighting on seabird distraction

- Implement research to understand at-sea locations and behavior, and the impact of at-sea habitats and activities on population dynamics and life history traits.
- Investigate population genomic structure of the species across the Hawaiian Islands by using advanced sequencing technologies to evaluate genetic diversity, connectivity, and identify conservation management units.
- Develop research projects to evaluate the impact of current conservation and minimization actions on population viability.

References:

Hawai'i Natural Heritage Program [Hawai‘i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai'i, Center for Conservation Research and Training. Honolulu, Hawai‘i.

Holmes N, Friefeld H, Duvall F, Penniman J, Laut M, Creps N. 2011. Newell's Shearwater and Hawaiian Petrel Recovery: A Five-Year Action Plan. Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu, HI; Pacific Cooperative Studies Unit, Honolulu, HI; and U.S. Fish and Wildlife Service, Honolulu, HI.

Hu, D. G.E. Ackerman, C.S.N. Bailey, D.C. Duffy, and D.C. Schneider. 2015. Hawaiian petrel monitoring protocol – Pacific Island Network. Natural Resources Report NPS/PACN/NRR–2015/993. National Park Service, Fort Collins, Colorado.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).
Joyce, TW. 2013. Personal communication. Scripps Institute of Oceanography, La Jolla, California.
NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Raine, André F., Driskill, S., Raine, H. , Rothe, J , Rossiter, S , Anderson, T., Bache, M. 2023. Post-fledging distribution of 'ua'u (Hawaiian petrel, Pterodroma sandwichensis) from Kaua'i, Hawai'i and effectiveness of rehabilitation. Endangered Species Research. Vol. 52: 27–40, https://doi.org/10.3354/esr01268

Simons TR, Hodges CN. 1998. Dark-rumped petrel (*Pterodroma phaeopygia*). *In* The Birds of North America, No. 345 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2011. Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

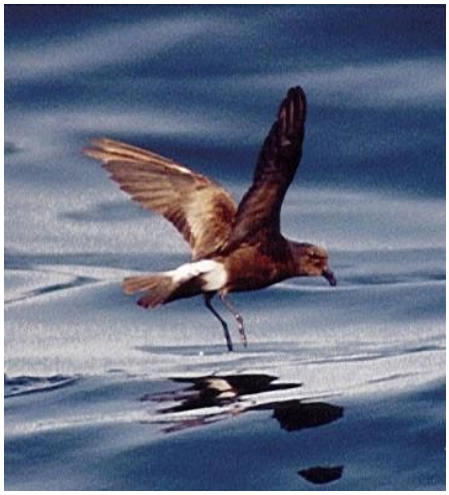


Photo: Steve McConnell

Seabirds

ʻAkēʻakē or Bandrumped Storm Petrel

Hydrobates castro cryptoleucura

SPECIES STATUS:
Hawaii Distinct Population Segment (DPS)
Federal Listed as Endangered, State Listed as Endangered, State Recognized as Indigenous, NatureServe Heritage Rank G4 - Apparently Secure, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The ʻakēʻakē or band-rumped storm-petrel is a medium sized, highly pelagic storm-petrel (Family: Hydrobatidae), and is the smallest and rarest seabird that breeds in Hawaiʻi. Adults are primarily blackish-brown and have a sharply defined narrow white band across rump area. Flight is characterized by shallow wing beats and long glides just over the surface of the ocean. Foraging alone or with conspecifics, ʻakēʻakē feed while sitting on the water or by dipping prey while flapping just above the ocean surface, often pattering water with feet. There is no diet information from Hawaiʻi, but elsewhere diet primarily consists of small fish, squid, and some crustaceans. Breeding biology in Hawaiʻi is poorly known, but these birds are known to nest in burrows or natural cavities in a variety of high-elevation, inland habitats. As with most seabirds, a single egg is laid per season. In Hawaiʻi, eggs are laid between May and June, and nestlings fledge in October. ʻAkēʻakē likely do not breed until they are three to seven years old, and likely live for 15 to 20 years.

DISTRIBUTION: Historically, was abundant and widespread throughout Main Hawaiian Islands (MHI). Nesting colonies occur on Kauaʻi at elevations around 600 meters (1,950 feet), on windward Lānaʻi around 610 meters (2000 feet), on Maui (in and around Haleakalā National Park) and, historically, in Ahihi-Kenaʻu Natural Area Reserve, and the island of Hawaiʻi (in Hawaiʻi Volcanoes National Park at elevations greater than 1,200 meters (3,900 feet) and generally between 6,000 to 10,000 ft, and on Lehua. Outside of Hawaiʻi, the species nests in Japan and on the Galapagos, and on several islands in the Atlantic. At sea, they occur in the Pacific and Atlantic oceans.

ABUNDANCE: In Hawaiʻi, breeding population size is unknown, but likely very small. The breeding population on Kauaʻi was estimated at between 171 and 221 breeding pairs in 2002. Worldwide population is unknown, but likely less than 25,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Breeds in a variety of remote, high-elevation, inland habitats. On Kauaʻi, colonies are in steep valleys vegetated with shrubs and grasses. On Maui and the island of Hawaiʻi, colonies occur on high, barren lava flows. Nesting in burrows or crevices in rock or lava has also been documented using artificial nest boxes.

THREATS: Due to its very small population size in the Hawaiian Islands, the ʻakēʻakē is susceptible to stochastic, genetic, environmental, and demographic events that could lead to extirpation. Important threats to the species include:

- Introduced predators: Adults and chicks are susceptible to predation by pigs (*Sus scrofa*), rats (*Rattus* spp.), feral cats (*Felis silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*), barn owls and pueo.
- Feral ungulates: Pigs, goats (*Capra hircus*), and sheep degrade nesting habitat.
- Artificial lighting: Street and resort lights, especially in coastal areas, likely disorient fledglings, causing them to eventually fall to the ground exhausted or increasing their chance of colliding with artificial structures (i.e., fallout). Once on the ground, fledglings are unable to fly and are killed by cars, cats, and dogs (*Canis familiaris*) or die of starvation or dehydration.
- Collisions: Adults and fledglings are susceptible to mortality from collisions with obstacles such as communication towers and utility lines while commuting between inland nest sites and the ocean at night.
- Colony locations: The remoteness of colonies, as well as the habitat in which they occur (e.g., steep terrain or dense forest), complicates monitoring predator and ungulate eradication, or control.

CONSERVATION ACTIONS: Past actions directed at ʻaʼo or Newell's shearwater (*Puffinus auricularis*) that have benefited ʻakēʻakē include the rescue and rehabilitation of downed fledglings by the Save Our Shearwaters (SOS) program and efforts to shade resort lighting and streetlights. Current and future conservation efforts on Kauaʻi and Maui Nui to benefit the ʻakēʻakē, ʻaʼo, and ʻuaʻu (Hawaiian petrel [*Pterodroma sandwichensis*]) include efforts to reduce and shield lighting, control predators and invasive species, conduct surveys to locate additional colonies, and develop revised population estimates using at-sea survey data. In addition to these efforts, future actions specific to Hawaiian populations of ʻakēʻakē should include the following:

- Locate existing colonies and protect and monitor them.
- Locate potential sites for the establishment of new breeding colonies.
- Continue efforts to eradicate and control predators and ungulates.
- Continue to identify fallout areas and minimize effects of powerlines and artificial lights.
- Continue to support the Kauaʻi and Maui SOS programs, particularly the public outreach about light fallout and its rescue and rehabilitation program. Consider establishing similar programs on other islands where appropriate.
- Social attraction in predator exclusion fencing and translocation when and if adequate source populations can be identified.
- Locate existing colonies, explore access using new technologies, and protect and monitor them.

MONITORING: Conduct at-sea and terrestrial surveys in known and likely habitats to evaluate the population size and status, and to locate unidentified breeding colonies.

RESEARCH PRIORITIES:

- Investigate new technologies or adapt existing technologies (e.g., radar, at-sea surveys, mark/recapture, automated acoustic monitoring, telemetry, genomics) to ascertain

population status and trends.
- Evaluate life history, habitat requirements, reproductive biology, and population status to assess management needs and conservation status of this poorly known species.
- Identify factors currently limiting populations.
- Evaluate mortality related to powerlines and coastal lighting.
- Evaluate if Hawaiian subspecies should be reclassified as its own species
- Determine effects of spectral content of night lighting on seabird distraction
- Locate existing colonies through auditory surveys and on-ground confirmation.
- Implement research at known nesting locations to understand at-sea locations and behavior, and the impact of at-sea habitats and activities on population dynamics and life history traits.
- Investigate population genomic structure of the species across the Hawaiian Islands by using advanced sequencing technologies to evaluate genetic diversity, connectivity, and identify conservation management units.

References:

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Slotterback JW. 2002. Band-rumped Storm-petrel (*Oceandroma castro*). *In* The Birds of North America, No. 673 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2014. Species Assessment and Listing Priority Assignment Form: *Oceandroma castro,* Band-rumped Storm-petrel. U.S. Fish and Wildlife Service, Region 1, Pacific Region.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Slotterback JW. 2002. Band-rumped Storm-petrel (*Oceandroma castro*). *In* The Birds of North America, No. 673 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2014. Species Assessment and Listing Priority Assignment Form: *Oceandroma castro,* Band-rumped Storm-petrel. U.S. Fish and Wildlife Service, Region 1, Pacific Region.

Photo: Ian Jones, USFWS

Seabirds

Tristram's Storm-Petrel

Oceanodroma tristrami

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G3 – Vulnerable, North American Waterbird Conservation Plan - High concern, IUCN Red List Ranking - Near threatened, Regional Seabird Conservation Plan - USFWS 2005 Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: Tristram's storm-petrel is a large storm-petrel (Family: Hydrobatidae) with long, pointed wings, and a notched tail. Adult males and females are entirely brownish-gray. Flight is typical of storm-petrels, gliding low over water searching for food. Forages alone or with conspecifics, and typically forages at night. Tristram's storm-petrel feeds by dipping prey from the ocean's surface on the wing, often pattering the water with feet. In Hawai'i, diet includes fish, squid, coelenterates, crustaceans, and insects. Tristram's storm-petrels are winter breeders, and are nocturnal at nesting colonies. Nests are placed in recesses in rocks, under piles of mined guano, or burrows that they excavate under vegetation. Eggs are laid between December through February and nestlings fledge by June. Little information on parental care of egg or young. Like most storm petrels, age at first breeding is likely three to five years and individuals likely live between 15 and 20 years.

DISTRIBUTION: Tristram's storm-petrels breed on Nihoa and on all NWHI except for Midway and Kure atolls, although they historically bred on both as well as on MHI. Outside of Hawai'i, breeding colonies only occur on three small Japanese islands. Outside the breeding season, Tristram's storm-petrels range across the subtropical central and western Pacific Ocean.

ABUNDANCE: In Hawai'i, breeding colonies are estimated at less than 10,000 pairs, with the largest populations occurring on Nihoa (2,000 - 3,000 pairs), Laysan (500 - 2,000 pairs), and Pearl and Hermes Reef (1,000 - 2,000 pairs). Between 2018-2022, a translocation project brought tristram's storm petrel chicks from the NWHI to the James Campbell National Wildlife Refuge on Oahu to create new protected breeding colonies safe from climate change. Worldwide population unknown.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Islands in Hawai'i and Japan, which include both low-lying coralline sand islands and high volcanic islands. For nesting, prefers recesses in rock scree, under mined guano piles, or burrows excavated under vegetation. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by

rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats. Extirpation from Midway and Kure atolls likely the result of the introduction of rats; since the eradication of rats from Midway in 1996, individuals have been mist- netted but nesting has not been documented.

- Invasive species: The continued expansion of golden crowned-beard (*Verbesina encelioides*) on Pearl and Hermes Reef and Kure likely will reduce nesting habitat. The effects of big-headed ants (*Pheidole megacephala*), and mice (*Mus musculus*) on Tristram's storm-petrels are unknown.
- Collisions: Disorientation due to artificial lighting increases vulnerability to collisions with man-made structures.
- Disease: Diseases like avian influenza may impact these and other seabird species.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of Tristram's storm-petrel should include the following:

- Eradicate golden crown-beard on Pearl and Hermes Reef, Midway, and Kure.
- Eradicate mice from Midway and facilitate recolonization using attraction programs.
- Determine population size, status, and trends in Hawai‘i.
- Continue protection and management of existing wildlife sanctuaries and refuges.
- Translocate birds from the NWHI to the higher MHI within protected areas.

MONITORING: Continue surveys of population and distribution in known and likely habitats, particularly for re-colonization of Midway Atoll.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to Tristram's storm-petrel include the following:

- Design a reliable monitoring program.
- Determine the effects of ants on reproductive success.
- Research basic life history traits, demography, and factors limiting populations.
- Determine effects of spectral content of night lighting on seabird distraction

References:

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Slotterback JW. 2002. Band-rumped Storm-petrel (*Oceandroma castro*). *In* The Birds of North America, No. 673 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Forest and Kim Starr, USFWS

Seabirds

Ua‘u kani or Wedge Tailed Shearwater

Ardenna pacifica

SPECIES STATUS:
State Recognized as Indigenous, NatureServe Heritage Ranking G4/G5 – Apparently Secure/Secure, IUCN Red List Ranking -Least Concern, Regional Seabird Conservation Plan – USFWS 2005

SPECIES INFORMATION: The ‘ua‘u kani or wedge-tailed shearwater is a large, abundant seabird (Family: Procellaridae) that produces a variety of wails and moans that surely inspired the Hawaiian name of this bird which means “calling or moaning petrel.” Individuals have long thin wings, a wedge-shaped tail, and a hooked bill. ‘Ua‘u kani are polymorphic, having two color phases, dark or light, and sexes are similar in appearance. Light-phase adults are grayish brown above with white underparts except for dark trailing edges of wings and tail. Dark-phase adults are uniformly sooty brown. Most Hawaiian ‘ua‘u kani are light phase birds. Flight is similar to that of albatross but flaps wings with greater frequency. Often forages in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. They use a variety of foraging techniques, most frequently plunges head into water while on the wing, also seizes prey while sitting on the water; often follows fishing vessels. In Hawai‘i, diet primarily consists of larval goatfish, flyingfish, squirrelfish, and flying squid. Like most seabirds ‘ua‘u kani breed in natal colonies, form long-term pair bonds, have high site fidelity, lay one egg per season, and both parents participate in all aspects of raising young. In Hawai‘i, nesting is synchronous, and most eggs are laid in June with most young fledging in November. Birds first breed at four years of age, and the oldest known individual was 29 years old.

DISTRIBUTION: Nests throughout the Northwestern Hawaiian Islands (NHWI) and on offshore islets of most of the Main Hawaiian Islands (MHI) and Kaua‘i, Oahu, Maui, Molokai, & Lāna‘i. Outside of Hawai‘i, nests on islands throughout the tropical and subtropical Indian and Pacific oceans. After the breeding season, they may migrate to the eastern Pacific Ocean.

ABUNDANCE: In Hawai‘i, population is estimated at 270,000 breeding pairs with the largest colonies on Laysan (125,000-175,000 pairs), Nihoa (30,000-40,000 pairs), and Lisianski (10,000- 30,000 pairs). The MHI population is estimated at 40,000-60,000 breeding pairs with the largest colonies on the offshore islands of Mānana (10,000-20,000 pairs), Moku Loa (10,000-20,000 pairs), Lehua (23,000 pairs), and Ka‘ula (1,500-2,500 pairs). Smaller populations occur on Moku Manu, Moku‘auia, Kāpapa, Molokini, Mōkapu Peninsula; Ka‘ena Point Natural Area Reserve, Black Point, James Campbel NWR and Kailua on O‘ahu; Mo‘omomi and Mokio on Molokai; Hawea, Pu‘u Keka‘a, Ho‘okipa, & Kama‘ole Beach Park III on Maui and Kīlauea Point National Wildlife Refuge on Kaua‘i. Worldwide population is

estimated at over 5 million birds.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Nests on low, flat islands and sand spits with little or no vegetation; sand dunes and coastal peninsulas on MHI, but also excavates burrows on the slopes of extinct volcanoes and in old volcanic craters. Burrows require firm soil or plant roots to stabilize loose soil; generally nesting habitat is devoid of tall woody plants. In locations where nest sites are scarce or the ground is too hard to excavate burrows, birds will nest in rock crevices or above ground. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like many seabirds, adults and nests are susceptible to mammalian predation by pigs (*Sus scrofa*), rats (*Rattus* spp.), feral cats (*Felis silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*). Barn Owls predate adult and young ʻuaʻu kani on rat-free offshore islets and across the shore of Kauaʻi. Although a native species, Black-crowned Night Heron (Nycticorax nycticorax) is documented to predate ʻuaʻu kani chicks on Lehua.
- Human disturbance. Laysan (*Telespiza cantans*) and Nihoa (*T. ultima*) finches will depredate eggs left unattended because of human disturbance. Trampling by humans can collapse burrows.
- Artificial lighting: Street and resort lights, especially in coastal areas, disorient fledglings, causing them to eventually fall to the ground exhausted or increasing their chance of collision with structures (i.e., fallout). Once on the ground, fledglings are unable to fly and are killed by cars, cats, and dogs or die of starvation or dehydration.
- Anthropogenic impacts: Powerline strikes, vehicle strikes and other man-made infrastructure like wind turbines can cause mortality.
- Overfishing: Because ʻuaʻu kani rely on predatory fish to drive prey to the surface, overfishing may be affecting Hawaiian populations.
- Contaminants. Mercury, lead, organochlorines and plastics have been detected in Hawaiian birds.
- Disease: Pox-like lesions have been observed on birds breeding on Maui and Molokaʻi. Diseases like avian influenza may impact these and other seabird species.

CONSERVATION ACTIONS: Actions specific to ʻuaʻu kani should include the following:

- Continue eradication and control of introduced predators at current and potential nesting sites on MHI.
- Limit human access to colonies.
- Continue to support the Save Our Shearwater (SOS) and Save Our Seabirds (SOS) programs, particularly theirpublic outreach about light fallout and its rescue and rehabilitation program. Consider establishing similar programs on other islands where appropriate.
- Continue to identify fallout areas and work to minimize effects of powerlines and lights.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Monitor contaminant levels and their effects, and investigate potential sources.
- Investigate the cause and effect of pox-like lesions in populations on Maui and Molokini.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on ʻuaʻu kani populations.
- Determine effects of spectral content of night lighting on seabird distraction
- Develop and implement population monitoring protocols to quantify demographic rates and connectivity between populations across the Hawaiian Islands, as well as the impact of different mortality sources on population viability.
- Investigate at-sea locations and behavior of the species through telemetry studies.
- Investigate population genomics using advanced sequencing technologies to understand genomic diversity and connectivity in the Hawaiian Islands.

References:

Hawai'i Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai'i, Center for Conservation Research and Training. Honolulu, Hawaiʻi.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

Whittow GC. 1997. Wedge-tailed shearwater (*Puffinus pacificus*). *In* The Birds of North America, No. 305 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Brenda Zaun, USFWS

Seabirds

A‘o or Newell’s Shearwater

Puffinus newelli

SPECIES STATUS:
Federally Listed as Threatened, State Listed as Threatened, State Recognized as Indigenous, NaturServe Heritage Rank G2/T2 – Imperiled Species/Imperiled Subspecies, IUCN Red List Ranking – Endangered, Regional Seabird Conservation Plan – USFWS 200

SPECIES INFORMATION: The ‘a‘o or Newell’s shearwater (Family: Procellaridae) is highly pelagic year-round, and is endemic to the Hawaiian Islands. Adult males and females are dark, sooty brown above, with white throat and underparts, and have a dark bill with a hooked tip. Flight is direct, fast and usually low over water, powered by rapid wing beats interspersed with glides; wing loading is higher than in more aerial shearwaters due to the species’ foraging method (see below). Often forages in large, mixed species flocks associated with schools of large, predatory fishes, which drive prey to the surface. ‘A‘o feed mainly by pursuit-plunging; individuals dive into water and swim using their partly folded wings for propulsion. Diet is not well known, but likely consists of fish and squid. ‘A‘o are colonial and nest on steep mountain slopes, with variable amounts of vegetation, where they lay a single egg in cavities and burrows, often located at the base of a tree. Breeding is highly synchronous, and eggs are laid in early June, and most young fledge by November. Both parents incubate the egg, and brood and feed the nestling. Parents forage hundreds of kilometers offshore and return to colony at night to feed chick. No post-fledging care is provided. Age at first breeding is six to seven years.

DISTRIBUTION: ‘A‘o nest on Kaua‘i, Maui, Hawai‘i, and may also nest on Moloka’i O‘ahu, but not confirmed. At Makamaka‘ole Seabird Exclosures on Maui social attraction, started in 2014, has drawn in some fifty adults, with a single chick being produced in 2021, 2022 and 2023. These are the only known and protected ‘a‘o nesting sites in Maui Nui. Nesting colonies do not occur outside of Hawai‘i. At-sea distribution includes the eastern and central subtropical Pacific Ocean.

ABUNDANCE: Apparently abundant prior to the arrival of Polynesians, hunting and predation by introduced species resulted in declines of ‘a‘o, and the species was thought to be extinct by 1908. The species was rediscovered at sea in 1947 and breeding birds were found on Kaua‘i in 1967. Abundance is difficult to estimate because of the remoteness and terrain of colonies. In the early 1990s, the population was estimated at 84,000 birds based on at-sea surveys (included adults and non-breeding birds); the population in the subsequent decade (1998-2011) was estimated at roughly 27,000 birds based on revised population estimates using at-sea survey data and are broadly validated by radar detections. Due to differences in sampling methods it is unknown whether these lower estimates reflect a population decline or a difference in the proportion of the total population sampled. The breeding population was estimated at 14,600 pairs, 75-90 percent of which nest on

Kauaʻi, based on demographic data. The population is in serious decline; radar detections on Kauaʻi declined significantly from 1993 to 2023, and three colonies reported as active between 1980 and 1994 were abandoned.

LOCATION AND CONDITION OF KEY HABITAT: On Kauaʻi, most colonies occur between 160 and 1,200 meters (525 - 3,936 feet) elevation on steep, densely vegetated mountains, however, birds also nest on the dry, sparsely vegetated cliffs of the Nā Pali coast and on Lehua. On the island of Hawaiʻi, they nest within forested cinder cones. Colonies are usually located in areas of open native forest dominated by ʻōhiʻa (*Metrosideros polymorpha*) with a dense understory of ʻuluhe fern (*Dicranopteris linearis*).

THREATS:

- Historical hunting: Subsistence hunting by Polynesians likely reduced populations, and the species was likely captured using methods described for ʻuaʻu or Hawaiian petrel (e.g., artificial nests, nets, and smoke from fires).
- Introduced predators: Adults, eggs, and chicks are taken by introduced predators, including dogs (*Canis familiaris*), pigs (*Sus scrofa*), and rats (*Rattus exulans*). Europeans added barn owls (*Tyto alba*), additional rat species, feral cats (*Felis silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*), which is the main factor behind population decline. The largest colonies are on Kauaʻi, the only Main Hawaiian Island besides Lānaʻi where the small Indian mongoose is not established. An emerging new threat is introduced feral honey bees, documented to take over the burrows on Kauaʻi as well as causing mortality by killing adult birds (Raine et al., 2023).
- Habitat loss and degradation: Kauaʻi has lost about 75 percent of its forest in the last 150 years, and much of the remaining forest is being degraded by non-native plant species and feral ungulates
- Artificial lighting: Street and resort lights, especially in coastal areas, disorient fledglings, causing them to eventually fall to the ground exhausted or increasing their chance of colliding with artificial structures (i.e., fallout) such as powerlines. Once on the ground, thousands are killed annually by cars, cats, and dogs or die of starvation or dehydration. On Kauaʻi, approximately 350 fledglings were recovered annually from fallout in 1999 to 2010, far fewer than the thousands found per year in the late 1970s when the Save Our Shearwaters (SOS) program began; an unknown number are never found.
- Collisions: Adults and fledglings are susceptible to mortality from collisions with obstacles such as communication towers, overhead utility lines, and wind farm structures while commuting between inland nest sites and the ocean at night.
- Overfishing: Because ʻaʻo rely on predatory fish to drive prey to the surface, overfishing may be affecting the population.
- Colony locations: Remoteness of colonies, as well as the habitat they occur in (e.g., steep terrain or dense forest) complicates predator and ungulate eradication or control.
- Catastrophes: Given that a large proportion of the population breeds on Kauaʻi, catastrophic events like hurricanes could lead to extirpation.
- Breeding habitat loss: Habitat-modifying introduced plants such as Kahili Ginger and Australian Tree Fern are causing a reduction in available breeding habitat to the species on Kauaʻi.
- Improve Habitat: Improve colony locations, remoteness of colonies, as well as the habitat

they occur in (e.g., steep terrain or dense forest), complicates monitoring, predator and ungulate eradication or control.

CONSERVATION ACTIONS: Past and current actions include the SOS program which has recovered and released more than 31,000 downed fledgling shearwaters on Kauaʻi since 1978; presently all streetlights and some other types of lighting have been shielded on Kauaʻi; however, fallout still occurs and it is unknown whether these actions have improved survival. Fallout also occurs on Mauʻi. Current and future conservation efforts on Kauaʻi to benefit the ʻaʻo, ʻuaʻu (Hawaiian petrel), and ʻakēʻakē (band-rumped storm-petrel) include efforts to reduce and shield lighting, control predators and invasive species, and conduct surveys to locate additional colonies. In addition to these efforts, future actions specific to ʻaʻo should include the following:

- Continue predator and ungulate control at key colonies on Kauaʻi and the island of Hawaiʻi, and initiate predator control at other known and potential colony sites.
- Continue to support the initiatives of the SOS program, particularly its public outreach about light fallout and rescue and rehabilitation program, and maintain and strengthen similar programs on other islands where needed.
- Continue to identify areas where high fallout occurs, accurately estimate flight collision risk, and develop improved methods to minimize and mitigate the effects of powerlines and artificial lights.
- Eradicate or control invasive plants from current and potential colony sites.
- Prioritize restoration projects at occupied and unoccupied nesting areas based on likelihood of success and existing threats at each site.
- Develop methods, test, and implement social attraction and translocation in order to create safe, managed colonies.
- Develop partnerships with private landowners to assist conservation measures.
- Continue to explore poorly surveyed areas to locate and manage breeding colonies on islands with known breeding colonies

MONITORING: Conduct at-sea and terrestrial surveys in known and likely habitats to evaluate the population size and status. Monitor breeding incidence, breeding density, reproductive success, causes of mortality, population trends, return rates and effectiveness of management at breeding colonies. Assess the efficacy of predator control efforts.

RESEARCH PRIORITIES:

- Develop and implement standard survey and monitoring protocols that allow changes in population size and structure to be evident.
- Expand and refine radar studies to monitor population trends, locate colonies, and evaluate the effectiveness of conservation measures.
- Evaluate diet and at-sea distribution to determine the potential effects of fishing and food web changes related to climate and oceanographic factors, and provide input on spatial planning for marine protected areas.
- Expand long-term demographic studies to determine reproductive success, survival rates, and factors affecting the population.
- Determine effects of spectral content of night lighting on seabird distraction.
- Implement research to understand at-sea locations and behavior, and the impact of at-sea habitats and activities on population dynamics and life history traits.

- Investigate population genomic structure of the species across the Hawaiian Islands by using advanced sequencing technologies to evaluate genetic diversity, connectivity, and identify conservation management units.
- Develop research projects to evaluate the impact of current conservation and minimization actions on population viability.

References:

Ainley DG, Telfer TC, Reynolds MH. 1997. Newell's shearwater (*Puffinus auricularis*). *In* The Birds of North America, No. 297 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Holmes N, Friefeld H, Duvall F, Penniman J, Laut M, Creps N. 2011. Newell's Shearwater and Hawaiian Petrel Recovery: A Five-Year Action Plan. Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu, HI; Pacific Cooperative Studies Unit, Honolulu, HI; and U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Joyce, T. W. 2013. Personal communication. Scripps Institute of Oceanography, La Jolla, California.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2011. Newell's shearwater (*Puffinus auricularis newelli*). 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Seabirds

Christmas Shearwater

Puffinus nativitatis

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Ranking G3/G4 Vulnerable/Apparently secure, North American Water Bird Conservation Plan - High concern, Regional Seabird Conservation Plan - USFWS 2005, Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The Christmas shearwater is a medium-sized, dark-brown shearwater (Family: Procellaridae), with a short, wedge-shaped tail and a shiny, black bill. Adult males and females are entirely dark brown, although underparts are lighter than upperparts. Flight is characterized by fast, stiff wing beats, followed by long glides. Often forages in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. Christmas shearwaters feed from the surface by seizing prey while sitting on the water or by shallow pursuit plunges; also feeds by dipping or picking prey from the water while on the wing. Diet almost equally split between fish and squid (Ommastrephidae). Like most seabirds, Christmas shearwaters breed in their natal colonies, although colonies are often small, have high site fidelity, lay only one egg per season, and both parents participate in all aspects of raising young. In this species, divorce appears to occur at a higher frequency than in other seabirds. Christmas shearwaters nest in rock crevices or under dense vegetation. In Hawai‘i, eggs are laid beginning in February, and nestlings fledge in October or November. No post-fledging care is provided. Based on a small sample, age of first breeding is four years, and the oldest known individual was 17 years old.

DISTRIBUTION: Christmas shearwaters breed throughout NWHI, except for Necker Island and Gardner Pinnacles, and in MHI on offshore islets (e.g., Ka‘ula, Lehua, Moku Manu). Outside of Hawai‘i, Christmas shearwaters nest on islands throughout the central and eastern Pacific. Non-breeding distribution includes the eastern Pacific Ocean.

ABUNDANCE: In Hawai‘i, breeding colonies estimated at less than 3,000 pairs, with largest populations occurring on Laysan (1,500 - 2,000 pairs), Lisianski (400 - 600 pairs), Nihoa (200 - 250 pairs), and Midway Atoll (200 pairs). Worldwide population unknown but likely less than 10,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: The Christmas shearwater typically breeds on remote sandy islands in rock crevices or under dense vegetation, such as naupaka (*Scaevola sericea*), bunchgrass (*Eragrostis variabilis*), tree heliotrope (*Tournefortia argentea*), *Lepturus repens*, and beach morning glory (*Ipomea* spp.). Also has been known to nest in wooden debris, under buildings, or in abandoned burrows. Christmas shearwater eggs and young must be

shaded to protect them from lethal temperatures. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Invasive species: On Lisianski and Laysan, rabbits (*Oryctolagus cuniculus*) denuded the island reducing suitable nesting locations. Golden crown-beard (*Verbesina encelioides*) also degrades nesting habitat. Introduced big-headed ants (*Pheidole megacephala*) at Kure may cause nestling mortality, but also facilitate the destruction of native vegetation by a non-native scale insect.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of Christmas shearwaters should include the following:

- Eradication and control of introduced predators at current and potential nesting sites.
- Eradication and control of invasive species.
- Continued protection and management of existing wildlife sanctuaries and refuges.
- Translocations from the NWHI to the higher MHI sites above predicted sea level rise and within protected areas

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to the Christmas shearwater include the following:

- Conduct long-term demographic studies to determine population trends, survival rates, and reproductive success of this poorly known species.
- Updated population estimates.
- Locate foraging areas and determine non-breeding range and model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on Christmas shearwater populations.
- Determine effects of spectral content of night lighting on seabird distraction

References:

Hawai'i Natural Heritage Program [Hawai'i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai'i, Center for Conservation Research and Training. Honolulu, HI.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Seto NWH. 2001. Christmas shearwater (*Puffinus nativitatis*). *In* The Birds of North America, No. 561 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: David Leonard, USFWS

Seabirds

Manu-o-Kū or White (Fairy) Tern

Gygis alba

SPECIES STATUS:
State listed as Threatened, State recognized as Indigenous, NatureServe Heritage Rank G4 - Apparently secure, North American Waterbird Conservation Plan – Moderate concern, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The manu-o-Kū or white tern is a small, entirely white tern (Family: Laridae) with a pantropical distribution. Individuals have dark eyes and a thick, sharply pointed black bill with an electric blue base. Adult males and females are identical and there are no seasonal changes in plumage. Flight is buoyant and characterized by erratic changes in direction and speed. Manu-o-Kū (white tern) feed by dipping the surface or surface diving. Often joins mixed species feeding flocks and usually preys on fish driven to the surface by large, predatory fish. In Hawai‘i, the diet of white terns consists mostly of juvenile goatfish and flying fish. Breeding adults remain close to nest sites and forage in inshore areas such as shoals and banks with occasional forays into offshore waters. Not as colonial or social as most other terns, preferring to nest in loosely associated groups or singly. Manu-o-Kū (white tern) remain paired for several seasons and often return to the same nest site year after year. No nest is constructed; a single egg is laid wherever a suitable depression is found. Most nests are on tree branches, buildings, or other man-made structures, rock ledges, or on the ground. In Hawai‘i, manu-o-Kū or (white tern) breeds year-round, but most eggs are laid between February and June. Pairs will replace an egg after initial nest failure, and some successfully raise two or three broods per year. Both parents incubate egg and brood and feed the chick.
Fledglings are dependent on adults for up to two months. Birds first breed at five years of age, and the oldest known individual was 42 years old.

DISTRIBUTION: Manu-o-Kū (white tern) breed throughout the NWHI and on the island of O‘ahu. Outside of Hawai‘i, manu-o-Kū (white tern) breeds on islands throughout subtropical and tropical oceans, although breeding in the southern Atlantic Ocean is limited. Non-breeding distribution is unknown. Manu-o-Kū (white tern) typically remain near their breeding colonies year-round, seldom venturing far from shore.

ABUNDANCE: In the Hawaiian Archipelago, population is estimated at 15,000 breeding pairs, with largest populations occurring on Midway (7,500 pairs), Nihoa (5,000 pairs), and Laysan (1,000 pairs). On O‘ahu, the population continues to grow and is estimated to be 2,308 birds, including 1,408 breeders and ~900

nonbreeders, a dramatic increase from one bird in 1961 (Vanderwerf and Downs, 2018). Worldwide population unknown but likely exceeds 100,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Manu-o-Kū (white tern) breed on oceanic islands, both on low-lying coralline sand islands and high volcanic islands. Nests are not built, eggs are laid on whatever suitable depression is found. Nest sites include volcanic pinnacles, cliffs, rocky slopes, large bushes or trees, and man-made structures. **Marine**: Nearshore waters.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), barn owl, raptors and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats. However, given the remote nature of nesting sites (e.g., cliffs), manu-o-Kū (white terns) are less vulnerable to predation than many other seabirds. Historically, rats likely preyed on eggs, young and adults on Midway.
- Introduced insects: On Midway, big-headed ants (*Pheidole megacephala*) have been observed attacking pipped eggs and incubating adults. On Kure, introduced scale insects are killing native vegetation, but the effects on manu-o-Kū (white tern) are unknown.
- Overfishing: Because manu-o-Kū (white tern) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.
- Tree trimming: Tree maintenance and trimming in the MHI can cause take of nests and chicks affecting populations in the MHI.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In Hawai‘i, currently there are no ongoing management actions specific to manu-o-Kū (white tern).

- Establish populations on other MHI
- Outreach and coordination with arborist communities regarding safe and beneficial practices for white terns

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to the manu-o-Kū (white tern) include the following:

- Determine the effect of introduced invertebrates on nesting habitat and their potential for limiting populations.
- Understand predator threats and their impacts to nesting success rate of the species to inform management actions
- Research white tern movements across the islands to understand breeding range,

foraging range and inform management decisions.
- Understand post-fledgling behavior and survival of rehabbed and released birds to refine protocols of rescue and release of birds

References:

Eric A. VanderWerf and Richard E. Downs (2018). Current distribution, abundance, and breeding biology of White Terns (Gygis alba) on Oahu, Hawaii, The Wilson Journal of Ornithology 130(1):297–304

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Niethammer KR, Patrick-Castilaw LB. 1998. White tern (*Gygis alba*). *In* The Birds of North America, No. 371 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Forest and Kim Starr, USFWS

Seabirds

‘Ewa‘ewa or Sooty Tern

Sterna fuscata

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G5 – Secure, North American Waterbird Conservation Plan – Moderate concern, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The ‘ewa‘ewa or sooty tern is an abundant and gregarious tern (Family: Laridae) with a pantropical distribution, and is able to remain on the wing for years. Eight ‘ewa‘ewa (sooty tern) subspecies are recognized, and one (*S. f. oahuensis)* breeds in Hawai‘i. Individuals have long, slender wings and a deeply forked tail. Adult males and females are blackish above, except for white forehead and white on the edges of the outer most tail feathers, and entirely white below. The sharp bill, legs, and feet are black. Flight is characterized by powerful flapping, gliding and soaring, capable of long-distance migration and breeding adults remain aloft between breeding seasons. Generally forages in large mixed species feeding flocks, typically feeding over schools of predatory fishes, especially yellowfin tuna (*Neothunnus macropterus*) and skipjack tuna (*Katsuwonus pelamis*). ‘Ewa‘ewa (sooty tern) feed primarily by seizing prey from the water or air while on the wing, infrequently by shallow dives; species’ plumage has poor waterproofing and easily becomes waterlogged. In Hawai‘i, ‘ewa‘ewa (sooty tern) diet consists of squid, goatfish, flyingfish, and mackerel scad. Nests in large, dense colonies consisting of thousands to a million pairs of terns. Individuals return to natal colony to breed, some long-term pair bonds have been documented, and breeders prefer to return to previous nest locations. Nests are shallow scrapes often lined with bits of shell or vegetation. Timing of breeding varies among years and locations, even within Hawai‘i, but generally eggs are laid beginning of February and most birds fledge by July. Both parents incubate single egg and brood and feed chick. Parents continue feeding young for two weeks after fledging and young remain aloft until they return to breed. Birds first breed between four and ten years of age and the oldest known individual was 32 years old.

DISTRIBUTION: ‘Ewa‘ewa (sooty tern) breed throughout the NWHI and on Moku Manu off of the island of O‘ahu. Outside of Hawai‘i, ‘ewa‘ewa (sooty tern) breed on most islands throughout the world’s tropical oceans. Outside the breeding season, ‘ewa‘ewa (sooty tern) are highly pelagic.

ABUNDANCE: In Hawai‘i, population estimated at greater than one million breeding pairs with the largest populations occurring on Laysan (500,000 pairs) and Lisianski (500,000 pairs). Worldwide population is estimated at between 60 and 80 million breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ‘Ewa‘ewa (sooty tern) breed on oceanic islands and atolls. Nest is usually on sandy substrates with sparse vegetation. **Marine**: Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Native predators: ‘Iwa or great frigatebirds (*Fregata minor*), cattle egrets (*Bubulcus ibis*), ‘akekeke or ruddy turnstones, (*Arenaria interpres*) ‘auku‘u or black-crowned night herons (*Nycticorax nycticorax*), Laysan (*Telespiza cantans*) and Nihoa (*T. ultima*) finches will depredate eggs and chicks.
- Overfishing: Because ‘ewa‘ewa (sooty terns) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.
- Oil pollution: ‘Ewa‘ewa (sooty terns) populations are vulnerable to oil spills.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ‘ewa ‘ewa (sooty terns) should include the following:

- Eradication and control of introduced predators at current and potential nesting sites.
- Continued protection and management of existing wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ‘ewa‘ewa (sooty terns) include the following:

- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on ‘ewa‘ewa (sooty terns) populations.

References:

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Schreiber EA, Feare DJ, Harrington BA, Murray BG, Robertson WB, Robertson MJ, Woolfenden GE. 2002. Sooty tern (*Sterna fuscata*). *In* The Birds of North America, No. 665 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Seabirds

Pākalakala or Gray-backed Tern

Sterna lunata

SPECIES STATUS:
State recognized as Indigenous NatureServe Heritage Rank G3/G4 – Vulnerable/Apparently secure North American Waterbird Conservation Plan - Moderate concern Regional Seabird Conservation Plan - USFWS 2005, Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The pākalakala or gray-backed tern (Family: Laridae) is endemic to the central Pacific and breeds on small and remote islands and atolls, however, its historical and current distribution are poorly known. Adults are mostly slate gray above and white below with a black crown and nape. Forehead has a narrow white patch that is continuous with white eye-brow that extends above and past eye and is completely bordered with black. Flight is direct and graceful and body appears to move up and down with each wing beat. Outside the breeding season, may remain in flight continuously. Often forages with ʻewaʻewa or sooty terns (*S. fuscata*) and ʻuaʻu kani or wedge-tailed shearwaters (*Puffinus pacificus*). Pākalakala (gray-backed terns) feed mainly by plunge diving or by dipping the surface while hovering.
Diet primarily consists of fish, especially five-horned cowfish, juvenile flyingfish, goatfish, herring, and dolphinfish, but also eats squid, crustaceans, mollusks, and marine and terrestrial insects. Pākalakala (gray-backed terns) nest in shallow depressions in sand or gravel, and like most seabirds lay a single egg per season. In Hawaiʻi, nesting season varies from year to year, but most eggs are laid in February and March and most nestlings fledge by late July. Both males and females incubate egg, and brood and feed the chick. Oldest known bird was 25 years old.

DISTRIBUTION: Pākalakala (gray-backed terns) breed throughout NWHI, and a few pairs have been recorded breeding on Moku Manu off of the island of Oʻahu. Outside of Hawaiʻi, pākalakala (gray-backed terns) nest on the Marianas, Howland and Baker, Johnston, Wake, Jarvis, Line Islands, American Samoa, the Marquesas, and Tuamotu. Non-breeding distribution includes the central Pacific Ocean.

ABUNDANCE: In Hawaiʻi, population estimated at 44,000 breeding pairs, with largest populations occurring on Lisianski (20,000 pairs), Nihoa (12,000 pairs), and Laysan (10,000 pairs). Worldwide population unknown but likely on the order of 70,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Pākalakala (gray-backed terns) breed on remote islands and atolls. Nests are constructed in a variety of habitats (e.g., rocky ledges, open, sandy beaches) but usually at the base of shrubs or refuse. On Midway and Kure, individuals' nest on runways. Nests are typically shallow depressions in sand or gravel and

in surf zones, making them vulnerable to storm tides. **Marine**: Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Human disturbance: Pākalakala (gray-backed terns) are sensitive to nest disturbance, and flush from nests when humans approach. Exposed eggs and chicks are vulnerable to predation by ʻiwa or great figatebirds (*Fregata minor*), ʻakekeke or ruddy turnstones (*Arenaria interpres*), kioea or bristle-thighed curlews (*Numenius tahitiensis*), and Laysan (*Telespiza cantans*) and Nihoa (*T. ultima*) finches.
- Manmade structures: On Kure, collisions with man-made structures have resulted in mortality.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of pākalakala (gray-backed terns) should include the following:

- Eradicate cats, mice (*Mus musculus*), and rats from islets off MHI.
- Protect colonies from human disturbance.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to the pākalakala (gray-backed tern) include the following:

- Long-term demographic studies are needed to determine population trends, survival rates, and reproductive success.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

Mostello CS, Palaia NA, Clapp RB. 2000. Gray-backed tern (*Sterna lunata*). *In* The Birds of North America, No. 525 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: USFWS

Seabirds

Noio or Black Noddy

Anous minutus

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G5 – Secure, North American Waterbird Conservation Plan –Moderate concern, Regional Seabird Conservation Plan USFWS 2005, Bird of Conservation Concern - 2021

SPECIES INFORMATION: The noio or black noddy is a medium-sized, abundant, and gregarious tern (Family: Laridae) with a pantropical distribution. Seven noio (black noddy) subspecies are generally recognized, and two are resident in Hawai‘i: *A. s. melanogenys* (MHI) and *A. s. marcusi* (NWHI). Individuals have slender wings, a wedge-shaped tail, and black bill which is slightly decurved. Adult males and females are sooty black with a white cap and have reddish brown to bright orange legs and feet; bill droops slightly. Flight is swift with rapid wing beats and usually direct and low over the ocean; this species almost never soars high. Often forages in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. Noio (black noddy) generally forage in nearshore waters and feeds mainly by dipping the surface from the wing or by making shallow dives. Opportunistic, in Hawai‘i, noio (black noddy) primarily takes juvenile goatfish, lizardfish, herring, flyingfish, and gobies. Nests in large, dense colonies that include non-breeding juvenile birds. Established pairs return to the same nest site year after year. Breeding is highly variable and egg laying occurs year-round. Both parents incubate single egg, and brood and feed chick. Birds first breed at two to three years of age, and the oldest known individual was 25 years old.

DISTRIBUTION: Noio (black noddy) breed throughout the Hawaiian Archipelago, including all islands of NWHI and the coastal cliffs, sea caves and offshore islets of MHI. Outside of Hawai‘i, noio (black noddy) breed on islands throughout the world’s tropical oceans. Noio (black noddy) typically remain near (within 80 kilometers [50 miles]) their breeding colonies year-round.

ABUNDANCE: In Hawai‘i, population estimated at 12,000 breeding pairs with the largest populations occurring on Midway Atoll (6,000 pairs) and Nihoa (5,000 pairs). Worldwide population is estimated at 1,000,000 to 1,500,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Noio (black noddy) breed on oceanic and offshore islands, both on low-lying coralline sand islands and high volcanic islands. In Hawai‘i, noio (black noddy) place their nests on ledges and in crevices of coastal cliffs, in sea caves, and in ironwood (*Casuarina* spp.) trees. **Marine**: Nearshore waters.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats, however the MHI support large populations of non-native mammalian predators.
- Native predators: ʻIwa or great frigatebirds (*Fregata minor*), Laysan Finches (*Telespiza cantans*), and shorebirds will depredate eggs and chicks. Barn Owls potentially predate on Noio/Noio Kōhā at the breeding locations.
- Habitat degradation. Non-native vegetation such as golden crown-beard (*Verbesina encelioides*) can alter potential nesting habitat and the removal of non-native ironwood trees from Midway could result in a reduction in nest sites.
- Human disturbance: Kayak and zodiac tours of sea caves used for nest sites can result in adults flushing from nests, resulting in predation by native birds.
- Nearshore pollution: Because noio (black noddy) forage close to shore, oil spills and dumping of waste may be more important to this species than those that forage far offshore. Oiled individuals are regularly seen in the NHWI.
- Overfishing: Because noio (black noddy) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of noio (black noddy) should include the following:

- Eradicate golden crown-beard and other exotic species on all islands used for breeding, especially those that can change the structure of the existing vegetation (e.g., scale insects).
- Eradication and control of introduced predators at current and potential breeding colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to noio (black noddy) include the following:

- Conduct long-term banding and demographic studies to determine dispersal dynamics and demographic parameters.
- Determine the source of oil affecting birds in the NWHI.
- Determine the significance of recreational activities (e.g., kayaking), and if appropriate determine protocols to reduce disturbance.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on noio (black noddy) populations.

References:

Gauger VH. 1999. Black noddy (*Anous minutus*). *In* The Birds of North America, No. 412 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Forest and Kim Starr, USFWS

Seabirds

Noio Kōhā or Brown Noddy

Anous stolidus

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G5 – Secure, North American Waterbird Conservation Plan – Not currently at risk, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The noio kōhā or brown noddy is a medium-sized, abundant tern (Family: Laridae) with a pantropical distribution, and is very similar to noio (black noddy) in appearance and behavior. Five subspecies of noio kōhā (brown noddy) are recognized, and one (*A. s. pileatus*) is resident in Hawai‘i. Individuals have slender wings and a wedge-shaped tail. Adult males and females are dark brown with a white cap and have a black bill, legs, and feet; males are larger than females. Flight is swift with rapid wing beats and usually direct and low over the ocean, this species almost never soars high. Often forages in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. Noio kōhā (brown noddy) generally forage in nearshore waters and mainly feed by dipping the surface from the wing or by making shallow dives. In Hawai‘i, diet is comprised mostly of fish, but squid are also taken. Breed in large, dense colonies and nest on the ground, on cliffs or in trees. In Hawai‘i, breeding is synchronous with peaks occurring in the spring and summer.
Pairs stay together throughout the year, but there is little information on the length of pair bonds. Both parents incubate the single egg, and brood and feed chick. Birds first breed at three to seven years of age, and the oldest known individual was 25 years old.

DISTRIBUTION: Noio kōhā (brown noddy) breed throughout the Hawaiian Archipelago, including all islands of NWHI and the offshore islets of MHI. Outside of Hawai‘i, noio kōhā (brown noddy) breed on island in the tropical Atlantic and Pacific oceans. Noio kōhā (brown noddy) typically remain near (within 100 kilometers [62 miles]) their breeding colonies year-round.

ABUNDANCE: In Hawai‘i, population estimated at 112,000 breeding pairs with the largest populations occurring on Nihoa (35,000 pairs) and Ka‘ula (35,000 pairs). Worldwide population is estimated 500,000 to 1,000,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Noio kōhā (brown noddy) breed on small islands or islets, both on low-lying coralline sand islands and high volcanic islands and use a wide variety of nesting locations, including the ground, trees, shrubs, cliffs and human-made structures. In Hawai‘i, nests are predominantly located on open ground or under vegetation, or on human-made structures. **Marine:** Nearshore waters.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats. Barn Owls potentially predate on Noio/Noio Kōhā at the breeding locations.
- Native predators: ʻIwa or great figatebirds (*Fregata minor*), ʻaukuʻu or black-crowned night herons (*Nycticorax nycticorax*), and Laysan (*Telespiza cantans*) and Nihoa (*T. ultima*) finches will depredate eggs and chicks, especially when adults are flushed from nests by human disturbance.
- Overfishing: Because noio kōhā (brown noddy) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of noio kōhā (brown noddy) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to noio kōhā (brown noddy) include the following:

- Conduct long-term banding and demographic studies to determine dispersal dynamics and demographic parameters.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on noio kōhā (brown noddy) populations.

References:

Chardine JW, Morris RD. 1996. Brown noddy (*Anous stolidus*). *In* The Birds of North America, No. 220 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife

Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Seabirds

Blue-gray Noddy

Procelsterna cerulean

SPECIES STATUS:
State recognized as Indigenous,
NatureServe Heritage Rank G4 Apparently secure,
North American Waterbird Conservation Plan - High concern
Regional Seabird Conservation Plan - USFWS 2005 ,
Bird of Conservation Concern - USFWS 2021

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G4 Apparently secure, North American Waterbird Conservation Plan - High concern Regional Seabird Conservation Plan - USFWS 2005, Bird of Conservation Concern - USFWS 2021SPECIES INFORMATION: The blue-gray noddy or Necker Island tern is the world's smallest tern (Family: Laridae) and is widely distributed across the Pacific. Five subspecies are recognized, and one (*P. c. saxatilis*), is resident in Hawai‘i. Adult males and females are entirely bluish gray and have a partial white eye-ring, a short, slender bill, and a shallow forked tail.

Flight is characterized by constant and rapid wing beats. The blue-gray noddy feeds nearshore, often with other species, by hover-dipping and surface-dipping. The species captures the smallest prey of any Hawaiian seabird, mainly larval lizardfishes, flounders, goatfishes, and flyingfish, as well as squid, crustaceans, and insects. Blue-gray noddies use a variety of substrates for nesting. In Hawai‘i, they nest in aggregations among cavities or crevices in lava flows. In Hawai‘i, nesting appear to occur throughout the year, and eggs have been found March through September. Little is known about the breeding behavior or biology of the blue- gray noddy. The oldest known bird was 11 years old, but blue-gray noddies likely live longer.

DISTRIBUTION: Blue-gray noddies breed mainly on Necker and Nihoa, but small colonies also are present on La Perouse Pinnacle, French Frigate Shoals, and Gardner Pinnacles. Historically the species bred on Ka‘ula Island off of Ni‘ihau. Outside of Hawai‘i, blue-gray noddies nest on islands throughout the Pacific Ocean. Blue-gray noddies typically remain near their breeding colonies year-round, and are rarely found far from land.

ABUNDANCE: In Hawai‘i, population estimated at 3,600 breeding pairs with 3,500 pairs on Necker and Nihoa combined. Worldwide population estimated at 100,000 breeding pairs, but inaccessible nesting locations make accurate counts difficult.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Blue-gray noddies breed on remote islands and atolls. They nest on a variety of substrates, but in NHWI mostly use crevices or cavities in ancient lava flows. Currently all breeding colonies in Hawai‘i occur in the Hawaiian Islands National Wildlife Refuge or the Midway Atoll National Wildlife Refuge.

Marine: Nearshore waters.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Native predators: On Nihoa and Laysan, native finches (*Telespiza* spp.) are responsible for considerable egg mortality.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of blue-gray noddy should include the following:

- Continue protection and management of wildlife sanctuaries and refuges.
- Conduct social attraction to protected areas in the MHI.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to the blue gray-noddy include the following:

- Development and implementation of standardized survey protocols to determine current population size and status.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Holly Freifeld, USFWS

Seabirds

ʻĀ or Masked Booby
Sula dactylatra

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Ranking G5 – Secure, North American Waterbird Conservation Plan - Moderate concern, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The ʻā or masked booby is the largest booby (Family: Sulidae), and like its Hawaiian congeners, has a pantropical distribution. Four ʻā (masked bobby) subspecies are recognized, and one (*S. d. personata*) is resident in Hawaiʻi. Individuals have long, pointed wings and a short, wedge-shaped tail. Adult males and females are overall white, except for a brownish black tail, black trailing wing edges and black facial skin around the bill. Large bill varies in color from yellow to orange and is brighter in males; females are larger than males.

Flight is characterized by strong flapping interspersed with gliding, rhythmically ascending with flapping and descending while gliding. ʻĀ (masked booby) forage alone or in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. Forages as far as 150 kilometers (90 miles) from shore, and ʻā (masked booby) captures prey by plunge-diving from up to 30 meters (100 feet) over the water, often diving to a depth of three to four meters (10 – 13 feet). In Hawaiʻi, diet is comprised almost entirely of fish, primarily flyingfish and jacks. ʻĀ (masked booby) breed in dense colonies and most return to their natal colony to breed, and at Kure at least 45 percent of pairs remained together through a second breeding season. Nest on open ground often near a cliff edge or on low sandy beaches; eggs are laid in a shallow scrape. Unlike most seabirds, ʻā (masked boobies) typically lay two eggs per breeding season. The eggs hatch asynchronously, and the first chick to hatch usually pushes the other sibling out of the nest. In Hawaiʻi, breeding season is synchronous, and eggs are laid between January and July and young fledge five months after eggs are laid. Both parents incubate eggs, and brood and feed chicks. Adults continue to feed young up to six months after fledging. Birds first breed at three to four years of age and the oldest known individual was 20 years old.

DISTRIBUTION: ʻĀ (masked booby) breeds mainly in NWHI, but also breeds in MHI on Kaʻula, Lehua, and Moku Manu. Outside of Hawaiʻi, ʻā (masked booby) breed on islands in the tropical waters of the Pacific and Atlantic oceans and the Red Sea. Outside the breeding season birds are most common near their breeding colonies, but individuals may wander thousands of kilometers from colonies.

ABUNDANCE: In Hawaiʻi, population estimated at 2,500 breeding pairs with most occurring

on NHWI; approximately 450 pairs breed in the MHI. The worldwide population is estimated at several hundred thousand birds.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ʻĀ (masked boobies) breed on small islands or islets, both on low-lying coralline sand islands and high volcanic islands, nesting in the open on sandy beaches or on cliff ledges. **Marine***:* Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Non-native plants: Invasive plants, mainly golden crown-beard (*Verbesina encelioides*), has resulted in loss of nesting habitat.
- Human disturbance: Pairs often susceptible to human disturbance.
- Overfishing: Because ʻā (masked booby) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ʻā (masked booby) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Eradication of golden crown-beard, especially from Midway Atoll, Kure, and Pearl and Hermes.
- Limit human disturbance to colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ʻā (masked booby) include the following:

- Long-term banding and demographic studies are needed to determine dispersal patterns and demographic parameters.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on to ʻā (masked booby) populations.

References:

Anderson DJ. 1993. Masked booby (*Sula dactylatra*). *In* The Birds of North America, No. 73 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: USFWS

ʻĀ or Brown Booby
Sula leucogaster

SPECIES STATUS:
State recognized as Indigenous, State NatureServe Heritage Rank G5 – Secure, North American Waterbird Conservation Plan – Moderate concern, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The ʻā or brown booby is a large, striking seabird (Family: Sulidae) with a pantropical distribution. Four ʻā (brown booby) subspecies are recognized, and two (*S. l. plotus & S.l. brewsteri*) are resident in Hawaiʻi. Individuals have long pointed wings and a relatively short, wedge-shaped tail. Adult males and females are overall dark brown, with white belly and underwings with a sharp demarcation across lower breast between the white of belly and brown of neck. Large bill and legs and feet are yellow in females and grayish-green in males; females are larger than males. Flight is characterized by strong flapping interspersed with gliding. Will forage alone, but most often forages in large, mixed species flocks associated with schools of large predatory fishes which drive prey species to the surface. ʻĀ (brown booby) generally forages in nearshore waters and captures prey by plunge-diving from one to 15 meters (3 – 50 feet) above the water, often remaining underwater for 25 to 40 seconds. In Hawaiʻi, diet is comprised of flying fish, squid, mackerel scad, juvenile goatfish, and anchovy.
Nest in small colonies of tens to hundreds of pairs and most return to natal colony to breed. ʻĀ (brown booby) is the only ground nesting booby that builds a nest, and its construction is an important part of courtship. Nests are constructed from whatever is available including branches, seabird bones, and human debris. Unlike most seabirds, ʻā (brown booby) typically lays two eggs per breeding season. The eggs hatch asynchronously, and the first chick to hatch usually pushes the other sibling out of the nest. In Hawaiʻi, peak egg laying occurs between March and May and chicks fledge by September. Both parents incubate eggs and brood and feed chicks. Adults continue to feed young up to 37 weeks after fledging. Birds first breed at four to five years of age and the oldest known individual was 26 years old.

DISTRIBUTION: ʻĀ (brown booby) breed throughout the NWHI and in MHI on offshore islets (e.g., Moku Manu, Lehua), on Moku Mana at Pauwalu Point Seabird Sanctuary on Maui, and possibly on the island of Oʻahu on the cliffs of Ulupaʻu Head at the Kāneʻohe Bay Marine Corps Base. Outside of Hawaiʻi, ʻā (brown booby) breed on islands in the tropical waters of the Pacific, Indian, and Atlantic oceans, the Caribbean and Red seas, and seas north of Australia. Little is known about movements and distribution outside the breeding season.

ABUNDANCE: In Hawaiʻi, population estimated at 1,400 breeding pairs with the largest population occurring on Lehua. Worldwide population estimate for *S. l. plotus* is 50,000 to 70,000 breeding pairs.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ʻĀ (brown booby) breed on small islands or islets, both on low-lying coralline sand islands and high volcanic islands, nesting on open ground or on cliff ledges. **Marine:** Nearshore waters.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Human disturbance: Newly formed pairs are often very susceptible to human disturbance.
- Overfishing: Because ʻā (brown booby) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ʻā (brown booby) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Limit human disturbance in colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ʻā (brown booby) include the following:

- Long-term banding and demographic studies are needed to determine dispersal patterns and demographic parameters.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the long-term effects of overfishing on ʻā (brown booby) populations.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Schreiber EA, Norton RL. 2002. Brown booby (*Sula leucogaster*). *In* The Birds of North America, No. 649 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The

American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

ʻĀ or Red-Footed Booby

Sula sula

Photo: Jack Jeffery

SPECIES STATUS:
State recognized as Indigenous, NatureServe Heritage Rank G5 – Secure, North American Waterbird Conservation Plan –Not at risk, Regional Seabird Conservation Plan - USFWS 2005

SPECIES INFORMATION: The ʻā or red-footed booby is the smallest booby (Family: Sulidae), and like its Hawaiian congeners has a pantropical distribution. Three ʻā (red-footed booby) subspecies are recognized, and one (*S. s. rubripes*) is resident in Hawaiʻi. Individuals have long pointed wings and a relatively long, wedge-shaped tail. Several color phases exist, ranging from all brown to all white; almost all Hawaiian birds are white. Adult male and females are overall white, except for brownish black primary and secondary wing feathers; females are larger than males. Feet and legs orange to red, bill bluish except for base of lower mandible which is pinkish, and facial skin around bill ranges from pink to red and blue. Flight is characterized by strong flapping interspersed with gliding; may glide for long distances. ʻĀ (red-footed booby) forage alone or in mixed species feeding flocks, generally feeding further from land than congeners. ʻĀ (red-footed booby) capture prey by plunge-diving generally from four to eight meters (13 – 26 feet) over the water. In Hawaiʻi, diet is mainly comprised of flyingfish and squid, but also includes mackerel scads, saury, and anchovies. ʻĀ (red-footed booby) breed in colonies ranging from ten to ten thousand pairs and pairs generally retain mates throughout several breeding seasons. Unlike other boobies, ʻā (red-footed booby) roost and build nests in shrubs or trees. In Hawaiʻi, breeding season is synchronous, but can occur throughout the year. Egg laying peaks in February through April and most young have fledged by September. Both parents incubate egg, and brood and feed chick. Adults continue to feed young up to four months after fledging. Birds first breed at three to four years of age and the oldest known individual was 22 years old.

DISTRIBUTION: ʻĀ (red-footed booby) breed throughout the NWHI and at a limited number of sites on MHI including Kīlauea Point National Wildlife Refuge on Kauaʻi, the cliffs of Ulupaʻu Head at the Kāneʻohe Bay Marine Corps Base on Oʻahu, and on offshore islets including Moku Manu and Lehua; on Maui about 1000 birds arrived in 2018 at Pauwalu Point Seabird Sanctuary and continue to breed there as well as some birds on Moku Mana. Outside of Hawaiʻi, ʻā (red-footed booby) breed on islands in the tropical waters of the Pacific, Indian, and Atlantic oceans, Caribbean Sea, and seas north of Australia. Little is known about the movements of the ʻā (red-footed booby) outside nesting season, but birds in Hawaiʻi appear to disperse eastward and move between islands.

ABUNDANCE: In Hawai‘i, population estimated at between 7,000 and 10,500 breeding pairs. The worldwide population is estimated at less than 300,000 breeding pairs, with the majority residing in the eastern Pacific.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ‘Ā (red-footed booby) breed on small islands or islets, both on low-lying coralline sand islands and high volcanic islands. Nest in bushes or trees, including beach magnolia (*Scaevola sericea*), ironwood (Casurina equisitafolia), strawberry guava (Psidium cattleanum), Hau (Hibiscus tiliaceus), and beach heliotrope (*Tournefortia argentea*). Will occasionally nest on deserted man-made structures, on bare ground, or on low piles of vegetation. Builds nest of twigs, grass, and other vegetation. **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests are susceptible to predation by rats (*Rattus* spp.), and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Invasive species: Introduced big-headed ants (*Pheidole megacephala*) at Kure may facilitate the destruction of native vegetation by a non-native scale insect, thus reducing nesting habitat.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ‘ā (red-footed booby) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Eradication of invasive species that may alter ‘ā (red-footed boobies) nesting habitat (e.g., scale insects).
- Limit human disturbance in colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ‘ā (red-footed booby) include the following:

- Long-term banding and demographic studies are needed to determine dispersal patterns and demographic parameters.

References:

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation

plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

Schreiber EA, Schreiber RW, Schenk GA. 1996. Red-footed booby (*Sula sula*). *In* The Birds of North America, No. 241 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: David Smith

Seabirds

Iwa or Great Frigatebird

Fregata minor

SPECIES STATUS:
State recognized as Indigenous,
NatureServe Heritage Rank G4 – Apparently secure,
North American Waterbird Conservation Plan – Moderate concern,
Regional Seabird Conservation Plan – USFWS 2005 ,
Bird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The ʻiwa or great frigatebird is a large, graceful seabird (Family: Fregatidae) related to boobies and tropicbirds, with a pantropical distribution. Five ʻiwa (great frigatebird) subspecies are recognized, and one (*F. m. palmerstoni*) breeds in Hawaiʻi. Individuals have slim bodies, a long deeply forked tail, a long-hooked bill, and almost useless legs and feet. Adult males are almost entirely black, with varying amounts of a dark green sheen on head and neck; during courtship males inflate large, red gular pouch. Adult females are larger than males, and are black with a white breast patch and a gray throat; both sexes may have a buff bar on the upper surface of wings. Flight is characterized by long periods of soaring. An adept aerial flier, the species obtains some of its food by harassing other seabirds until they regurgitate their prey. Although ʻiwa (great frigatebird) captures most of its own prey, this behavior inspired both its Hawaiian and English names: ʻiwa means "thief" and "frigate" refers to the fast ships used by pirates. Often feeds far from land alone or in pairs, but will join mixed species feeding flocks, especially ʻewaʻewa or sooty terns (*Sterna fuscatata*) and ʻuaʻu kani or wedge-tailed shearwaters (Ardenna *pacifica*), feeding over schools of predatory fishes. ʻIwa (great frigatebird) take prey on the wing, seizing it by dipping bill into water or from the air. In Hawaiʻi, diet primarily consists of flyingfish and squid. Nests in colonies, often with other species, ranging from ten to thousands of pairs, and constructs platform nests in low bushes. Unlike many seabirds, pairs usually switch partners every breeding season, likely because females often only nest every two to four years. Both parents incubate single egg, and brood and feed chick. Post-fledging feeding is provided by female for up to 18 months. Birds first breed at eight to ten years of age, and the oldest known individual was 37 years old.

DISTRIBUTION: ʻIwa (great frigatebird) breed throughout the NWHI. Large numbers roost on offshore islets of the MHI, but breeding has not been documented. Outside of Hawaiʻi, ʻiwa (great frigatebird) nest on islands mainly in the tropical Atlantic, Indian, and Pacific oceans. Outside the breeding season, adults remain relatively close to breeding colonies, but young and nonbreeders disperse throughout tropical oceans.

ABUNDANCE: In Hawai‘i, population is estimated at 10,000 breeding pairs with the largest breeding colonies occurring on Nihoa (3,500 – 4,500 pairs) and Laysan (2,000 - 2,500 pairs). Smaller colonies in NWHI include French Frigate Shoals (350 –3 75 pairs), Necker (700 - 900 pairs), Lisianski (750 – 850 pairs), Pearl and Hermes Atoll (300 – 400 pairs), and Kure Atoll (200 -250 pairs). Worldwide population is estimated at 500,000 – 1,000,000 individuals. Numbers at roost locations in MHI include Moku Manu (0 - 1 pairs), Ka‘ula (250 – 350 pairs), and Lehua (5 - 10 pairs).

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: ‘Iwa (great frigatebird) breed and roost on small remote islands, typically within regions with tradewinds. Builds nests in the tops of various species of bushes and trees, including beach naupaka (*Scaevola sericea*), beach heliotrope (*Tournefortia argentea*), pisonia trees (*Pisonia grandis*), and mangrove trees (*Brugiera* spp., *Rhizophora* spp.) **Marine:** Pelagic.

THREATS:

- Introduced predators: Like all seabirds, adults and nests susceptible to predation by rats (*Rattus* spp.) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.
- Habitat degradation: Introduced herbivores, insects, and plants can degrade native vegetation used for nesting. Rabbits (*Oryctolagus cuniculus*) denuded vegetation on Laysan, Lisianski, and Lehua islands greatly reducing nesting habitat; with the eradication of rabbits, Laysan and Lisianski have since recovered and support large colonies.
- Overfishing: Because ‘iwa (great frigatebird) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.

CONSERVATION ACTIONS: The following management goals are important to Pacific seabird conservation: maintain, protect, and enhance habitat; eradicate or control non-natives; minimize bycatch and other negative effects of fishing; improve the effectiveness of oil spill response efforts; identify contaminates and hazardous substances; and minimize the effects of powerlines, towers, wind turbines and lights (USFWS 2005). The goal of these management actions is not only to protect seabird populations and their breeding colonies, but also to re-establish former breeding colonies thereby reducing the risk of extinction. In addition to these efforts, future management specific to Hawaiian populations of ‘iwa (great frigatebird) should include the following:

- Eradication and control of introduced predators at current and potential breeding colonies.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Most research priorities for seabirds are related to determining the most appropriate methods for achieving the above goals**.** Research priorities specific to ‘iwa (great frigatebird) should include the following:

- Surveys of colonies to determine current population status.
- Model interactions and importance of predatory fish, seabirds, and their prey to determine the

long-term effects of overfishing on ʻiwa (great frigatebird) populations.

References:

Metz VG, Schreiber EA. 2002. Great frigatebird (*Fregata minor*) *In* The Birds of North America, No. 681 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

Photo: Forest and Kim Starr, USFWS

Seabirds

Short-tailed albatross

Phoebastria albatrus

SPECIES STATUS:
Federally Listed as Endangered, State Listed as Endangered, NatureServe Heritage Rank G1 – Critically Imperiled, IUCN Red List Ranking – Vulnera

SPECIES INFORMATION: The short-tailed albatross is the largest seabird (Family: Diomedeidae) found in Hawai‘i. Adult males and females are mostly white, with varying amounts of black, mostly on the upper side of the wings, and a golden wash on the head. Huge pink bill has a bluish tip and legs and feet are pale pink. Like other albatrosses, they use air currents to glide and soar for long periods of time and feed by seizing prey from the surface while sitting on the water. They forage closer to land than other albatross species. Scavenges from carrion and follows fishing boats. In Japan, their diet consists primarily of shrimp, squid, and fish, including bonita, flyingfish, and sardines. As far back as the 1930s, individuals have occurred among nesting mōlī or Laysan (*P. immutabilis*) and ka‘upu or black-footed (*P. nigripes*) albatross at Midway Atoll. See fact sheets for mōlī or ka‘upu for details of breeding biology.
Like other albatrosses, the short-tailed albatross likely has a life span of at least 50 years.

DISTRIBUTION: Small numbers of birds nest on Midway Atoll and visit Kure Atoll in the Northwestern Hawaiian Islands. Outside of Hawai‘i, the species nests on several small islands offshore of Japan. At sea, the short-tailed albatross ranges widely across the north Pacific Ocean.

ABUNDANCE: The worldwide population is estimated at 4,350 individuals, with an increasing population trend. The population in the Hawaiian Islands is very small; one pair has nested at Midway Atoll since 2011, and another pair (suspected female-female pair) has attempted to breed at Kure Atoll since 2010.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial: Nests on islands and atolls. Nests are similar to other albatross species. **Marine**: Pelagic.

THREATS: The primary threat to this species is the limited breeding distribution, and a catastrophic event at one of the main colonies could have detrimental effect on the population. Other threats to the short-tailed albatross include the following:

- Human disturbance and conflict: Historically the most common albatross in the north

Pacific Ocean, the species' population numbered in the millions. By the 1930s the short-tailed albatross was thought to be extinct as a result of wanton killing for their feathers (millinery trade).

- Fishery bycatch: U.S. longline fisheries bycatch has been greatly reduced in the last 10-20 years and associated mortalities is thought to be infrequent and low. However, the amount of bycatch mortality from fisheries outside of U.S. waters is relatively unknown and remains a potential threat to the species.
- Marine pollution: As is true for other albatrosses, ingestion of plastic debris and toxic effects of oil, metals, mercury, and persistent organic pollutants are threats.
- Catastrophic events: Volcanic eruptions, earthquakes, landslides, and typhoons at breeding colonies have caused reproductive failures on nesting colonies in Japan.

CONSERVATION ACTIONS: Conservation actions for short-tailed albatross should include the following:

- Continue social attraction project (e.g., decoys and playing of vocalizations) to establish a breeding population on Midway and Kure Atoll.
- Continue efforts to reduce fisheries-related seabird bycatch.
- Continue protection and management of existing wildlife sanctuaries and refuges.

MONITORING: Continue satellite tracking of short-tailed albatross to determine at-sea distribution. Continue monitoring of nesting pairs on Midway Atoll and Kure Atoll.

RESEARCH PRIORITIES:

- Estimate annual mortality from U.S. and foreign fisheries bycatch and use demographic models to determine the effect of this mortality on population.
- Research and develop techniques and gear to minimize seabird bycatch.
- Evaluate molting behavior and assess potential vulnerability to oil spills or collisions with vessels during molt.
- Evaluate potential changes to prey availability as a result of climate change.
- Conduct contaminants analyses on addled eggs, feathers, and dead birds as they are available.

References:

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2008. Short-tailed Albatross Recovery Plan. Anchorage, Alaska.

U.S. Fish and Wildlife Service. 2014. Short-tailed Albatross (*Phoebastria albatrus*). 5-Year Review: Summary and Evaluation. Anchorage, Alaska.

VanderWerf, EA. 2012. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, Hawai‘i.

Photo: DOFAW

Migratory Birds

Kōlea or Pacific Golden-Plover

Pluvialis fulva

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan - High concern

SPECIES INFORMATION: The Kōlea or Pacific golden-plover is a moderately small yellow- and-buff mottled shorebird (Family: Charadriidae) which winters in the Main Hawaiian Islands (MHI) and breeds in Siberia and westernmost Alaska. Most adults arrive in Hawai‘i in August, while juveniles arrive in October; spring departures begin in late April. Kōlea feed primarily on terrestrial insects such as cockroaches, moths, caterpillars, and earwigs, all of which they locate by sight. During the breeding season, they are also known to eat berries, leaves, and seeds.
Kōlea show high site fidelity to wintering grounds and will chase intruders from their territories while foraging. Hawai‘i is thought to support a large proportion of the world’s wintering Kōlea population.

DISTRIBUTION: Kōlea winter across the tropical Pacific, in upland and coastal areas from Hawai‘i to Japan. In Hawai‘i, kōlea are more common in NWHI year-round, but between August and May are also commonly seen on all of the MHI.

ABUNDANCE: Reliable estimates of the global kōlea population have not been made. One estimate of the east Asian population was 90,000, while the population of the MHI has been estimated at 74,000 individuals. In the late 1960s, the O‘ahu population was estimated at about 15,000. From 2013 to 2023, the average number of kōlea in Hawai‘i State waterbird surveys has been about 1,588 individuals across MHI. Estimated wintering densities range from 0.22 to 44.7 birds per hectare in wild habitats such as forest trails and coastal mudflats. Densities in developed habitats in Hawai‘i have been estimated as 1.4 birds per hectare on golf courses and 5.2 birds per hectare on lawns.

LOCATION AND CONDITION OF KEY HABITAT: The winter range of Kōlea is extremely varied, including crop fields, pastures, coastal salt marshes, mudflats, beaches, mangroves, grassy areas at airports, cemeteries, athletic fields, parks, residential lawns, golf courses, roadsides, and clearings in heavily wooded areas. In Hawai‘i, birds also use open stands of ironwood (*Casuarina spp.*) and small urban lawns and gardens in areas such as downtown Honolulu. Military bases and airports often provide important wintering grounds. Where suitable habitats (pastures, etc.) occur on mountain slopes, kōlea range to at least 2,500 meters (8,125 feet) elevation. Extensive land-clearing in Hawai‘i, dating back to the Polynesian colonization, has probably improved wintering conditions by creating open habitat with plentiful insects.

THREATS: Hunting was a significant threat until 1941 when it was prohibited, and populations are thought to have rebounded since then. Effects of pesticide exposure on wintering grounds and along migratory routes are unknown, but on golf courses in Hawai‘i, Kōlea come into contact with herbicides

and pesticides that may be harmful. Aircraft strikes at airports in Hawai‘i occur often in the fall, apparently as naive juvenile birds attempt to establish foraging territories on airport grounds.

CONSERVATION ACTIONS: To protect the ability of wintering kōlea to survive while in Hawai‘i and to return in good condition to breeding grounds in Alaska, current statewide and island-specific conservation actions should include:

- Protection of current habitat.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Kōlea studies remain fragmentary, probably because the species is neither endemic nor endangered. Research priorities should include the following:

- Increased study of all aspects of ecology and behavior of kōlea in Hawai‘i, and comparative research on unstudied populations elsewhere.
- Evaluation of conditions on winter range habitats as related to expanding human activities (e.g., agriculture, reclamation, urbanization, pollution).
- Increased effort to make accurate population estimates, along with systematic monitoring wherever possible to facilitate the recognition of trends and potential problems.

References:

Johnson OW, Connors PG. 1996. Pacific golden-plover (Pluvialis fulva). In The Birds of North America, No. 201-202 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union

Photo: Jim Denny

Migratory Birds

ʻAkekeke or Ruddy Turnstone

Arenaria interpres

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan—High Concern

SPECIES INFORMATION: The ʻakekeke, or ruddy turnstone, is a small, calico-colored shorebird (Family: Scolopacidae) that is one of the most northerly breeding shorebirds. Each year ʻakekeke migrate from tropical coastlines to the Arctic Circle, where they breed in coastal areas and island interiors. ʻAkekeke have short bills and bright reddish-orange legs. They spend their days probing among rocks and pebbles along the shoreline in search of insects, especially flies, spiders, beetles, and grubs. Outside of the breeding season, however, their diet becomes much more diversified, extending to crustaceans, mollusks, worms, small fish, and even carrion, rubbish, and bird eggs.

DISTRIBUTION: During breeding season, ʻakekeke range from the eastern coast of Greenland to the north-eastern coast of Siberia, with most of the North American population concentrated on the northern coast of Alaska and the Arctic islands north of Canada. In winter, ʻakekeke range across a wide swath of tropical coastal regions from southeastern Asia to southwestern Africa and southern Europe. In Hawaiʻi, ʻakekeke are more prevalent on shorelines of the NWHI than in the MHI.

ABUNDANCE: Global population has been estimated at approximately 445,000 individuals, of which about 60 percent (267,000) breed in North America. Trend analysis from 1972 to 1983 suggested that the U.S. Atlantic Coast population was in decline, but high variability of counts both within and between years increased uncertainty about the statistical validity of this trend. Average winter population in the MHI from 2013 to 2023, based on State waterbird surveys, was 678, while during breeding season counts averaged 478. Abundance in the NWHI has not been estimated but is probably larger than the MHI population.

LOCATION AND CONDITION OF KEY HABITAT: In winter, ʻakekeke are almost exclusively coastal, foraging mostly along stony or rocky shorelines with abundant seaweed. However, especially in Hawaiʻi and other Pacific Islands, ʻakekeke are also common on sandy shorelines and in mudflats and river deltas. Preferred habitats include ocean beaches along sheltered coastlines or bordering estuaries and other wetlands.

THREATS: Across most of their winter range, primary threats to ʻakekeke are human industrial and recreational activity leading to habitat loss and degradation by means of chemical contamination and disturbance. Avian diseases are also a threat.

CONSERVATION ACTIONS: To protect the ability of wintering ‘akekeke to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of coastal habitat.
- Protection and restoration of additional coastal habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Little study of visiting ‘akekeke has been undertaken, probably in part because their annual presence and numbers are uncertain. Research priorities should include the following:

- Identification of stopover sites, their biological attributes, and long-term usage patterns.
- Better understanding of ecological requirements for successful over-wintering, along with growth and development of wintering birds, for all age groups.
- Better understanding of time and energy budgets in relation to molt and preparation for spring migration.
- Measurement of growth and post fledging-survival rates for first arrivals at wintering location.
- More information on known and suspected threats, including degradation of coastal ecosystems, direct interactions with humans, habitat disturbance and destruction, and toxic and chemical contamination.

References:

Nettleship DN. 2000. Ruddy turnstone (Arenaria interpres). In The Birds of North America, No. 537 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Jim Denny

Migratory Birds

Koloa Māpu or Northern Pintail

Anas acuta

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The Koloa māpu, or northern pintail, is a dabbling duck (Family: Anatidae), common throughout the northern hemisphere, that winters in the main Hawaiian Islands, typically arriving in August, and departing for Siberia, Alaska, or Canada in late March or April. Koloa māpu feed primarily on the seeds and leafy parts of aquatic grasses, as well as aquatic invertebrates such as snails and beetles, with live prey being especially important in the early spring. As with most dabbling ducks, koloa māpu are sexually dichromatic in plumage, but less dramatically so than mallards. Breeding males are dark brown on the head and upper neck, white across the lower throat, and gray about most of the body, while female plumage is mottled light and dark brown. Nonbreeding male plumage is similar to that of females. Being gregarious, koloa māpu form pair bonds but remain promiscuous during breeding. They are known to hybridize with six other North American duck species (mallard, black duck, green-winged teal, American wigeon, Chiloe wigeon, and redhead) and with at least three other species in Eurasia.

DISTRIBUTION: Common throughout the southern and western United States and Mexico during the winter, shifting to the northernmost central U.S., west central Canada, and Alaska during the breeding season. Koloa māpu are also common through Eurasia. In Hawai‘i, koloa māpu have been sighted routinely on all of the MHI, but have not been recorded in the NWHI.

ABUNDANCE: Among the most populous of North American ducks, koloa māpu surveys (USFWS) for the region from 1955 through 1995 yield an average breeding population estimate of over three million birds, with populations declining from over six million in the early 1970s to less than three million into the early 1990s. A fairly common visitor to the Main Hawaiian Islands (MHI), koloa māpu are usually present each year in the low hundreds. State Waterbird surveys from 2013 to 2023 provide an average of 216 birds per year wintering in the MHI.

LOCATION AND CONDITION OF KEY HABITAT: During winter, koloa māpu utilize a variety of shallow inland freshwater and intertidal habitats, typically shallow wetlands with little emergent cover (although at night they prefer emergent stands of food plants). They will also use flooded agricultural habitats (especially rice, corn, wheat, soybeans, and pastures), reservoirs, tidal wetlands, bays, and estuarine habitats. In Mexico, koloa māpu favor areas where excess irrigation water flows into salt flats or tidal basins; also mangrove mud flats,

irrigation reservoirs, and ephemeral ponds. Some of these types of areas are already protected; others have been lost to development.

THREATS: Primary threats include the following:

- Loss of wetland habitat to development, pollution, or habitat-modifying invasive plants.
- Avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering koloa māpu to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Only one published study of visiting koloa māpu has been undertaken, probably in part because of their annual presence and numbers are uncertain. Research priorities should include the following:

- Better understanding of habitat needs and preferences, including foraging and population limiting factors.
- Population reactions to habitat modifications, changes in food availability, and competition with other migrants.
- Life-history and population dynamics in wintering areas.
- Better understanding of geographic relationship between nesting areas and wintering areas.
- Make-up of local populations relative to survival and condition during winter.

References:

Austin JE, Miller MR. 1995. Northern pintail (Anas acuta). In The Birds of North America, No. 163 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Udvardy MD, Engilis, Jr., A. 2001. Migration of northern pintail

Migratory Birds

Koloa Mōhā or Northern Shoveler

Anas clypeata

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The koloa mōhā, or northern shoveler, is a common North American dabbling duck (Family: Anatidae) that winters in the Main Hawaiian Islands (MHI), typically arriving in September and October and departing for Alaska by March or April. By virtue of their unusually large flat bills, koloa mōhā are adapted to a diet primarily of aquatic invertebrates such as water fleas (*Daphnia spp.*) and crustaceans (copepods and ostracods), which they obtain by filtration. In addition to nektonic prey, however, koloa mōhā are also known to eat seeds and gastropods. Like many ducks, koloa mōhā are sexually dichromatic in plumage, with breeding males sporting a dark green head, white throat, and brown belly, in contrast to the females' more uniform mottled brown plumage. Koloa mōhā are less gregarious than other dabbling ducks, are among the most territorial during breeding, and maintain pair bonds longer than other similar species. They are known to hybridize with at least three other North American duck species (blue-winged and cinnamon teals, and muscovy ducks) and with several other species in Eurasia.

DISTRIBUTION: Common throughout the southern and western United States and Mexico during the winter, shifting to the northernmost central U.S., west central Canada, and Alaska during the breeding season. Koloa mōhā are also common through Eurasia. In Hawai‘i, koloa mōhā have been sighted routinely on all of the MHI, but have not be recorded in the NWHI.

ABUNDANCE: U.S. Fish and Wildlife Service surveys from 1955 through 1995 yield an average breeding population estimate of approximately 1.87 million birds in North America, with a rising trend through the mid-1990s. Estimates for 1994 and 1995 were high at approximately three million. The most abundant dabbling duck wintering in the MHI (mallards are year- round residents), koloa mōhā numbers in State waterbird surveys from 2013 to 2023 averaged 158 birds. There is some evidence of a downward trend over the long-term data .

LOCATION AND CONDITION OF KEY HABITAT: During winter, koloa mōhā utilize a variety of wetland habitats, including freshwater and saline marshes, and agricultural ponds. They prefer shallow open lakes containing dense growth of aquatic vegetation, and tend not to forage on dry land. In Mexico, they are known to inhabit coastal lagoons, estuaries, and some mangrove swamps. Some of these areas are already protected, but much habitat has been lost to development.

THREATS: Primary threats include the following:

- Loss of wetland habitat to development, pollution, or habitat-modifying invasive plants.

- Avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering American koloa mōhā to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Little study of visiting koloa mōhā has been undertaken, probably in part because of their annual presence and numbers are uncertain. Research priorities should include the following:

- Better understanding of habitat needs and preferences, including foraging and population limiting factors.
- Increased understanding of movements of individuals that overfly the Hawaiian
- Islands.

References:

Dubowy PL. 1996. Northern shoveler (Anas clypeata). In The Birds of North America, No. 217 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Eric VanderWerf

Migratory Birds

Lesser Scaup

Aythya affinis

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The lesser scaup is a medium-sized black and white diving duck (Family: Anatidae), one of the most abundant and widespread ducks in North America. Lesser scaups winter in the Main Hawaiian Islands (MHI), typically arriving in October and departing for Alaska or Canada as early as February. Lesser scaups feed primarily on aquatic invertebrates such as insects, crustaceans, and mollusks; seeds and vegetative parts of aquatic plants are also important. As with many ducks, lesser scaups are sexually dichromatic in plumage, with breeding males showing a dramatic contrast between their white body and black head, neck, throat, and rump. Female plumage is a more monochromatic dark brown.

Nonbreeding male plumage shows less contrast, with the body becoming more brown at the margins. Being gregarious, lesser scaups form pair bonds but remain promiscuous during breeding. They are known to hybridize with four other North American duck species (greater scaup, ring-necked duck, redhead, and canvasback) in the wild, and with four others (tufted duck, European pochard, American wigeon, and wood duck) in captivity.

DISTRIBUTION: Common throughout the southern and western United States and Mexico during the winter, shifting to the northernmost central U.S., west central Canada, and Alaska during the breeding season. Lesser scaups are also common through Eurasia. In Hawai‘i, lesser scaups have been sighted routinely on all of the MHI, but have not been recorded in the NWHI. ABUNDANCE: Lesser scaup surveys (by USFWS) from 1955 through 1995 yield an average breeding population estimate of 5,512,445 ± 147,090 (SE) in North America (the most abundant diving duck in the region), with winter population estimates declining by about half since the 1960s. A fairly common visitor to the Main Hawaiian Islands, Hawai‘i State waterbird surveys of lesser scaups from 2013 to 2023 have averaged 85 birds.

LOCATION AND CONDITION OF KEY HABITAT: Winter diet of lesser scaups varies geographically, but specific dietary habits of Hawaiian migrants have not been documented in the published literature. On the continental U.S., lesser scaups are found along lake coastlines, reservoirs, and fresh to brackish coastal bays and estuaries. During severe weather, they may move to more saline waters, and they are more common in such saline habitats than other diving ducks. In Texas, they are found on hypersaline estuaries, usually close to inland freshwater ponds where individuals go to drink. Unlike other, more herbivorous diving ducks, distribution

of lesser scaups during migration and winter is not closely related to distribution of aquatic plant foods.

THREATS: Primary threats include the following:

- Loss of wetland habitat to development, pollution, or habitat-modifying invasive plants.
- Avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering lesser scaups to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Little study of visiting lesser scaups has been undertaken, probably in part because of their annual presence and numbers are uncertain. Research priorities should include the following:

- Better understanding of habitat needs and preferences, including foraging and population limiting factors.
- Increased understanding of movements of individuals that overfly the Hawaiian Islands.
- Better understanding of adaptation to modified wintering habitats and how they affect migration routes.

References:

Austin JE, Custer CM, Afton AD. 1998. Lesser scaup (Aythya affinis). In The Birds of North America, No. 338 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Migratory Birds

Hunakai or Sanderling

Calidris alba

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The hunakai, or sanderling, is a sandpiper (Family: Scolopacidae) which is well-known for its habit of foraging at the edge of the surf zone and running up and down the beach to avoid waves while probing the sand for invertebrates. Hunakai are small, plump sandpipers, usually about 19 centimeters (7.5 inches) in length, with bills that are short, straight, and black. Their legs and feet are also black, but the rest of their body is white about the head, pale-gray on the back and ventrally white. Hunakai winter in the Hawaiian Islands, arriving by October and departing for breeding areas in the Arctic Circle by June, with juvenile birds tending to migrate later than adults. Hunakai diet changes markedly with the season, consisting almost exclusively of insects during the breeding season, and consisting of hippid crabs, isopods (*Excirolana spp*.), insects, talitrid amphipods, polychaete worms, and small bivalve mollusks in winter. Hunakai of both sexes are strongly territorial in and above the intertidal zone, but otherwise forage in non-territorial flocks.

DISTRIBUTION: Hunakai may be the most widespread maritime shorebird wintering in North America, with a winter range extending from British Columbia to southern Chile and from Maine to Argentina. Pacific winter range extends from Hawai‘i and the Mariana and Marshall Islands through more southerly archipelagos (Phoenix, Union, and Galapagos Islands).

ABUNDANCE: Global population size is unknown, but the North American population is estimated to be 300,000 individuals. Estimated population for Hawai‘i, based on State waterbird surveys from 2013 through 2023 yield an average summer count for the MHI of 71, and a winter MHI count of 232. NWHI populations may be larger, but data are lacking. In other areas, such as Mexico, shoreline densities of hunakai have been estimated at six birds per kilometer (about nine birds per mile) on sandy beaches, and about one-third of that on rocky coastlines. Trend data are sparse and not conclusive, but suggest a slight decline in numbers through the Americas since the late 1950s.

LOCATION AND CONDITION OF KEY HABITAT: Preferred foraging habitat during winter is sandy beach, mainly intertidal zone at high tide. Tidal sandflats and mudflats are also used, along with shores of lakes and rivers. Hunakai occasionally make use of rocky shores, sloughs, and river mouths, and have been rarely detected at sewage-treatment plants and municipal dumps. Hunakai tend to exhibit strong fidelity to wintering sites.

THREATS: The most severe threats to this species are considered to be environmental (e.g., effects of global warming and oil spills). Global warming is expected to have the greatest impact on breeding populations, although reduced food supplies for wintering birds could also result in

adverse impacts. The greatest threats to wintering birds in Hawai‘i include loss and degradation of habitat and avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering hunakai to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional habitat.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Hunakai have been only minimally studied. Research priorities should include the following:

- Better understanding of habitat requirements and behavioral plasticity, to improve assessments of probable responses to coastal (beach) development, habitat degradation, pollution, and other human disturbances.
- Increased understanding of movements of individuals that overfly the Hawaiian Islands, support needed studies of the extent to which distinct breeding populations exist and whether migration routes and wintering areas are population-specific.

References:

Macwhirter B, Austin-Smith P, Kroodsma D. 2002. Sanderling (Calidris alba). In The Birds of North America, No. 653 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Eric VanderWerf

Migratory Birds

ʻŪlili or Wandering Tattler

Heteroscelus incanus

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan—Moderate concernBird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: The ʻūlili, or wandering tattler, remains one of North America's least known birds. ʻŪlili winter in the Hawaiian Islands, arriving in stages (adults from July to August, juveniles September to November) and showing strong winter range fidelity. Diet varies with season, and in winter mainly consists of invertebrates such as marine worms, aquatic insects, mollusks, crustaceans, and small fish. On nonbreeding grounds, forages in intertidal habitats (such as coral reefs), less frequently in soft mud or sand, picking food from moist substrates or surface of shallow water. ʻŪlili also forage along mountain streams, in wetlands, fish ponds, and human-modified areas.

DISTRIBUTION: ʻŪlili breed mostly in mountainous areas of Alaska, and also in eastern Siberia, but densities are sparse so that precise identification of breeding areas is lacking. Winter range includes most of Oceania from Hawaiʻi through more southerly archipelagos. Most abundant in southern and central Pacific. Less common or infrequent in more distant areas of the Pacific. In Hawaiʻi, ʻūlili are more prevalent on shorelines of the NWHI than in the MHI.

ABUNDANCE: Global population has been estimated at between 10,000 and 25,000 birds, of which 90 percent breed in North America. ʻŪlili are not particularly common in Hawaiʻi: State waterbird surveys from 2013 through 2023 yield an average summer count for the MHI of 66 and a winter MHI count of 113 . NWHI populations are probably larger: estimates at Laysan Island in 1984 and 1985 were 450 and 170, respectively. Monitoring in Hawaiʻi has not been regular or thorough enough to detect trends, but where monitoring data are more detailed, trend analysis is inconclusive.

LOCATION AND CONDITION OF KEY HABITAT: Wintering habitats throughout the Pacific and mainland Asia are more varied than breeding habitat. ʻŪlili are common in coastal areas on coral reefs and the basalt platforms of most atolls and islands. They will also make use of soft substrates, especially river mouth areas and littoral margins of lagoons. In the NWHI, they can be found on pickleweed (*Sesuvium portulacastrum*) flats, and elsewhere in Hawaiʻi they will forage in grassy areas around airports and golf courses.

THREATS: Primary threats include the following:

- Loss of wetland habitat to development, pollution, or habitat-modifying invasive plants.
- Avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering ʻūlili to survive while in Hawaiʻi and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: ʻŪlili have been only minimally studied. Research priorities should include the following:

- Basic research on demography in wintering habitat.
- More information about population sizes and trends, and population regulation.
- Better understanding of habitat needs and preferences, including foraging needs, population limiting factors, and adaptation to modified wintering habitats and how they affect migration routes.
- Increased understanding of movements of individuals that overfly the Hawaiian Islands.

References:

Gill RE, McCaffery BJ, Tomkovich PS. 2002. Wandering tattler (Heteroscelus incanus). In The Birds of North America, No. 642 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Eric VanderWerf

Migratory Birds

American Wigeon

Anas americana

SPECIES STATUS:
State recognized as Indigenous

SPECIES INFORMATION: The American wigeon, or "Baldpate," is a widespread North American dabbling duck (Family: Anatidae), which winters in small numbers in the Hawaiian Islands. Wigeons are common across most of North America, with a breeding population estimated in excess of three million. While wigeons are dun-colored across most of the body, breeding males sport a bright white stripe across the crown of the head, bright green patches on either side of the head, and contrasting white and dark plumage on the rump. During the breeding season, males' contrasting colors are used in courtship displays to attract females and discourage competing males. However, in winter, male plumage is much more similar to that of females, retaining the brown body coloration but changing to dark gray on the head and neck. Wigeons are the most vegetarian of dabbling ducks, eating the stems and leafy parts of aquatic plants, leafy parts of grasses, and leaves and seeds of some marsh and crop plants. Breeding females, however, feed largely on insects (including dragonflies and damselflies), mollusks, and crustaceans.

DISTRIBUTION: In North America, wigeons' winter range extends across the central and southern United States, south through Mexico, and along the U.S. east coast as far north as Cape Cod. In Hawai‘i, they have been sighted throughout the Main Hawaiian Islands (MHI) but have not been recorded in the Northwestern Hawaiian Islands.

ABUNDANCE: U.S. Fish and Wildlife Service surveys from 1955 through 1997 yield an average breeding population estimate of approximately 2.62 million birds for North America. The 1997 estimate was 3,117,600 ± 161,600 (SE), about 19 percent higher than the long-term average. In Hawai‘i, State Waterbird counts of American wigeons from 2013 to 2023 have averaged 23 birds throughout the MHI.

LOCATION AND CONDITION OF KEY HABITAT: Wigeons winter in a wide range of habitats including freshwater marshes, rivers, lakes, impoundments, estuaries, bays, and agricultural lands that provide an abundance of emergent and submergent vegetation. In Hawai‘i, wigeons winter at Kanahā Pond State Wildlife Sanctuary and Kealia Pond National Wildlife Refuge on Maui, and near Waipi‘o on O‘ahu. Use of agricultural lands suggests flooded taro fields could attract wigeons. Some suitable habitat of these types is already protected, primarily wetlands within the bounds of wildlife refuges and sanctuaries.

THREATS: Primary threats include the following:

- Loss of wetland habitat to development.
- Degradation of habitat due to pollution, hydrology alteration, or invasions by alien species.
- West Nile virus or other avian diseases.

CONSERVATION ACTIONS: To protect the ability of wintering American wigeons to survive while in Hawai‘i and to return in good condition to breeding grounds in North America, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Little study of visiting wigeons has been undertaken, probably in part because of their annual presence and numbers are uncertain. Research priorities should include the following:

- Better understanding of habitat needs and preferences, including foraging and population limiting factors.
- Increased understanding of movements of individuals that overfly the Hawaiian Islands.

References:

Mowbray T. 1999. American wigeon (Anas americana). In The Birds of North America, No. 401 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Photo: Eric VanderWerf

Migratory Birds

Kioea or Bristle-thighed Curlew

Numenius tahitiensis

SPECIES STATUS:
State recognized as Indigenous
IUCN Red List Ranking-VulnerableBird of Conservation Concern - USFWS 2021

SPECIES INFORMATION: Kioea, or Bristle-thighed curlews, are large-bodied shorebirds (Family: Scolopacidae) that twice annually make a nonstop migration of at least 4,000 kilometers (2,480 miles) between Hawai‘i and Alaska. They typically arrive in Hawai‘i in late July and August and depart in early May for breeding grounds in western Alaska. Kioea (Bristle-thighed curlews) are the only migratory shorebirds that winter exclusively on oceanic islands, that become flightless during molt, and that use tools in foraging. Documented tool use behavior consists of picking up rocks with their bills and hurling them at albatross eggs to crack them open. Males and females are identical in plumage, but females are slightly larger and have slightly straighter and less tapered bills. Kioea are highly opportunistic feeders during winter, consuming a variety of prey such as intertidal and terrestrial invertebrates, seabird eggs and hatchlings, carrion, lizards, rodents, and fruit. Males are highly territorial during breeding season, defending large territories of up to 275 hectares (680 acres) with dramatic aerial displays, chases, and complex vocalizations.

DISTRIBUTION: The species breeds in two relatively small areas of Alaska near the Kotzebue Peninsula. Winter range comprises most oceanic islands across the Pacific, from the Marshall Islands in the west to Pitcain Island at the southeasterly extreme. In Hawai‘i, highest numbers are in the Northwestern Hawaiian Islands (NWHI), with small numbers wintering the Main Hawaiian Islands (MHI), particularly the islands of O‘ahu and Hawai‘i.

ABUNDANCE: Estimates based on surveys conducted between 1988 and 1992 of the species' breeding range in Alaska estimated the population at 3,200 breeding pairs. Based on a study conducted between 1988 and 1990, about 800 birds were thought to winter in NWHI: 300–350 on Laysan, 300–400 on Lisianski Island, and 100 at Midway. Hawai‘i State waterbird surveys since 1996 yield an average of 23 birds in the MHI in summer, and 28 in the winter.

LOCATION AND CONDITION OF KEY HABITAT: No detailed study has been published describing winter habitat use. However, wintering kioea have been observed to use a variety of habitats, including tidal mudflats, marshy areas, edges of mangrove swamps and lagoons, reefs, saltpans, channels among islets, beaches, airport runways, and open areas well away from shoreline. In the MHI, they occur in open grassy areas, vegetated dunes, and wetlands, while in

the NWHI, they are found on beaches and shoreline coral ledges some of the time but more often in grass- and forb-dominated interior portions. Censuses on Laysan Island in fall 1988 obtained 68 percent of sightings inland in beach morning glory (*Ipomoea pes-caprae*), native bunchgrass (*Eragrostis variabilis*), or a mix of both; only one percent of sightings were on beaches.

THREATS: Factors limiting Kioea populations are not well-documented. Habitat alteration in winter range, especially human development of shoreline areas, is considered to be severe. Other threats may include degradation of habitat due to pollution or invasions by alien species. Populations may also be adversely affected by avian disease. Ingestion of ubiquitous plastic debris in northern parts of winter ranges is likely, but not confirmed. Curlews on Midway forage in lead-contaminated soils, but tissue concentrations of lead have not been studied in curlews.

CONSERVATION ACTIONS: To protect the ability of wintering kioea to survive while in Hawai‘i and to return in good condition to breeding grounds in Alaska, statewide and island-specific conservation actions should include:

- Protection of current habitat.
- Protection and restoration of additional wetland habitat, especially where it can be reclaimed from abandoned urban or agricultural uses.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: Comprehensive studies of kioea were not undertaken before the late 1980s. Priorities for further research should include the following:

- Identification of high concentrations of wintering birds.
- Identification of migratory stopover sites (if any) south of the Hawaiian Islands.
- Monitoring of population trends.
- Protection and management of key islands and atolls throughout winter ranges.

References:

Marks JS, Tibbitts L, Gill RE, Jr., McCaffery B. 2002. Bristle-thighed curlew (Numenius tahitiensis). In The Birds of North America, No. 705 (Poole A, Gill F, editors). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Northwestern Hawaiian Islands Passerines

Photo: Kate Willis, USFWS

ʻEkupuʻu or Laysan finch

Telespiza cantans

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Vulnerable
Northwestern Hawaiian Islands Passerines Recovery Plan— USFWS 1984

SPECIES INFORMATION: The Laysan finch is an omnivorous, ground-nesting Hawaiian honeycreeper (Family: Fringillidae) endemic to Kamole (Laysan Island) in the Northwestern Hawaiian Islands. Laysan finches have black legs, large feet, and relatively large bills suitable for eating seeds. They are vocally inventive and have a varied song repertoire. Males and females have different plumage; males are a brighter yellow over a larger proportion of their head and body than females. Males are also about 6 percent larger by weight than females. Laysan finches are known to feed on seeds, fruits, leaves, flowers, stems, seedlings, roots, carrion, invertebrates, and eggs. Typically found in pairs during the breeding season, Laysan finches are non- territorial and forage in small groups (four to twelve individuals) during the non-breeding season. The breeding biology of the species has been well-documented, in addition to studies of geographic variation in genetics, morphology, and nest substrate choice. During breeding season, males defend their mates and nest sites, while females construct nests and incubate eggs. Females rely upon males for nuptial feedings during the incubation period. In good years, Laysan finches are quite fecund, and double and even triple clutches have been documented. Given the remoteness of their habitat, Laysan finches are among the most-studied endangered birds.

DISTRIBUTION: Restricted to the approximately 200 hectare (450 acre) vegetated area of Laysan Island. Since 1967, translocated finches have occupied the 12 hectare (25 acre) and 2 hectare (4 acre) vegetated areas of Southeast Island and Grass Island (respectively) at Manawai (Pearl and Hermes Reef). Between 1973 and 1998, populations also existed at North Island and Seal-Kittery Island at Pearl and Hermes Reef; those populations were extinct by 1998.

ABUNDANCE: The U.S. Fish and Wildlife Service (USFWS) conducted transect surveys at Laysan Island during most years in 1966–2012 and now uses point-transect distance sampling surveys (Bak et al, 2024). The most recent survey was on Laysan was in 2019 and indicated a stable population estimated at 17,657 (11,994–23,320) (Bak et al. 2024. At Pearl and Hermes (Manawai), the population was estimated at more than 700 birds (with 523 on Southeast Island) in

1983 (USFWS 1984). During the summer of 2024, the Manawai ʻekupuʻu population was surveyed using repeated point counts and extrapolating detections across suitable habitat, yielding an estimate of 420 (range 298-542) on Southeast Island. Only a single bird was detected on Grass Island (Idle 2024). This contraction in range is likely due to overwash driven by storms and large wave events. .

LOCATION AND CONDITION OF KEY HABITAT: Laysan finches reside year-round on the flat, low-elevation islands of Laysan and Pearl and Hermes Reef. Climate is similar to that of nearby Midway Atoll. Finches inhabit all vegetated areas of the islands, foraging among several vegetation associations of grasses, herbs, and prostrate vines. On Laysan, however, the finches nest primarily in tussocks of the bunchgrass *Eragrostis variabilis*, whose seeds are also a major food source. *Eragrostis* is markedly less abundant at Pearl and Hermes, particularly at Southeast Island, and finches there frequently nest in marine debris (plastic crates, etc.) that have washed up onto the island. The highly invasive annual plant Verbesina encelioides was accidentally introduced to Manawai in 2017 and has since replaced much of the native vegetation on Southeast Island, the only islet in the atoll that still harbors a self-sustaining finch population (Idle 2024). Several freshwater seeps drain into Laysan Island's hypersaline lake; Pearl and Hermes islands have no sources of fresh water, so finches get water from rainfall and from dew accumulations on plants. Plant communities at both Laysan and Pearl and Hermes Reef have been altered by human activity, most notably by both intentional and accidental introductions of alien plants. The entire range of this species occurs within the Hawaiian Islands National Wildlife Refuge.

THREATS: Laysan finches have not generally been as strongly impacted by the factors that threaten other native Hawaiian birds, such as habitat loss, predation by introduced mammals, and disease. Habitat loss, for example, has been prevented by the island ’s status as a refuge, and disease establishment has been impeded by the lack of standing fresh water necessary for mosquito breeding. However, the finches' remoteness carries with it a different, but related, set of threats:

- Invasive alien plants: Habitat quality has been degraded by weed invasions. Finches have integrated some invasive plants into their diet, but changes to the quality of nesting habitat have been more problematic: *Setaria verticillata* appears to have displaced *Eragrostis variabilis* at Southeast Island (Pearl and Hermes Reef), leading to lower nest density and lower reproductive success among nests in *Setaria*. Conversely, the more recent invasion at Southeast by *Verbesina encelioides* appears to have caused the population to quadruple within two years, only to subsequently crash.
- Population size: Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.
- Introduced mammals: The risk of rat (*Rattus* spp.) introduction via transport (i.e., ships, planes) is of concern as rats are known to have decimated passerine populations in the Northwestern Hawaiian Islands in the past as a result of shipwrecks.
- Sea level rise: Both the Intergovernmental Panel on Climate Change and the U.S. Environmental Protection Agency project sea level to increase 34-42 centimeters (13-16

inches) by 2100. The mean elevation at Southeast Island is just over 1 meter (3 feet), so that during spring tides, most of the island would be inundated. Grass Island would lose less area, but is already too small to provide significant reduction of extinction risk for the species. Therefore, if sea level does rise as projected, both of the Pearl and Hermes Reef populations would be seriously jeopardized.

CONSERVATION ACTIONS: Laysan finch persistence requires that the integrity of the island's small, remote ecosystems be maintained. This requires excluding and removing any introduced non-native insects, plants, passerine birds, avian disease, and mammalian and reptilian land animals. Quarantine measures in place for researchers appear to be reducing the rate of new introductions, but many species already established (e.g., *Verbesina encelioides*) are extremely difficult to eradicate. Thus, rigorous statewide reduction or elimination of non-native invertebrate and plant introduction through stricter quarantine and reduced ship groundings are needed. In addition to these efforts, future management specific to the recovery of Laysan finches may include the following:

- Conduct aggressive weed control and native plant restoration to stabilize habitat quality.
- Prevent the introduction of rats and other possible predators.
- Stabilize islands to minimize erosional and submersion-based losses of land area.
- Within the next five years, t ranslocate each population to one additional island based on the outcome of the 2024 SWOT ("Strength, Weaknesses, Opportunities, Threats"
- workshop.
- Once mosquitos-free habitat is available in the MHI, select predator-free sites for reintroduction informed by the fossil record (Olson and James 1989, James and Olson 1991).

MONITORING: Continue current program of point-distance survey sampling and habitat monitoring.

RESEARCH PRIORITIES: More research is needed on best quarantine techniques, methods for early detection of alien species, and eradication methods. Research priorities specific to Laysan finches include the following:

- Conduct additional demographic studies to further refine estimates of population structure, dispersal, survivorship, nesting phenology and success, and other life history and behavioral characteristics.

References:

Bak, T., R. Camp, C. Farmer, R. Rounds, S. Plentovich, J. Vetter, and P. Banko. 2024. Nihoa and Laysan Island and passerines population abundances, trends, and habitat utilization. Hawai'i Cooperative Studies Unit Technical Report HCSU-107. University of Hawai'i at Hilo. 35 pages. https://hdl.handle.net/10790/5393

Idle, J. 2024. Manawai/Holoikauaua (Pearl and Hermes Atoll) Trip Report June 29 – August 11, 2024. Unpublished report to the U.S. Fish and Wildlife Service.

James, H. F. and S. L. Olson. 1991. Descriptions of thirty-two new species of birds from the Hawaiian Islands: Part 2: Passeriformes. Ornithological Monographs 46.

Morin M., Conant S. 2002. Laysan finch (Telespiza cantans) and Nihoa finch (Telespiza ultima). In The Birds of North America, No. 639 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences;

and Washington DC: The American Ornithologists' Union.

Olson, S. L., and H. F. James. 1982. Prodromus of the fossil avifauna of the Hawaiian Islands. Smithsonian Contributions to Zoology, No. 365.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Northwestern Hawaiian Islands passerines. Portland, (OR): U.S. Fish and Wildlife Service. 66 pp.

U.S. Fish and Wildlife Service. 2014. Laysan Finch (Telespiza cantans) 5-Year Review, Short Form Summary. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Northwestern Hawaiian Islands Passerines

Nihoa millerbird

Acrocephalus familiaris

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking— Endangered
Northwestern Hawaiian Islands Passerines Recovery Plan—USFWS 1984

SPECIES INFORMATION: The Nihoa millerbird is an obligate insectivore endemic to Nihoa Island in the Northwestern Hawaiian Islands. The Nihoa millerbird and its congener, the Laysan millerbird, are the only known Old World warblers (subfamily Sylviinae) known to have colonized the Hawaiian Archipelago. The Laysan subspecies, discovered first, was named "millerbird" because of its fondness for feeding on large miller moths (Family Noctuidae). Although the Laysan subspecies was driven to extinction by 1923 after European rabbits (*Oryctolagus cuniculus*) were introduced to Laysan in 1903, the Nihoa millerbird has persisted. Nihoa millerbirds are small (about 13 centimeters, or about 5 inches, in length), drably colored, and highly active due to their insectivorous habits. Male and female Nihoa millerbirds have similar plumage, but differ in size, with males being slightly larger than females. Nihoa millerbirds feed exclusively on insects and larvae, especially moths and caterpillars (Lepidoptera), gleaned from shrubs and bunchgrass tussocks. Like most insectivores, Nihoa millerbirds are territorial, and display a high degree of year-to-year territory fidelity. During breeding season, both sexes construct nests and incubate eggs.

DISTRIBUTION: Nihoa millerbirds are now restricted to the approximately 63 hectares (156 acres) area of Nihoa Island. Of those 63 hectares, approximately 40 hectares (100 acres) are considered suitable habitat for millerbird territories. With a mean territory size estimated at 0.2–0.4 hectares (0.5–1 acres), Nihoa Island can support, on average, between 100 and 200 millerbird territories. In 2011 and 2012 a total of 50 Nihoa millerbirds were translocated from Nihoa Island to Laysan Island, which has a land area of approximately 411 hectares (1,016 acres). The initial population of 50 birds has increased to more than 400 birds.

ABUNDANCE: The most recent population estimate on Nihoa Island (2022) was 1,181 (754–1,648). This is almost double the estimated population in 2010 (Bak et al. 2024). On Laysan, the initial population of 50 translocated birds has increased to 410 (275–595) birds as of 2019 (Bak et al. 2024)

LOCATION AND CONDITION OF KEY HABITAT: Nihoa millerbirds reside year-round

on the steep-sided, rocky, and shrub-covered island of Nihoa. Maximum elevation is 277 meters (839 feet), with steep cliffs on three of the island's four sides. Nihoa's vegetation community comprises about 25 species of plants; the four most abundant are (in descending order of abundance): the shrub *Chenopodium oahuense*, the shrub *Solanum nelsonii*, the shrub *Sida fallax* and the bunchgrass *Eragrostis variabilis*. Millerbirds are found throughout the island's 32 to 40 hectares (80 to 100 acres) of optimal habitat, and in suboptimal habitat as well. Millerbirds have not been observed to congregate at, or drink from, Nihoa's five to seven small freshwater seeps. The entire range of this species occurs within the Hawaiian Islands National Wildlife Refuge.

The habitat used by the translocated birds on Laysan is primarily composed of the shrub *Scaevola taccada*, with the bunchgrass *Eragrostis variabilis*, and the vine *Ipomoea pes-caprae* also present.

THREATS: Limiting factors are primarily weather (i.e., drought and storms), variations in food supply (typically due to weather), and availability of appropriate nest sites. Nihoa finches have been observed breaking and eating millerbird eggs, but the incremental mortality attributable to this behavior has not been estimated. Additional threats include:

- Invasive alien plants: Habitat quality could be degraded by weed invasions. The millerbird diet of mature and larval insects depends on the abundance of native plant populations, which could be adversely affected by competition with invasive alien plants such as *Miconia calvescens* or *Clidemia hirta*.
- Invasive alien arthropods: Preferred food insects could be suppressed by competition with, or predation by, introduced arthropods, especially invasive ants, which might not be attractive or palatable to millerbirds.
- Arthropod irruptions: Periodic irruptions of a nonnative grasshopper on Nihoa Island reduce plant cover and degrade habitat.
- Population size: Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.
- Introduced mammals: The risk of rat (*Rattus* spp.) introduction via transport (i.e., ships, planes) is of concern as rats are known to have decimated passerine populations in the Northwestern Hawaiian Islands in the past as a result of shipwrecks.

CONSERVATION ACTIONS: Nihoa millerbird persistence requires that the integrity of the island's small, remote ecosystems be maintained. This requires excluding and removing any introduced non-native plants, insects, passerine birds, avian disease, and mammalian and reptilian land animals. Quarantine measures and visitation restrictions in place for researchers appear to be controlling the rate of new introductions, but species that do become established may be extremely difficult to eradicate. Thus, rigorous statewide reduction or elimination of non-native invertebrates and plants introductions through stricter quarantine and reduction of ship groundings are necessary. In addition to these efforts, future management specific to the recovery of Nihoa millerbirds may include the following:

- Conduct aggressive weed control and native plant restoration to stabilize habitat quality.
- Monitor and, when warranted, conduct aggressive control of unstable arthropod populations.
- Prevent the introduction of rats and other possible predators.
- Future translocations to 2 or more islands within the main Hawaiian Islands could lead to downlisting.

MONITORING: Continue point-distance survey sampling counts and habitat monitoring on both Nihoa and Laysan.

RESEARCH PRIORITIES: More research is needed on best quarantine techniques, best methods for early detection of alien species, and best eradication methods. Current knowledge suggests that Nihoa millerbird reproduction may be driven by variable external environmental factors, such as rainfall, but knowledge of breeding behavior and demographics is limited. The millerbird population is small, and the extirpation of the Laysan subspecies suggests an urgent need to establish another population. Research priorities specific to Nihoa millerbirds include the following:

- Conduct additional demographic studies to further refine estimates of population structure, dispersal, survivorship, nesting phenology and success, and other life history and behavioral characteristics.
- Further study translocation techniques and habitat restoration on target islands. Keeping insectivorous passerines alive for translocation is extremely difficult, but known techniques could be refined using non-endangered closely related species.

References:

Bak, T., R. Camp, C. Farmer, R. Rounds, S. Plentovich, J. Vetter, and P. Banko. 2024. Nihoa and Laysan Island and passerines population abundances, trends, and habitat utilization. Hawai‘i Cooperative Studies Unit Technical Report HCSU-107. University of Hawai‘i at Hilo. 35 pages. https://hdl.handle.net/10790/5393

Dalton M, Kohley R and Heindl B. 2014. Trip Report: Population Monitoring of Millerbirds on Laysan, June 28-September 28, 2014. Unpublished report for the American Bird Conservancy and U.S. Fish and Wildlife Service. 45pp.

Morin M, Conant S. 2002. Laysan millerbird (*Acrocephalus familiaris familiaris*) and Nihoa millerbird (*Acrocephalus familiaris kingi*). *In* The Birds of North America, No. 302 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: the American Ornithologists' Union.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Northwestern Hawaiian Islands passerines. Portland, (OR): U.S. Fish and Wildlife Service. 66 pp.

U.S. Fish and Wildlife Service. 2010. Nihoa Millerbird (*Acrocephalus familiaris kingi*) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Photo: Craig Rowland, USFWS

Northwestern Hawaiian Islands Passerines

Nihoa finch

Telespiza ultima

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Recovery Plan— USFWS 1984

SPECIES INFORMATION: The Nihoa finch (palihoa) is an omnivorous, ground-nesting Hawaiian honeycreeper (Family: Fringillidae) endemic to Nihoa Island in the Northwestern Hawaiian Islands (NWHI). Nihoa finches have black legs, large feet, and sturdy bills suitable for seed- eating, but in all body dimensions they are smaller than the congeneric Laysan finches. Males and females have different plumage; males are a brighter yellow over a larger proportion of their head and body than females. Nihoa finches are known to feed on seeds, fruits, leaves, flowers, stems, seedlings, roots, carrion, invertebrates, and eggs. Although their social behavior has not been thoroughly studied, Nihoa finches are thought to be similar to Laysan finches in being non-territorial outside of the breeding season. During breeding season, males defend nest sites in rock crevices, while females construct nests and incubate eggs. Females rely upon males for nuptial feedings during the incubation period.

DISTRIBUTION: Restricted to the approximately 63-hectare (156 acre) area of Nihoa Island. An introduced population at Tern Island, French Frigate Shoals, was extinct by the early 1980s.

ABUNDANCE: The most recent population estimate (2022 is 6,592 (4,594–8,655)) (Bak et al. 2024).

LOCATION AND CONDITION OF KEY HABITAT: Resides year-round on the steep-sided, rocky, and shrub-covered island of Nihoa. Finches prefer open but vegetated habitat and forage in all areas of the island. Finches frequently congregate around Nihoa's five to seven small freshwater seeps, or at ephemeral puddles of fresh water. About 25 species of plants compose Nihoa's vegetation community; the four most abundant are (in descending order of abundance): the shrub *Chenopodium oahuense*, the shrub *Solanum nelsonii*, the shrub *Sida fallax*, and the bunchgrass *Eragrostic variabilis*. Finch presence is positively correlated with *Sida fallax* height and percent cover, and also with mean and maximum *Solanum nelsoni* height. The entire range of this species occurs in the Hawaiian Islands National Wildlife Refuge.

THREATS: Limiting factors for Nihoa finches are primarily weather (i.e., drought and storms), variations in food supply (typically due to weather), and availability of appropriate nest sites. During population highs, the proclivity of Nihoa finches to break conspecific eggs might increase, but this has not been studied. Additional threats include:

- Invasive alien plants: Habitat quality could be degraded by weed invasions. While the finches, being omnivorous, would likely integrate some invasive plants into their diet, native plant populations could be adversely affected by competition with invasive alien plants such as *Miconia calvescens* or *Clidemia hirta*. To the extent that such alien plants would be lower-quality food resources, the finch population would be affected.
- Arthropod irruptions: Periodic irruptions of a native grasshopper on Nihoa Island reduce plant cover and degrade habitat.
- Population size: Small populations are plagued by a variety of potentially irreversible problems that fall into three categories: demographic, stochastic, and genetic; the former are usually most problematic. Demographic factors include skewed sex ratios and stochastic factors include natural disasters. Habitat fragmentation exacerbates demographic and genetic problems.
- Introduced mammals: The risk of rat introduction via transport (i.e., ships, planes) is of concern as rats are known to have decimated passerine populations in the NWHI in the past as a result of shipwrecks.

CONSERVATION ACTIONS: Nihoa finch persistence requires that the integrity of the island's small, remote ecosystems be maintained. This requires excluding and removing any introduced non-native insects, plants, passerine birds, avian disease, and mammalian and reptilian land animals. Quarantine measures and visitation restrictions in place for researchers appear to be controlling the rate of new introductions, but species that do become established may be extremely difficult to eradicate. Thus, rigorous statewide reduction or elimination of non-native invertebrate and plant introductions through stricter quarantine and reduction of ship groundings are necessary. In addition to these efforts, future management specific to the recovery of Nihoa finches may include the following:

- Conduct aggressive weed control and native plant restoration to stabilize habitat quality.
- Prevent the introduction of rats and other possible predators.
- Within the next five years, translocate Nihoa Finches to Lisianski, the island selected by Morin and Conant and again by Rounds et al (2024) during the 2024 “Strength, Weaknesses, Opportunities, Threats”(SWOT)
- SWOT workshop. Once mosquitos-free habitat is available in the MHI, select predator-free sites for reintroduction informed by the fossil record (Olson and James 1989, James and Olson 1991 James)

MONITORING: Continue current program of point-distance survey sampling and habitat monitoring.

RESEARCH PRIORITIES: More research is needed on best quarantine techniques, best methods for early detection of alien species, and best eradication methods. Research priorities specific to Nihoa finches include the following:

- Conduct additional demographic studies to further refine estimates of population

structure, dispersal, survivorship, nesting phenology and success, and other life history and behavioral characteristics.

- Assess which management options (e.g., translocation) would be most beneficial in terms of extinction risk reduction.

References:

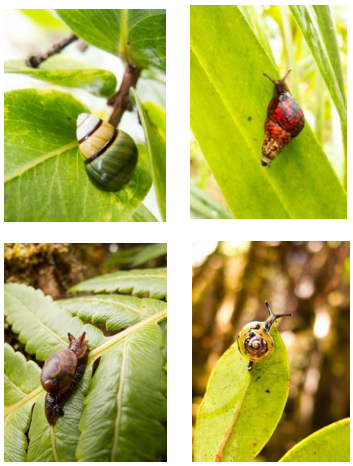
Bak, T., R. Camp, C. Farmer, R. Rounds, S. Plentovich, J. Vetter, and P. Banko. 2024. Nihoa and Laysan Island and passerines population abundances, trends, and habitat utilization. Hawai‘i Cooperative Studies Unit Technical Report HCSU-107. University of Hawai‘i at Hilo. 35 pages. https://hdl.handle.net/10790/5393

Morin M., Conant S. 2002. Laysan finch (*Telespiza cantans*) and Nihoa finch (*Telespiza ultima*). *In* The Birds of North America, No. 639 (Poole A, Gill F, editors.). Philadelphia, (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Northwestern Hawaiian Islands passerines. Portland, (OR): U.S. Fish and Wildlife Service. 66 pp.

U.S. Fish and Wildlife Service. 2011. Nihoa Finch (*Telespiza ultima*) 5-Year Review. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Upper left: *Achatinella byronii*, Upper right: *Laminella sanguinea*, Lower left: *Succinea* sp. Lower right: *Philonesia* sp. Photos by: D. R.



Terrestrial Invertebrates

Land snails

Orders Styl mmatophora, Archaeogastropoda

ORDERS INCLUDE:
44 Achatinelline species Federally/State Listed as Endangered
13
Native Families 750 + Native Species

GENERAL INFORMATION: The Hawaiian Islands hosted one of the most spectacular evolutionary radiations of land snails known to science with 99 percent of the 750 + valid species endemic to the islands. All but two families, Hydrocenidae and Helicinidae, are in the order Stylommatophora. The families Amastridae and Achatinellidae are the most speciose with 325 and 209 species, respectively. The family Endodontidae may contain as many as 200 undescribed species; to date only 33 are described. The phylogenetic and life history traits of some species in the family Achatinellidae, especially those in the genera *Achatinella* and *Partulina* are well understood, however the basic ecology of most other species is severely lacking.

DISTRIBUTION: Land snails are known from all Main Hawaiian Islands and Northwestern Hawaiian Islands.

ABUNDANCE: Because of declines in the availability and suitability of appropriate habitat, combined with the widespread presence of introduced predators, particularly non-native carnivorous snails (*Euglandina rosa and Oxychilus alliarius*), rats (*Rattus* spp.), and chameleons (*Chamaeleo jacksonii*), it is believed that 60 percent of native snail species are extinct, with remaining species in steep decline. While abundance estimates are available for most species in the genus *Achatinella*, and some species in the genera *Partulina*, *Perdicella*, *Newcombia*, *Laminella*, and *Amastra,* most other species are poorly understood because of a lack of systematic surveys.

LOCATION AND CONDITION OF KEY HABITAT: Hawaiian land snails occur in all native forests, including dry, mesic, and wet.

THREATS:

- Loss and degradation of habitat.
- Non-native invasive predators, particularly carnivorous snails, rats, and chameleons.
- Small population sizes and low reproductive rates makes them vulnerable to demographic and environmental stochastic threats such as loss of genetic diversity, inbreeding, hurricanes, fires, and disease.
- Global warming.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.

- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices;
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations;
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage;
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails;
- Improve predator-proof fencing with research and development of more effective barriers and materials;
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet;
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc;

- Conduct investigations on the impacts of herbicide on snail populations;
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.

Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hadfield, M. G., and S. E. Miller. 1989. Demographic studies on Hawaii's endangered tree snails: *Partulina Proxima*. Pac. Sci. 43:1–16.

Hadfield, M. G., S. E. Miller, and A. H. Carwile. 1993. The decimation of endemic Hawai'ian tree snails by alien predators. Am. Zool. 33:610–622.

Hadfield, M. G., B. S. Holland and K. J. Olival. 2004. Contributions of *ex situ* propagation and molecular genetics to conservation of Hawaiian tree snails. Experimental Approaches to Conservation Biology, M. Gordon and S. Bartol, eds. University of California Press. Pp. 16 – 34.

Hadfield, M. G., and J. E. Saufler. 2009. The demographics of destruction: isolated populations of arboreal snails and sustained predation by rats on the island of Moloka'i 1982–2006. Biol.

Invasions 11:1595–1609. doi:10.1007/s10530-008-9409-9

Hawai'i Department of Land and Natural Resources. 2015. Hawai'i's State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai'i.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson's chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Me 1 Introduction. Honolulu: University of Hawai'i Press.

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina*

species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus Achatinella. Portalnd, Oregon.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169

Achatinella sowerbyana, Photo by David Sischo

Terrestrial Invertebrates

Hawaiian tree snails

Subfamily Achatinellinae

SPECIES STATUS:
99 species 44 Federally Listed as
Endangered 44 State Listed as Endangered State

Recognized as Endemic

SPECIES INFORMATION: Achatinellinae is an endemic subfamily of snails which includes around 100 described species in the genera *Achatinella, Partulina*, *Perdicella*, and *Newcombia*. Unfortunately, about half of these species are thought to be extinct, and what remains are facing imminent extinction (Hadfield 1986, Yeung and Hayes 2018). These large arboreal snails range in size from approximately 10 to 20 millimeters and give live birth to three to seven offspring per year. Members of the genus typically live upwards of ten years and are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees (Hadfield and Miller 1989, Hadfield et al. 1993). Having beautiful shells, Hawai‘i’s tree snails have been described as the “jewels of the forest” and are well known in the islands. In Hawaiian tradition snails sing and many are referenced in mele, hula, and mo`ōlelo (Sato et al. 2018).

DISTRIBUTION: Members of this subfamily are all single-island endemics occurring on O‘ahu, M‘aui, Moloka‘i, Lana‘i, and Hawai‘i Island.

ABUNDANCE: The entire subfamily is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas
of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be

impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term

- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hadfield, M. G., and S. E. Miller. 1989. Demographic studies on Hawaii's endangered tree snails: *Partulina Proxima*. Pac. Sci. 43:1–16.

Hadfield, M. G., S. E. Miller, and A. H. Carwile. 1993. The decimation of endemic Hawai'ian tree snails by alien predators. Am. Zool. 33:610–622.

Hadfield, M. G., B. S. Holland and K. J. Olival. 2004. Contributions of *ex situ* propagation and molecular genetics to conservation of Hawaiian tree snails. Experimental Approaches to
Conservation Biology, M. Gordon and S. Bartol, eds. University of California Press. Pp. 16 – 34.

Hadfield, M. G., and J. E. Saufler. 2009. The demographics of destruction: isolated populations of arboreal snails and sustained predation by rats on the island of Moloka'i 1982–2006. Biol.
Invasions 11:1595–1609. doi:10.1007/s10530-008-9409-9

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O’ahu Tree Snails of the genus Achatinella. Portalnd, Oregon.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Photo: D. R. Sischo; *Amastra cylindrica*

Hawaiian Land snails

Family Amastridae

SPECIES STATUS:
325 species
State Recognized as Endemic

SPECIES INFORMATION: The family Amastridae is the most speciose snail family in the islands with 325 described species. Even more special is the fact that the entire family is endemic to the Hawaiian Islands. In general, Amastrids are considered to be ground dwelling or semi arboreal, and they are detritivores, feeding on dead and decaying leaves of a variety of native plants, with many having a preference and close association to plants in the Urticaceae (nettle family). Of all the Hawaiian land snails, no group has seen more extinction than those in the family Amastridae (Régnier et al. 2015). This family's existence is confined entirely to the main Hawaiian Islands, with no closely related members anywhere else in the world (Cowie et al.1995). Of the 325 described species, only 15 were thought to remain in 2014 (Régnier et al. 2015). However, since 2014 extensive surveys have documented more than a half dozen additional species just barely hanging on– bringing the total alive today to only 23 species of the 325. Nearly half of these owe their continued existence to rediscoveries made only possible through continued surveys, followed by emergency captive rearing and reintroduction efforts by researchers at the Bishop Museum, the Honolulu Zoo, and the Division of Forestry and Wildlife's Snail Extinction Prevention Program. All this is to say, without conservation intervention in the form of captive propagation, and reintroduction into protected areas, the outlook of the few remaining species in the Amastridae family is bleak, and Hawaii will lose one of the only endemic animal families left in the islands.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests. Some species such as those in the genus *Leptachatina* occur mostly on rocky talus. Snails are often associated with plants in the Urticaceae (nettle family).

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al.

1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants, particularly in the Urticaceae.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.

- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i's State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson's chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Auriculella pulchra, Photo by David Sischo

Terrestrial Invertebrates

Hawaiian tree snails

Subfamily Auriculellinae

SPECIES STATUS:
32 species State Recognized as Endemic

SPECIES INFORMATION: Auriculellinae is an endemic subfamily of snails which includes 32 described species in the genes *Auriculella* (Yeung et al. 2020). These small arboreal snails range in size from approximately 6 millimeters or less and lay eggs. Species are mostly nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawai‘i’s tree snails have been described as the “jewels of the forest” and are well known in the islands. In Hawaiian tradition snails sing and many are referenced in mele, hula, and mo`ōlelo (Sato et al. 2018).

DISTRIBUTION: Members of this subfamily are all single-island endemics occurring on O‘ahu, M‘aui, Moloka‘i, Lana‘i, and Hawai‘i Island.

ABUNDANCE: The entire subfamily is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working

towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hadfield, M. G., and S. E. Miller. 1989. Demographic studies on Hawaii's endangered tree snails: *Partulina Proxima*. Pac. Sci. 43:1–16.

Hadfield, M. G., S. E. Miller, and A. H. Carwile. 1993. The decimation of endemic Hawai'ian tree snails by alien predators. Am. Zool. 33:610–622.

Hadfield, M. G., B. S. Holland and K. J. Olival. 2004. Contributions of *ex situ* propagation and molecular genetics to conservation of Hawaiian tree snails. Experimental Approaches to Conservation Biology, M. Gordon and S. Bartol, eds. University of California Press. Pp. 16 – 34.

Hadfield, M. G., and J. E. Saufler. 2009. The demographics of destruction: isolated populations of arboreal snails and sustained predation by rats on the island of Moloka'i 1982–2006. Biol.

Invasions 11:1595–1609. doi:10.1007/s10530-008-9409-9

Hawai'i Department of Land and Natural Resources. 2015. Hawai'i's State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai'i.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson's chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Yeung NW, Slapcinsky J, Strong EE, Kim JR, Hayes KA (2020) Overlooked but not forgotten: the first new extant species of Hawaiian land snail described in 60 years, *Auriculella gagneorum* sp. nov. (Achatinellidae, Auriculellinae). ZooKeys 9501-31

Cookeconcha hystricella Phone to N. Yeung

Terrestrial Invertebrates

Hawaiian Land snails

Family Endodontidae

SPECIES STATUS:
33 species
State Recognized as Endemic

SPECIES INFORMATION: The Endodontid family is endemic to Oceania with 33 described species from the Hawaiian Islands (Pilsbry 1905). Little is known regarding habitats or life history of this group as almost the entire family has gone extinct from the Hawaiian Islands. Today only three species are known to occur, two species in the genus *Cookeconcha* from O‘ahu, and one species in the genus *Endodonta* from the Northwestern Hawaiian Island of Nihoa. This group is extremely imperiled.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands and on Northwestern Hawaiian Islands, where *Endodonta christenseni*, an extant species on the island of Nihoa is believed to be the last *Endodonta* on Earth (Hayes et al. 2020).

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native dry and mesic forests, as well as coastal strand. On Nihoa, *Endodonta christenseni* is found in extremely dry exposed habitat in clumps of the native grass *Eragrostis variabilis.*

THREATS: All remaining Hawaiian species in the family are in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.

- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Pilsbry, H.A. & Vanatta, E.G. 1905. Hawaiian species of Endodonta and Opeas. Proceedings of the Academy of Natural Sciences of Philadelphia 57: 783–786.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H.

2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Kala subrutila, Photo by David Sischo

Terrestrial Invertebrates

Hawaiian Land Snails

Family Euconulidae and Oxychilidae

SPECIES STATUS:
66 species
State Recognized as Endemic

SPECIES INFORMATION: Hawai'i has 60 species of Euconulids and six species of Oxychilids (Yeung and Hayes 2018). These flat round snails with a shell diameter of 3-10 mm resemble cinnamon buns, and can be found on the ground and in the vegetation. Interestingly, the shells of the euconulids and oxychilids are translucent, so the colors you see on the shell are actually the snails organs and body showing through.

DISTRIBUTION: All Hawaiian species are endemic with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: Both families are experiencing range reductions and extinctions.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for these families include wet and mesic native forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity. .

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce

offspring for reintroduction or augmentation of wild populations.

- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Pilsbry, H.A. & Vanatta, E.G. 1905. Hawaiian species of Endodonta and Opeas. Proceedings of the Academy of Natural Sciences of Philadelphia 57: 783–786.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Vitrinid sp. N. Yeung

Hawaiian Land snails

Families Gastrodontidae and Vitrinidae

SPECIES STATUS:
4 species
State Recognized as Endemic

SPECIES INFORMATION: Hawai‘i has one known species of vitrinid and three species of gastrodontids (Yeung and Hayes 2018). Both families are globally distributed with Hawaiian endemic species. Little is known about their life histories or conservation status.

DISTRIBUTION: Members of this family are endemic to the main Hawaiian Islands.

ABUNDANCE: Little is known of their abundance and distribution.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this family is native wet and mesic forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo).

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson’s chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.

- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.

Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Plueropoma sp.

Terrestrial Invertebrates

Hawaiian Land snails

Family Helicinidae

SPECIES STATUS:
14 species
State Recognized as Endemic

SPECIES INFORMATION: 14 species of Helicinidae are endemic to the Hawaiian Islands, although the family is distributed globally. Only eight species are known to persist (Yueng and Hayes 2018). Interestingly, this family is operculate, having a small "door" or hard piece on its foot that allows the animal to seal up tight, A common feature of inter-tidal and marine snails. The operculum protects the snails from predators and from drying out. Species can be both arboreal and ground dwelling.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range. They are critically imperiled wherever they occur.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: All remaining Hawaiian species in the family are in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp*.)*, *Euglandina spp.,* and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al*.* 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic

relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:
- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.

- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Pilsbry, H.A. & Vanatta, E.G. 1905. Hawaiian species of Endodonta and Opeas. Proceedings of the Academy of Natural Sciences of Philadelphia 57: 783–786.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Elasmias sp., Photo by David Sischo

Terrestrial Invertebrates

Hawaiian land snails

Subfamilies Pacificellinae and Tornatellidinae

SPECIES STATUS:
77 species State Recognized as Native or Endemic

SPECIES INFORMATION: Snails in the subfamilies Pacificellinae and Tornatellidinae are small micro snails occurring throughout the Pacific. Most species are single island endemics however several species have multi-island distributions. These micro snails range in size from approximately 2 to 4.5 millimeters (Cowie 1995, Goulding et al. 2023). Little is known about their life history or conservation status but they are likely experiencing similar declines to other more well-studied groups.

DISTRIBUTION: Members of this subfamily occur throughout the Hawaiian Archipelago

ABUNDANCE: These entire subfamilies are likely experiencing range reductions and extinctions across their ranges.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in a variety of habitat types from costal strand to mountain summits.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and

Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:
- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best

distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Goulding, T. C., Yeung, N. W., Slapcinsky, J., Strong, E. E., Kim, J. R., Brook, F. J., & Hayes, K. A. (2023). Tiny snails with large distributions: systematics and delimitation of the Pacific land snails Pacificella and Lamellidea (Stylommatophora: Achatinellidae: Pacificellinae). Bulletin of the Society of Systematic Biology.

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hadfield, M. G., and S. E. Miller. 1989. Demographic studies on Hawaii's endangered tree snails: *Partulina Proxima*. Pac. Sci. 43:1–16.

Hadfield, M. G., S. E. Miller, and A. H. Carwile. 1993. The decimation of endemic Hawai'ian tree snails by alien predators. Am. Zool. 33:610–622.

Hadfield, M. G., B. S. Holland and K. J. Olival. 2004. Contributions of *ex situ* propagation and molecular genetics to conservation of Hawaiian tree snails. Experimental Approaches to Conservation Biology, M. Gordon and S. Bartol, eds. University of California Press. Pp. 16 – 34.

Hadfield, M. G., and J. E. Saufler. 2009. The demographics of destruction: isolated populations of arboreal snails and sustained predation by rats on the island of Moloka'i 1982–2006. Biol. Invasions 11:1595–1609. doi:10.1007/s10530-008-9409-9

Hawai'i Department of Land and Natural Resources. 2015. Hawai'i's State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai'i.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson's chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus Achatinella. Portalnd, Oregon.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Succinea sp. David Sishco

Terrestrial Invertebrates

Hawaiian Land snails

Family Succineidae

SPECIES STATUS:
42 species
State Recognized as Endemic

SPECIES INFORMATION: Hawai‘i has 42 endemic species in the globally distributed family Succineidae. Only 29 species are known to be extant (Yeung and Hayes 2018). These snails range in size from approximately 5-12 mm and are both arboreal and ground dwelling and lay large gelatinous egg masses. Locally, these snails are known as “Snot in a Hat,” because their large body often does not fit inside their small-flat shells. These are some of the most commonly observed snails along upper elevation hiking trails.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this family is native wet and mesic forests, with some species occurring in coastal strand.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo).

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and

Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:
- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of

individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific Science* 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Vertiginid sp. Photo by N. Yeung

Terrestrial Invertebrates

Hawaiian Land Snails

Family Vertiginidae And Pupillidae

SPECIES STATUS:
66 species
State Recognized as Endemic

SPECIES INFORMATION: Hawai'i has 55 species of vertiginids and one species of pupillid, both families have unidentified cryptic diversity (Yeung and Hayes 2018). All species are considered micro-mollusks with adult shell sizes being less than 3 mm. These tiny snails often go unnoticed as without a microscope they look like a grain of sand. However, under the microscope you will see that these snails have very textured, domed shells with whorls often stacking on top of one another resembling a bee hive.

DISTRIBUTION: All Hawaiian species are endemic with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: Both families are experiencing range reductions and extinctions.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for these families include both low and high elevation forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.*)*, *Euglandina spp.,* and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al*. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity. .

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or

produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:
- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

Clarke B., Murray J., and Johnston M. 1984. The Extinction of Species by a Program of Biological Control. *Pacific*

Science 38: 97-104

Cowie, RH. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. Evolution 49:1191-202.

Cowie, R.H. 2001. Can snails ever be effective and safe biocontrol agents? *International Journal of Pest Management* 47: 23-40

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019.
Version 1.2 Department of Land and Natural Resources, Honolulu, HI.

Gerlach J, Barker GM, Bick CS, Bouchet P, Brodie G, Cristensen CC, Collins T, Coote T, Cowie RH., Fiedler CG, Griffiths O L, Florens FBV, Hayes K., Kim J, Meyer J, Meyer WM, Richling I, Slapcinsky JD, Winsor L, Yeung NW (2020) Negative impacts of invasive predators used as biological control agents against the pest snail *Lissachatina fulica*: the snail *Euglandina 'rosea'* and the flatworm *Platydemus manokwari*. Biological Invasions. 10.1007/s10530-020-02436-w

Hadfield, M. G. 1986. Extinction in Hawaiian Achatinelline snails. Malacologia 67:67–81.

Hawai‘i Department of Land and Natural Resources. 2015. Hawai‘i’s State Wildlife Action Plan. Prepared by H. T. Harvey and Associates, Honolulu, Hawai‘i.

Hayes, K.A., Slapcinsky, J., Sischo, D.R., Kim, J.R., & Yeung, N.W. *The last known Endodonta species? Endodonta christenseni sp. nov. (Gastropoda: Endodontidae).. Bishop Museum occasional papers*, *138* (). Retrieved from https://par.nsf.gov/biblio/10281647.

Holland, B.S., C.C. Christensen, K.A. Hayes, and R.H. Cowie. 2008. Biocontrol in Hawaii: A response to Messing (2007). *Proceeding of the Hawaiian Entomological Society*. 40:81-83.

Holland, B. S., S. L. Montgomery, and V. Costello. 2010. A reptilian smoking gun: first record of invasive Jackson’s chameleon (*Chamaeleo jacksonii*) predation on native Hawaiian species. Biodivers. Conserv. 19:1437–1441. doi:10.1007/s10531-009-9773-5

Meyer WM, Yeung NW, Slapcinsky J. Hayes KA (2017). Two for one: inadvertent introduction of *Euglandina* species during failed bio-control efforts in Hawaii. Biological Invasions 19: 1399– 1405.

Pilsbry, H.A. & Vanatta, E.G. 1905. Hawaiian species of Endodonta and Opeas. Proceedings of the Academy of Natural Sciences of Philadelphia 57: 783–786.

Régnier, C., Bouchet, P., Hayes, K. A., Yeung, N. W., Christensen, C. C., Chung, D. J., Fontaine, B., & Cowie, R. H. 2015. Extinction in a hyperdiverse endemic Hawaiian land snail family and implications for the underestimation of invertebrate extinction. *Conservation biology: the journal of the Society for Conservation Biology*, *29*(6), 1715–1723.

Sato, A. Y., Price, M. R., & Vaughan, M. B. (2018). Kāhuli: Uncovering Indigenous ecological knowledge to conserve endangered Hawaiian land snails. *Society & Natural Resources, 31*(3), 320–334.

Solem, A. 1990. How many Hawaiian land snail species are left? and What can we do for them? Bishop Mus. Occas. Pap. 30:27–40.

Yeung, N.W., Hayes K.A. 2018. Biodiversity and Extinction of Hawaiian Land Snails: How Many Are Left Now and What Must We Do To Conserve Them – A Reply to Solem (1990). Integrative and Comparative Biology, 58(6)1157-1169.

Terrestrial Invertebrates

Mites (and Ticks)
Order Acari

ORDER INCLUDES:
39 Native Families
79 Native Genera
9 Indigenous Species
107 Endemic Species

GENERAL INFORMATION: Mites are the most diverse and abundant arachnid, and except for ticks, many mites are barely visible to the naked eye. The order is ubiquitous and is one of the oldest terrestrial animal taxa. Feeding habits of mites vary greatly; some species are predators of other mites, some species are parasites of animals, while others feed on plants, fungus, decaying organic matter, excrement, or carrion. Many non-native mites are considered to be pests, while some are considered useful for biocontrol of other pests. All ticks, except one species of *Ixodes* described from sea and shore birds on Laysan Island (Kauō) are non-native to Hawai‘i. Ticks are external parasites of vertebrates, feeding on blood, and can transmit the widest variety of pathogens of any blood-sucking arthropod, including bacteria, rickettsiae, protozoa, and viruses. The order Acari is poorly known in Hawai‘i and the group is in desperate need of taxonomic scrutiny. While approximate native families, genera, and species numbers are listed, the status of some species is questionable. These numbers are not exact and will vary with additional research.

DISTRIBUTION: Mites and ticks are known from all the MHI as well as some of the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mites and ticks inhabit a wide range of terrestrial and aquatic habitats. Key habitats are unknown but are mostly host-dependent.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward mites should include:
- Conduct surveys to determine the distribution and abundance of known mites and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Support specialized taxonomic work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Schuster R, Murphy PW. 1991. The acari: reproduction, development and life-history strategies. New York, (NY): Chapman and Hall. 554 pp.

Vredevoe, Larisa. Background information on the biology of ticks. Available at: http://entomology.ucdavis.edu/faculty/rbkimsey/tickbio.html.

Zhang Z-Q. 2003. Mites of greenhouses: identification, biology and control. Cambridge, (MA): CABI Publishing. 256 pp.

Theridion grallator. Photo: Ryan Chang

Terrestrial Invertebrates

Spiders
Order Araneae

ORDER INCLUDES:
Kauaʻi cave wolf spider, Federally Endangered
16 Native Families
44 Native Genera
184+ Endemic Species

GENERAL INFORMATION: Spiders have four pairs of legs, no antennae, and are predaceous. Worldwide, there are over 75,000 species. Hawaiʻi is home to at least 184 endemic species believed to have originated from 34 founder species. The original spider colonizers are thought to have reached Hawaiʻi by ballooning, a method of travel where a spider is carried by the wind on a strand of web. Eighty percent of the known Hawaiian native spider species belong to ten genera in seven families: *Cyclosa* (Araneidae), *Orsonwelles* (Linyphiidae), *Pagiopalus* and *Pedinopistha* (Philodromidae), *Havaika* (Salticidae), T*etragnatha* (Tetragnathidae), *Argyrodes, Ariamnes*, and *Theridion* (Theridiidae), and *Mecaphesa* (Thomisidae). However, many more species remain to be described, particularly in the genera *Argyrodes, Tetragnatha,* and *Theridion* and perhaps also in *Cyclosa* and *Havaika*. Widespread endemic species include *Tetragnatha quasimodo*, *Mecaphesa anguliventris*, *M. facunda*, and *Pagiopalus* spp. The happy-face spider (pictured above) is a well-known species that comes in a variety of color morphs. This variation may have evolved to reduce predation by preventing birds from establishing a reliable search image. Like many invertebrates found in Hawaiʻi, some taxa of spiders have undergone extensive adaptive radiations. For example, the genus *Tetragnatha* (long-jawed spiders) contains about 37 described and around 13–23 additional undescribed endemic species that occur throughout the MHI and are found in various native habitats. The constituent species encompass a spectrum of colors, shapes, sizes, ecological affinities, and behaviors. They reach their highest diversity in montane wet and mesic forests, dry forests, high and low shrublands, and scrub. There are likely many species yet to be discovered in this genus. In the NWHI, the small islands of Nihoa and Mokumanamana (Necker) have a unique pair of endemic trapdoor spiders (*Nihoa mahina* and *N. hawaiiensis*), with no representatives on the MHI. Due to the lack of taxonomic specialists and the fact that most species are nocturnal, many Hawaiian native spiders remain poorly known or undescribed.

DISTRIBUTION: Spiders are known from all the MHI in addition to a few of the NWHI.

ABUNDANCE: As a group, unknown. A lack of systematic surveys hampers population estimates. However, the loss of native habitats likely means species within the order are declining. Of the known species, *Adelocosa anops* (limited to a single cave on Kauaʻi) and *Doryonychus raptor* (restricted to high elevation habitats on Kauaʻi) appear to be the most threatened on the MHI, while populations of single island endemics from the NWHI such as *Nihoa mahina* and *Nihoa hawaiiensis* remain mostly unknown.

LOCATION AND CONDITION OF KEY HABITAT: Spiders occur in all habitats in Hawai‘i including caves, lava flows, forests, and shrublands. Key habitat requirements are poorly known but mostly consist of mixed native to mostly native forests and ecosystems.

THREATS:

- Predation by invasive, non-native species, especially social insects such as ants and wasps, and perhaps also other spiders.
- Loss or degradation of habitat. *Adelocosa anops* (Lycosidae*)* is known from a single cave on Kaua‘i which is threatened by development.
- Insufficient information for species assessments.
- Lack of expertise to describe the large number of undescribed new species and review groups with taxonomic uncertainty.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward spiders should include:

- Forest restoration. Spider populations have responded positively to reforestation efforts at Auwahi Dry Forest in East Maui.
- Conduct surveys and document non-native predators and parasitoids of spiders.
- Control of invasive non-native invertebrate predators like ants and vertebrate predators such as coqui frogs.
- Conduct surveys to determine the distribution and abundance of known spiders and to document new species to science.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa, including radiations from the following families and genera: Lycosidae, Theridiidae (*Argyrode*s, *Ariamnes,* and *Theridion*), Araneidae (*Cyclosa, Araneus*), Linyphiidae, Philodromidae *(Pagiopalus* and *Pedinopistha*)*,* Oonopidae, Salticidae (*Havaika*), Thomisidae (*Mecaphesa*)*, and* Tetragnathidae (*Doryonychus* and *Tetragnatha*).
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Bellvert A, Gillespie RG, Arnedo MA. 2021. A happy family: systematic revision of the endemic *Theridion* spiders (Araneae, Theridiidae) of the Hawaiian Islands. Invertebrate Systematics 35: 1-58.

Berry JW, Williams, A. 2017. The status of *Argiope trifasciata kauaiensis* (Araneae: Araneidae) on Kaua‘i, Hawai‘i. Bishop Museum Occasional Papers 119: 9-13.

Blackledge TA, Binford GJ, Gillespie RG. 2003. Resource use within a community of Hawaiian spiders (Araneae: Tetragnathidae). Annales Zoologici Fennici 40: 293–303.

Blackledge TA, Gillespie RG. 2004. Convergent evolution of behavior in an adaptive radiation of Hawaiian web-building spiders. Proceedings of the National Academy of Sciences USA 101: 16228-16233.

Garb JE. 1999. An adaptive radiation of Hawaiian Thomisidae: biogeographic and genetic evidence. Journal of Arachnology 27: 71-78.

Gillespie RG. 1991. Hawaiian spiders of the genus Tetragnatha: I. Spiny leg clade series. Journal of Arachnology 19: 174-209.

Gillespie RG. 1992. Hawaiian spiders of the genus Tetragnatha: II. Species from natural areas of windward East Maui. Journal of Arachnology 20: 1-17.

Gillespie RG. 1994. Hawaiian spiders of the genus Tetragnatha: III. *T. acuta* clade. Journal of Arachnology 22: 161-168.

Gillespie RG. 2002. Hawaiian spiders of the genus Tetragnatha: IV. New, small species in the spiny leg clade. Journal of Arachnology 30: 159-172.

Gillespie RG. 2003. Hawaiian spiders of the genus Tetragnatha: V. Elongate web-builders from Oahu. Journal of Arachnology 31: 8-19.

Gillespie RG. 2004. Community assembly through adaptive radiation in Hawaiian spiders. *Science* 303: 356-359.

Gillespie R. 2005. The ecology and evolution of Hawaiian spider communities. American Scientist 93: 122-131.

Gillespie, RG, Rivera, MAJ. 2007. Free-living spiders of the genus *Ariamnes* (Araneae, Theridiidae) in Hawaii. The Journal of Arachnology 35(1): 11-37.

Gillespie RG, Reimer N. 1993. The effect of alien predatory ants (Hymenoptera: Formicidae) on Hawaiian endemic spiders (Araneae: Tetragnathidae). Pacific Science 47: 21-33.

Gruner DS. 2004. Attenuation of top-down and bottom-up forces in a complex terrestrial community. Ecology 85: 3010-3022.

Hormiga G. 2002 Orsonwelles, a new genus of giant linyphiid spiders (Araneae) from the Hawaiian Islands. Invertebrate Systematics 16: 369-448.

Hormiga G, Arnedo MA, Gillespie RG. 2003. Speciation on a conveyor belt: sequential colonization of the Hawaiian Islands by *Orsonwelles* spiders (Araneae: Linyphiidae). Systematic Biology 52(1): 70-88.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Krushelnycky PD, Loope LL, Gillespie RG. 2007. Inventory of arthropods of the west slope shrubland and alpine ecosystems of Haleakala National Park. Pacific Cooperative Studies Unit, University of Hawai‘i at Mānoa Technical Report 148, 52 pp.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Oxford GS, Gillespie RG. 2001 Portraits of evolution: studies of coloration in Hawaiian spiders. BioScience 51:521-528.

Rivera M, Gillespie R. 2010. New species of endemic kleptoparasitic spiders of the genus *Argyrodes* (Araneae: Theridiidae) in the Hawaiian Islands. Pacific Science 64: 221-231.

Suman TW. 1964. Spiders of the Hawaiian Islands: catalog and bibliography. Pacific Insects 6: 665-687.

Suman TW. 1965. Spiders of the family Oonopidae in Hawaii. Pacific Insects 7: 225-242.

Suman TW. 1970. Spiders of the family Thomisidae in Hawaii. Pacific Insects 12: 773-864.

Vandergast AG, Gillespie RG. 2004 Effects of natural forest fragmentation on a Hawaiian spider community. Environmental Entomology 33: 1296-1305.

Vandergast AG, Gillespie RG, Roderick GK. 2004. Influences of volcanic activity on the population genetic structure of Hawaiian *Tetragnatha*. Molecular Ecology 13: 1729-1743.

Nihoa mahina. Photo: Sheldon Plentovich/USFWS

Terrestrial Invertebrates

Brushed Trapdoor Spiders
Order Araneae
Family Barychelidae
Genus *Nihoa*

GENUS INCLUDES:
2 Endemic Species

GENERAL INFORMATION: Barychelidae are known as brushed trapdoor spiders. Two species are found in Hawai‘i, both being endemic: *Nihoa hawaiiensis* (Raven, 1988) and *Nihoa mahina* Churchill & Raven, 1992. Not much is known about these species as there have not been any official surveys or biological studies to date.

DISTRIBUTION: Mokumanamana (Necker, *N. hawaiiensis*) and Nihoa (*N. mahina)* (NWHI).

ABUNDANCE: As a group unknown. A lack of systematic surveys hampers population estimates. However, anecdotal evidence suggests mature adults are less frequently seen during service trips. Invasive ants have been seen attacking immature spiders that researchers come across (S. Plentovich, personal communication, October 1, 2024).

LOCATION AND CONDITION OF KEY HABITAT: *Nihoa mahina* and *N. hawaiiensis* are only found on the rocky intertidal zones of these small Leeward islands.

THREATS:
- Predation by invasive ants.
- Loss or degradation of habitat by invasive weeds.
- Climate change and sea level rise.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward brushed trapdoor spiders should include:
- Control of invasive ants and other non-native invertebrates.
- Control of invasive weeds.
- Conduct surveys to determine the distribution and abundance of these species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of the two species of *Mahina*.

References:

Churchill, Raven, RJ. 1992. Systematics of the intertidal trapdoor spider genus *Idioctis* (Mygalomorphae: Barychelidae) in the western Pacific with a new genus from the northeast. Memoirs of the Queensland Museum 32: 9-30.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Raven, RJ. 1994. Mygalomorph spiders of the Barychelidae in Australia and the western Pacific. Memoirs of the Queensland Museum 35: 291-706.

Hogna hawaiiensis. Photo: W. Haines.

Terrestrial Invertebrates

Wolf Spiders
Order Araneae
Family Lycosidae

FAMILY INCLUDES:
Kauaʻi cave wolf spider, Federally Endangered
7 Native Genera
11 Endemic Species

GENERAL INFORMATION: Wolf spiders are agile hunters, mostly living on the ground. These spiders are known for having two of their eight eyes very large, giving them excellent eyesight for hunting their prey. The endemic Hawaiian Lycosidae are an amazing example of adaptive shifts. They have colonized and adapted to the harsh terrains of lava flows, high elevations, and dark cave systems where the Kauaʻi cave wolf spider, *Adelocosa anops*, evolved to have no eyes. Each of the seven genera has only one or two species, indicating multiple independent colonizations of the islands.

DISTRIBUTION: Wolf spiders are recorded from the MHI except Niʻihau, Kahoʻolawe, and Lānaʻi. One species is found on Laysan (NWHI).

ABUNDANCE: As a group, unknown. A lack of systematic surveys hampers population estimates. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Wolf spiders occur in a wide range of extreme habitats in Hawaiʻi including lava tubes, lava flows, subalpine, alpine, and aeolian ecosystems.

THREATS:

- Predation by invasive, non-native arthropod species such as ants, other non-native spiders, lesser brown scorpions, and vertebrates such as cane toads.
- Loss or degradation of habitat. *Adelocosa anops* (Lycosidae*)* is known from a single cave on Kauaʻi that is threatened by development.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward wolf spiders should include:

- Conduct surveys and document non-native predators and parasitoids of spiders.
- Control of invasive non-native invertebrate predators like ants.
- Conduct surveys to determine the distribution and abundance of known spiders and to document new species to science.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

World Spider Catalog. 2024. World Spider Catalog. Version 25.5. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on 6 November 2024. doi: 10.24436/2.

Eumecochernes sp. Photo: Michael Slay.

Terrestrial Invertebrates

Pseudoscorpions
Order Pseudoscorpionida

ORDER INCLUDES:
7 Native Families
8 Native Genera
15 Native & Endemic Species

GENERAL INFORMATION: Pseudoscorpions are small predatory arachnids that prey on other arthropods. Unlike true scorpions, Pseudoscorpions do not have a stinging tail. Fertilization is either external or internal. Most females construct a brood nest. The order is poorly known in Hawai‘i.

DISTRIBUTION: Pseudoscorpions are known from Kaua‘i, Maui, O‘ahu, the island of Hawai‘i and on Midway Atoll and Laysan Island in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Pseudoscorpions prefer habitats that provide cracks, nooks, or crevices in which they can retreat. In Hawai‘i, caves are an important habitat; however, the importance of other habitats is unknown.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pseudoscorpions should include:
- Conduct surveys to determine the distribution and abundance of known pseudoscorpions and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:
- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Weygoldt P. 1969. The biology of pseudoscorpions. Cambridge, (MA): Harvard University Press. 145 pp.

Terrestrial Invertebrates

Springtails
Order Collembola

ORDER INCLUDES:
5 Native Families
32 Native Genera
95 Native Species
95 Endemic Species

GENERAL INFORMATION: Springtails are primitive, wingless hexapods related to insects. They are typically scavengers or fungivores; some also feed on living plant material. They go through a slight metamorphosis and usually grow to less than five millimeters (0.2 inches), and are often much smaller. Long-legged flies (Dolichopodidae), ants, and spiders are known to prey on springtails. The order is poorly known in Hawai‘i.

DISTRIBUTION: Springtails are known from all MHI except Kaho‘olawe and Ni‘ihau, and a few are found in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Because they are often sensitive to desiccation, springtails are most often found in damp habitats. However, they occur in a wide range of habitats, primarily in soil and leaf litter. Species also can be found in trees, lava tubes, and in the desert-like habitat at the summit of Mauna Kea and on coral atolls.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward springtails should include:
- Conduct surveys to determine the distribution and abundance of known springtails and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:
- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Christiansen K, Bellinger P. 1992. Insects of Hawaii: Volume 15 Collembola. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Neomachilis heteropus

Terrestrial Invertebrates

Jumping bristletails
Order Archaeognatha

ORDER INCLUDES:
1 Native Family
1 Native Genus
5 Native Species
5 Endemic Species and Subspecies

GENERAL INFORMATION: Jumping bristletails are primitive insects. They feed on algae, lichen, plant material, and possibly dead arthropods. Fertilization is external and may involve courtship. The order is poorly known in Hawai‘i. Compared to other invertebrate orders found in Hawai‘i, Archaeognatha is represented by very few taxa. Within the single-represented family, Machilidae, two endemic species and three subspecies of *Neomachilis* are described.

DISTRIBUTION: Bristletails are known from all MHI except Kaho‘olawe and Ni‘ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining. One species, *N. insularis*, is common and widely distributed while the other two, *N. heteropus* and *N. perkinsi*, are very rare.

LOCATION AND CONDITION OF KEY HABITAT: Bristletails occupy a variety of habitats including leaf litter on forest floors, rotting logs and stumps, dead tree fern fronds, bunch grass, caves, and lava tubes.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward bristletails should include:
- Conduct surveys to determine the distribution and abundance of known bristletails and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:
- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Sturm H. 1993. A new *Neomachilis* species from the Hawaiian Islands (Insecta: Archaeognatha: Machilidae). Bishop Museum Occasional Papers 36: 1-16.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2. Honolulu: University of Hawaii Press. 475 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Terrestrial Invertebrates

Beetles
Order Coleoptera

ORDER INCLUDES:
26 Native families
87 Native genera
1,348 Native Species
1,337 Endemic Species

GENERAL INFORMATION: The order Coleoptera is the largest order of animals in the world, containing well over a million species. Beetles can be found in all habitats and fill a huge variety of ecological niches. In Hawai‘i, beetles have undergone extensive adaptive radiations and are the dominant insects in most habitats. Carabid beetles are the dominant predatory insects in native wet forests, and species in the family Curculionidae (weevils) are the dominant herbivorous insects in all habitats. Different species of beetles also feed on fungi, some specialize on particular plant parts and others are detritivores. Diversity within most families is generally highest on Maui, O‘ahu, and Kaua‘i. The most speciose families include: Carabidae (5 genera/239 spp.), Curculionidae (10 genera/169 spp.), Belidae (*Proterhinus*/158 spp.), Ptinidae (3 genera/138 spp.), Cerambycidae (3 genera/128 spp.), Nitidulidae (7 genera/93 spp.), and Staphylinidae (12 genera/92 spp.). Many species are little known, especially in the families Belidae and Staphylinidae; substantial research has not been conducted on either family in over 100 years. As an example of the diversity of Hawai‘i’s beetles, two genera are briefly outlined below. *Blackburnia* (Family: Carabidae) are nocturnal, occupy a variety of ecological niches, and nearly all species are flightless and restricted to single islands or volcanoes. Endangered or threatened species in this genus are mostly known from shrublands and mesic koa forests. Recent research has discovered 38 new species (29% of the species in the genus), and non-native ants are a particular threat to this genus. *Rhyncogonus* (Family: Curculionidae weevils) are flightless, nocturnal weevils; most adults are herbivorous. Nearly all are endemic to single islands and are known from all the MHI and the NWHI. Members of the genus are the dominant leaf-chewing beetle group in Hawai‘i, and many species are specific to particular plant communities where they feed on a narrow range of host plants. Threats to this genera include habitat degradation by pigs (*Sus scrofa*), habitat-modifying non-native invasive plants, predation by ants, and human disturbance. All species in this genus are considered to be of concern. Recent research has discovered 15 new species (31% of the species in the genus).

DISTRIBUTION: Beetles are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the order are declining. Based on extensive collecting efforts in suitable habitats abundance of common species is estimated minimally at 5,000 adult individuals per hectare. In contrast, the rarest species are collected or observed once per decade. Comparing modern collections with those from the 1890s indicates that abundance in mesic koa (*Acacia koa*) forests, *Sophora-Deschampsia* shrublands, and low elevation mesic ‘ōhi‘a (*Metrosideros polymorpha*)

forests has declined precipitously. These habitats are often most heavily impacted by alien, social Hymenoptera (e.g., ants and vespid wasps) predators, other alien arthropods such as non-native Isopoda (sowbugs), and invasive weeds.

LOCATION AND CONDITION OF KEY HABITAT: Beetles are among the most ecologically diverse groups and occur in most terrestrial and aquatic habitats. Key habitat requirements of individual species are poorly known.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predators like ants (Formicidae) and wasps (Vespidae), non-naitve parasitoids (Hymenoptera), as well as non-native competitors such as non-native sowbugs (Isopoda) are negatively affecting native beetle populations.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Collecting certain showy or large beetles for sale may affect populations, especially in the genus *Plagithmysus* (Cerambycidae).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward beetles should include:

- Baiting and control of Argentine ant (*Linepithema humile*) in Haleakalā shrublands.
- Baiting and control of other invasive non-native ant species in native habitats.
- Rehabilitation of mesic forests on Oʻahu, Maui, Molokaʻi, and the island of Hawaiʻi.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Tibouchina*, *Alsophila*, and *Passiflora*.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known coleopterans and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Krushelnycky PD, Gillespie RG, Loope LL, Liebherr JK. 2005. Rediscovery and uncertain future of high-elevation Haleakala carabid beetles (Coleoptera). Pacific Science 59:399-410.

Liebherr JK. 2004. Patterns of endangerment or pathways to enlightenment? Reconstructing the Fauna Hawaiiensis. Sysematics and Biodiversity 2:175-189.

Liebherr JK, Zimmerman EC. 2002. Insects of Hawai'i : Volume 16 Hawaiian Carabidae (Coleoptera) Part 1: Introduction and Tribe Platynini. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Samuelson GA. 2003. Review of Hawaiian *Rhyncogonus*. Honolulu, (HI): Bishop Museum Press.

Zimmerman EC. 2001. Insects of Hawai'i: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Proterhinus sp.

Terrestrial Invertebrates

Primitive weevils
Order Coleoptera
Family Belidae
Genus *Proterhinus*

GENUS INCLUDES:
161 Endemic Species
19 Subspecies

GENERAL INFORMATION: *Proterhinus* is the only representative of the primitive weevil family Belidae in Hawai‘i and has evolved into the most diverse species radiation of the Hawaiian weevils (Curculionoidea). *Proterhinus* species are twig, stem, woodborers, and few are known to be leafminers. Larvae are thought to be host-specific, but hosts are known for only a few species, and adult host-specificity remains unclear. While 180 species and subspecies are described, the number of endemic species is estimated to be much higher. Known species are difficult to identify based on current keys and available resources. This group is in need of revision and taxonomic scrutiny.
DISTRIBUTION: *Proterhinus* are recorded from all the MHI except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat requirements of individual species are poorly known but associated with endemic forest plants.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host-specific plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native predators.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward primitive weevils should include:

- Baiting and control of invasive non-native ants and other predators.
- Rehabilitation of mesic koa forests on O‘ahu, Maui, Moloka‘i, and the island of Hawai‘i.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Tibouchina*, *Alsophila*, and *Passiflora*.

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known species and to document new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of endemic species.
- Initiate efforts to locate and identify new species.
- Conduct studies to document biology, habitat requirements, and life history of endemic species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In prep. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Swezey, OH. 1954. Forest entomology in Hawaii. An annotated checklist of the insect faunas of the various components of the Hawaiian forests. Bernice P. Bishop Museum Special Publication 44, ix, 266p.

Blackburnia pavida

Terrestrial Invertebrates

Ground Beetles
Order Coleoptera
Family Carabidae

FAMILY INCLUDES:
5 Native Genera
400 Native Species
400 Endemic Species

GENERAL INFORMATION: The ground beetles (Carabidae) are one of the largest families of animals with over 40,000 species worldwide. The entire group is predatory, sometimes with special adaptations to particular prey. Despite the common name of the family, many of the Hawaiian endemic species are arboreal, hiding during the day in crevices or moss mats and emerging at night to hunt on tree trunks. Others are riparian, specializing in stream bank habitats. The endemic fauna is dominated by two large genera: *Blackburnia* with 133 species (Liebherr and Zimmerman, 2000), and *Mecyclothorax* with 241 (Will and Liebherr, 2022). The remaining genera are much smaller. *Bembidion*, a worldwide genus, is represented by 23 endemic species found in a variety of habitats; *Paratachys* by five species of minute wingless beetles, mostly riparian with one cave dweller; and *Tachys oahuensis*, a lowland species also found on some of the Northwest Hawaiian Islands. *Blackburnia* are generally larger, and are widely distributed on all islands; many species have reduced hind wings and are flightless. *Mecyclothorax* are smaller and all are flightless; they are especially diverse on East Maui, with nearly half the total restricted to there, but absent from Kauaʻi. Many of both have very restricted ranges, making them highly vulnerable to local habitat disturbance; *Mecyclothorax* in particular are almost all limited to a single volcano and often a particular section of forest. Wing reduction is also found in the *Bembidion*; the flighted ones are often found on multiple islands, while the flightless species are island or mountain endemics. Subfossil cave sediments indicate that a robust lowland fauna was formerly present, including both extinct species and those now restricted to montane areas (Liebherr and Porch, 2015).

DISTRIBUTION: Ground beetles are known from all the MHI and several of the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. Many species are cryptic, inhabiting leaf litter and moss mats, requiring labor-intensive survey methods to find. However, the loss and degradation of native habitats likely means that species within the family are declining.

LOCATION AND CONDITION OF KEY HABITAT: Ground beetles are found in a wide variety of terrestrial habitats, primarily mesic and wet forests, leaf litter, and stream margins. Key habitat requirements of most individual species are poorly known.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predaceous ants (Formicidae) and parasitoid wasps (Scelionidae: *Trimorus* spp.) as well as non-native carabids such as *Metacolpodes buchanani* are negatively affecting native beetle populations.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Biocontrol agents or organisms may affect some native species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward beetles should include:

- Baiting and control of Argentine ant (*Linepithema humile*) in Haleakalā shrublands.
- Rehabilitation of mesic forests.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Clidemia*, *Tibouchina*, *Alsophila*, and *Passiflora*.
- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Conduct surveys to determine distribution and abundance of known taxa and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate studies to determine the effects of non-native organisms on beetle populations.

References:

Liebherr JK. 2004. Patterns of endangerment or pathways to enlightenment? Reconstructing the Fauna Hawaiiensis. Sysematics and Biodiversity 2:175-189.

Liebherr JK. 2015. The *Mecyclothorax* beetles (Coleoptera, Carabidae, Moriomorphini) of Haleakalā, Maui: Keystone of a hyperdiverse Hawaiian radiation. ZooKeys 544:1–407.

Liebherr JK, Porch N. 2015. Reassembling a lost lowland carabid beetle assemblage (Coleoptera) from Kauai, Hawaiian Islands. Invertebrate Systematics 29:191–213.

Liebherr JK, Zimmerman EC. 2000. Insects of Hawai'i : Volume 16 Hawaiian Carabidae (Coleoptera) Part 1: Introduction and Tribe Platynini. Honolulu: University of Hawai'i Press.

Will K, Liebherr JK. 2022. Two new species of *Mecyclothorax* Sharp, 1903 (Coleoptera: Carabidae: Moriomorphini) from the Island of Hawai'i. Pan-Pacific Entomologist 98(1):1–17.

Terrestrial Invertebrates

Nesotocus kauaiensis. Photo: W. Haines.

True Weevils and Bark Beetles
Order Coleoptera
Family Curculionidae

FAMILY INCLUDES:
15 Native genera
>356 Native Species
>353 Endemic Species
>7 Endemic Subspecies

Native genera and number of described native species*Acalles* 22 species
Anotheorus 3 species
Chaenosternum 1 species
Deinocossonus 1 species, 3 subspecies
Dryophthorus 19 species
Dryotribodes 1 species
Dryotribus 2 species
Heteramphus 12 species
Nesotocus 4 species
Oodemas 61 species, 4 subspecies
Orothreptes 1 species
Rhyncogonus 47 species
Seenomma 1 species
Stenotrupis 2 species
Xyleborus 22 species

The Hawaiian true weevils are diverse plant-feeding insects with several lineages of adaptive radiations, many of which need updated taxonomic assessment. Like many other groups, the weevils lack basic information on their status and biology. Some feed on living leaves, others bore in dead wood, others are found in leaf litter and their exact feeding habits are unknown. The scolytine genus *Xyleborus* are ambrosia beetles, boring tunnels in wood and feeding on fungi that they cultivate there rather than directly on the wood itself.

DISTRIBUTION: Recorded from all MHI (except Kahoʻolawe) and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats and host plants, and the increase in non-native invasive predators and parasitoids likely indicate that species populations are declining. At least 125 species are known from five or fewer individuals ever collected. Many species have not been collected since their original descriptions.

LOCATION AND CONDITION OF KEY HABITAT: Coastal/lowland, mesic, and montane.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host plants.
- Non-native predators such as ants, rats, and coqui frogs.
- Non-native parasites and parasitoids.
- Displacement by non-native competitors.
- Insufficient information on life histories of species, especially rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward weevils should include:

- Control of non-native predatory invasive ants, rats, and coqui frogs.
- Control of weeds in key habitats.
- Restoration of key habitats; planting host plants.
- Conduct surveys to determine distribution and abundance of known species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate efforts to locate and identify new species.
- Conduct studies to document the biology, habitat requirements, and life histories of rare and understudied species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In prep. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Samuelson GA. 2003. Review of *Rhyncogonus* of the Hawaiian Islands (Coleoptera: Curculionidae). Bishop Museum Bulletin in Entomology vol 11.

Rhyncogonus blackburni

Terrestrial Invertebrates

Broad-nosed weevils
Order Coleoptera
Family Curculionidae
Genus *Rhyncogonus*

GENUS INCLUDES:
47 Endemic Species

GENERAL INFORMATION: Species in the genus *Rhyncogonus* are flightless, nocturnal weevils. The *Rhyncogonus* genus is an exemplary example of beetles that have radiated in Hawai‘i into at least 47 described species. Adults are herbivorous leaf chewers and larvae are associated with roots or plant parts in the soil. Many species are specific to particular plant communities where they feed on a narrow range of host plants, but host-specificity of adult weevils and larvae is poorly understood. Nearly all species are endemic to single islands and are known from all the MHI and two of the NWHI. Threats to this genus include habitat degradation by pigs (*Sus scrofa*), habitat-modifying non-native invasive plants, predation by ants and rats, and human disturbance. All species in this genus are considered to be of concern.

DISTRIBUTION: Recorded from the MHI (except Ni‘ihau and Kaho‘olawe) and the NWHI (Laysan, Nihoa, and Mokumanamana).

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats and the increase in non-native invasive predators likely mean species within the genus are declining.

Samuelson 2003’s species status assessments indicate that at least 18 of 47 species of *Rhyncogonus* may possibly be extinct, with at least one definitely extinct. Surveys targeting *R. welchii* were conducted by the Bishop Museum between 2015 and 2020 in Halona Valley, O‘ahu. While possible feeding damage was noticed on *Sapindus oahuensis* foliage, no individuals were recovered (Evenhuis et al. 2021).

LOCATION AND CONDITION OF KEY HABITAT: Coastal/lowland and Montane.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host plants.
- Non-native predaceous ants (Hymenoptera: Formicidae) and predaceous rats.
- Non-native parasites and parasitoids.
- Non-native competitors.

- Insufficient information on life histories of almost all species hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Rhyncogonus* species should include:

- Control of non-native predatory invasive ant species, rats, and coqui frogs.
- Control of weeds in key habitats.
- Restoration of key habitats; planting host plants.
- Conduct surveys to determine distribution and abundance of known species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In review. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.

Evenhuis NL, Arakaki KT, Imada CT. 2021. Terrestrial arthropod survey of Halona Valley, Joint Base Pearl Harbor-Hickam, Naval Magazine Lualualei Annex, August–November 2020. Final report prepared for the U.S. Navy. Hawaii Biological Survey Contribution No. 2021-003. 37 pp.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Samuelson GA. 2003. Review of *Rhyncogonus* of the Hawaiian Islands (Coleoptera: Curculionidae). Bishop Museum Bulletin in Entomology vol 11.

Eopenthes sp.

Terrestrial Invertebrates

Click beetles
Order Coleoptera
Superfamily Elateroidea

Family Elateridae
47 Endemic species
Family Eucnemidae
54 Endemic species

GENERAL INFORMATION:
Family Elateridae
Dacnitus: 1 sp.
Eopenthes: 34 spp.
Itodacnus: 12 spp.

Family Eucnemidae
Dromaeolus: 49 spp.
Epiphanis: 1 sp.
Fornax: 4 sp.The superfamily Elateroidea includes click beetles, fireflies, and their relatives. In Hawai‘i it is represented by two families, Elateridae (true click beetles) and Eucnemidae (false click beetles). Both groups are capable of engaging a mechanism at the junction of the pro- and mesosterna to snap the body with an audible click, as a defense and to flip themselves over. The larvae of all species are found in dead rotting wood, where they may be detritivores or predators. All three elaterid genera (*Dacnitus*, *Eopenthes*, and *Itodacnus*) are strictly endemic to Hawai‘i. *Eopenthes* is the largest and most common, with 34 species. The 11 known species of *Itodacnus* are rarer, except for one species frequently found on Kaua‘i. *Dacnitus* is represented by a single species that has apparently not been seen since the 1800s. Among the eucnemids, *Dromaeolus* are by far the most diverse and abundant, though still rare; typically one or two individuals are found per Malaise trap sample. Forty-nine species are known, but most from only one or two specimens, and there are probably more undescribed. The four native *Fornax* species are all extremely rare, last collected in 1965, and the monotypic *Epiphanis* is only known from the original collections in 1895.

DISTRIBUTION: Click beetles are known from all the MHI except Kaho‘olawe and Ni‘ihau, and two *Itodacnus* are found on Necker and Nihoa.

ABUNDANCE: Unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the superfamily are declining. Larvae are cryptic in dead wood and adults are active for a relatively brief period in the summer, so they may be underrepresented by traditional survey methods. *Eopenthes* may be collected by sweeping and *Dromaeolus* in Malaise traps, but both are still rare.

LOCATION AND CONDITION OF KEY HABITAT: Click beetle larvae live in dead wood or other decaying matter, but the precise ecological role of the native species is unknown. All are reliant on native plants, primarily in upper-elevation forests.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Predation by invasive, non-native species, especially social insects such as ants (Formicidae) and wasps (Vespidae)
- Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward click beetles should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known click beetles and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Otto RL. 2017. The false click beetles (Coleoptera: Eucnemidae) of Hawai‘i. Zootaxa 4278:1–78.

Sharp D, Scott H. 1908. Coleoptera IV. Fauna Hawaiiensis 3(5):367–579.

Van Zwaluwenburg RH. 1959. Notes on the elaterid genus *Eopenthes*, Sharp (Coleoptera). Proceedings of the Hawaiian Entomological Society 17(1):117–125.

Apterocyclus waterhousei. Photo: W. Haines

Terrestrial Invertebrates

Stag beetles
Order Coleoptera
Family Lucanidae
Genus *Apterocyclus*

GENUS INCLUDES:
5 Endemic Species

GENERAL INFORMATION: Stag beetles (Lucanidae) are a family containing about 1,200 described species worldwide. In Hawai‘i, stag beetles are represented by a single endemic genus, *Apterocyclus*, which includes five species known only from the island of Kaua‘i (Paulsen and Hawks 2014). Adult *Apterocyclus* beetles are flightless and completely lack hind wings. Adult beetles are nocturnal and rarely encountered. Anecdotal observations suggest that adults may emerge synchronously when seeking mates, as there are historical reports of large congregations of beetles crawling in leaf litter at night (Osborn 1920, R. Rice personal communication). For the species whose larvae are known (*A. honoluluensis* and *A. waterhousei*), the grublike larvae live in the soil in koa forests where they feed on decaying organic matter (Swezey 1915). Little is known about the biology of the other three species, whose larvae are not documented. Nonnative rodents appear to be a major threat to *Apterocyclus* species, and scooped-out fragments of adult beetles are often found piled in hollows under logs in the same areas where larvae are found (W. Haines personal observation). Ants are also a likely threat to *Apterocyclus* larvae.

DISTRIBUTION: Kaua‘i; found in the montane plateau area from Kōke‘e to Makaweli.

ABUNDANCE: The status of stag beetle populations is unknown and difficult to assess, as adults are rarely encountered, and larvae live in the soil. Larvae of one species, *A. honoluluensis* can be relatively common under logs in koa forests of northwest Kaua‘i. A second species, *A. waterhousei*, has been recently collected in similar habitats but is less widespread than *A. honoluluensis*. A third species, *A. kawaii*, is known from only two specimens collected from private land as recently as 1996, and populations, if extant, are likely highly localized and rare. The other two species, *A. palmatus* and *A. munroi*, have not been recently seen and may be extinct, but because original collection data is vague, it is possible that populations still exist in remote locations that have not been surveyed (Paulsen and Hawks 2014).

LOCATION AND CONDITION OF KEY HABITAT:
Key habitat for *A. honoluluensis* and *A. waterhousei* includes mesic forests of Kaua‘i, especially koa-dominated forests, in Kōke‘e State Park, Nā Pali-Kona Forest Reserve, and Pu‘u Ka Pele Forest Reserve, which are largely intact and under active conservation management. Key habitat for *A. kawaii* and *A. munroi* may primarily be located on private land in the Makaweli region, though it is possible these species occur in other areas but have not been detected. Key habitat for *A. palmatus* is unknown, as the original collection locality is listed only as 4,000 ft elevation on Kaua‘i.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predaceous ants (Formicidae) as well as non-native competitors such as the coconut rhinoceros beetle (CRB).
- Rodents, including rats and mice, which prey on adult beetles and possibly larvae.
- Insufficient information hampers conservation efforts for rare species.
- Collecting beetles for sale or trade may affect populations.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Apterocyclus* stag beetles should include the following:

- Conduct surveys to assess status of the three species that have not been recently collected and whose status is unknown.
- Control non-native rodents in upland koa forests through the use of traps or other methods.
- Establish rodent-proof exclosures on Kauaʻi into which *Apterocyclus* and other vulnerable species can be translocated and monitored.
- Rehabilitate mesic koa forests on the island of Kauaʻi.
- Preserve, maintain, and restore habitats that support existing populations.

MONITORING:

- Establish new monitoring protocols for *Apterocyclus* larvae to detect population trends, especially in areas with different degrees of rodent control.

RESEARCH PRIORITIES:

- Initiate targeted searches for *Apterocyclus* species not recently collected or observed.
- Initiate studies to determine distributions of extant *Apterocyclus* species.
- Initiate studies to determine the effects of biocontrol organisms (including potential biocontrol agents for coconut rhinoceros beetle) on beetle populations.
- Initiate studies on *Apterocyclus* life history and rearing methods.

References:

Osborn, H.T. 1920. A note on *Apterocyclus* (Coleoptera, Lucanidae). *Proceedings of the Hawaiian Entomological Society*. 4(2): 375-376.

Paulsen, M.J. and D.C. Hawks. 2014. A review of the primary types of the Hawaiian stag beetle genus *Apterocyclus* Waterhouse (Coleoptera, Lucanidae, Lucaninae), with the description of a new species. *ZooKeys* 433: 77–88.

Swezey, O.H. 1915. Notes and Exhibitions, March 4th, 1915. *Proceedings of the Hawaiian Entomological Society*. 3(2): 114.

Anisolabis howarthi. Photo: Mike Slay

Terrestrial Invertebrates

Earwigs
Order Dermaptera

ORDER INCLUDES:
1 Native Family
3 Native Genera
10 Native Species
9 Endemic Species

GENERAL INFORMATION: Earwigs have slender, flattened bodies and are easily recognized by the pair of large pincers at the tip of their abdomens. Earwigs are nocturnal and most are carnivorous, although some species are omnivorous. Females lay eggs in the soil, under objects, or in other protected places, and guard eggs and care for young until they can find food for themselves. Earwigs hatch from eggs and molt as they grow, obtaining more antennal segments and progressively more developed wings with each molt. Earwigs are considered harmless to people, although some species emit a foul-smelling substance when disturbed. All native earwigs are members of the family Carcinophoridae. Six endemic species in the genus *Anisolabis* represent an adaptive radiation from a marine littoral ancestor, probably *A. maritima*, which is indigenous to Hawa‘i. *A. maritima* and *Euborellia eteronoma* are widespread and populations appear stable. *A. perkinsi*, known only from Kaua‘i, has apparently declined. *A. howarthi* is restricted to caves on Hawai‘i Island. It is rarely seen and each cave may harbor a distinct population. The other four *Anisolabis* species have not been recollected for at least 75 years and may be extinct. Two species were known from O‘ahu, one was endemic to Maui, and one was known from the island of Hawai‘i. One recently described species from Hawai‘i, *Paraflexolabis ornata*, is only known from three specimens and may not be native. Earwigs are not considered pests in Hawai‘i, although they are elsewhere in the world.

DISTRIBUTION: Earwigs are known from all the MHI and the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Earwigs occur in a variety of habitats including caves, coastal and marine littoral areas, mesic and sometimes wet forests, and possibly recent lava flows.

THREATS:
- Invasive predators and parasites.
- Possibly alien diseases.
- Loss or degradation of habitat.
- Possible disease.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward earwigs should include:

- Conduct surveys to determine the distribution and abundance of known earwigs and to document and identify new species.
  - Conserve areas supporting native species, especially cave habitats.
  - Conduct surveys searching for populations of species thought to be extinct.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Determine the status and population trends of *A. perkinsi* and initiate studies designed to determine the causes of its decline.
- Conduct studies to document the biology, habitat requirements, and life history of native species.
- *A. maritima* and *A. howarthi* populations possess geographic variation. Initiate studies to determine whether populations are distinct species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Brindle A. 1980. The cavernicolous fauna of Hawaiian lava tubes. 12. A new species of blind troglobitic earwig (Dermaptera: Carcinophoridae), with a revision of the surface living earwigs of the Hawaiian Islands. Pacific Insects 21:261-274.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Young FN, Kritksy G. 2002. A survey of entomology. Lincoln, (NE): Writers Club Press. 308 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Campsicnemus penicillatus. Photo: Karl Magnacca.

Terrestrial Invertebrates

True flies
Order Diptera

ORDER INCLUDES:
26 Native Families
77 Native Genera
1,500+ Native Species
1,500+ Endemic Species

GENERAL INFORMATION: All flies, except wingless species, have two pairs of wings; one pair is functional, the other (known as halteres) is highly modified. Because of their importance in genetic research, Dipterans are well-studied. The initial founders of Hawaiian populations are believed to have reached the islands on birds or by being caught in wind currents. Numerous adaptive shifts and unusual evolutionary developments characterize the species found in Hawai‘i, making the Hawaiian fauna globally significant. These include the freshwater canacids *Procanace* and the enigmatic coastal asteiid *Bryania bipunctata*. The most speciose genera include *Campsicnemus*, *Drosophila*, *Scaptomyza*, *Tylparua*, and *Lispocephala*. Species in the genus *Drosophila* are perhaps the best-known native dipterans because of the scientific interest in the group’s genetics and adaptive radiations. About a quarter of the world’s known species of Drosophilidae are endemic to Hawai‘i.

DISTRIBUTION: Native flies are known from all the Main Hawaiian Islands and many of the Northwestern Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Flies occur in a variety of freshwater and terrestrial habitats.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants, wasps, crustaceans, and fish prey on flies.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward flies should include the following:

- Conduct surveys to determine the distribution and abundance of known fly species and to document and identify new species.

- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to asses their stability and trends.

RESEARCH PRIORITIES:
- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Foote D, Carson H. *Drosophila* as monitors of change in Hawaiian ecosystems. Available at: http://biology.usgs.gov/s+t/noframe/t233.htm (last accessed 3 December 2004).

Hardy DE. 1960. Insects of Hawaii: Volume 10 Diptera: Nematocera–Brachycera. Honolulu: University of Hawai'i Press.

Nishida GM, editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Procanace acuminata.

Photo: Hawaii Biological Survey.

Terrestrial Invertebrates

Beach flies
Order Diptera
Family Canacidae
Genus *Procanace*

Genus Includes:
9 Endemic Species

GENERAL INFORMATION: Canacidae, or beach flies, is a relatively small family of acalyptrate Diptera found throughout coastal regions of the World. The genus *Procanace* contains nine endemic species in Hawai‘i. The endemic Hawaiian *Procanace* are notable within the genus and the family for their adaptation to freshwater habitats, rather than seashores like almost all others. They live along streams where the larvae feed on algae growing on rocks in fast-flowing sections and can be found from high elevations almost to sea level. A group of highly specialized endemic parasitoid wasps, *Aspidogyrus* (Hymenoptera: Figitidae) attacks them in the pupal stage.

DISTRIBUTION: Species are found on all the Main Hawaiian Islands except Ni‘ihau and Kaho‘olawe. Three species are endemic to Kaua‘i, while the rest are found on multiple islands.

ABUNDANCE: Largely unknown for individual species. Some taxa are locally abundant and can be observed in the hundreds of individuals while others are infrequently observed and known from only a few museum specimens. Seasonal abundance may vary with flow rate and water availability.

LOCATION AND CONDITION OF KEY HABITAT: Species in this genus are found in association with freshwater stream habitats throughout the MHI. They require fast stream flow, high oxygenation, and relatively high stream volume, so reduction in flow by human diversions and reduced rainfall has probably impacted habitat quality.

THREATS:

- Water scarcity. Extended periods of drought or human-made water diversions can threaten critical habitat by eliminating native stream ecosystems.
- Invasive species. These can have a negative impact either as predators or habitat competitors (Englund 2002; Englund and Polhemus 2002).

CONSERVATION ACTIONS: Specific management directed toward beach flies should include the following:

- Protect existing habitats in freshwater stream systems.
- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.

MONITORING: Aquatic insects have been extensively used as indicators of water quality in freshwater streams and lakes (Rosenberg et al. 2008). The fauna of the Hawaiian islands has a reduced number of these indicator species because of the remote location of the archipelago and the difficulty of colonization for many freshwater aquatic groups. Native Hawaiian damselflies (*Megalagrion* spp.) have been used as bioindicators (Englund 2001; Englund et al. 2007) but populations of these species are small, difficult to monitor, and are subject to conservation action. Developing native Diptera (Canacidae, Ephydridae, and Chironomidae) as bioindicators will provide a new management tool for native Hawaiian aquatic ecosystems and will lead to more secure sources of fresh water. Monitoring actions should thus include the following: establish new monitoring for species that are not currently monitored.

RESEARCH PRIORITIES:

- Link distribution and abundance data for *Procanace* with measures of water quality to create a model for aquatic ecosystem monitoring in Hawai‘i.

References:

Englund RA. 2001. Long-term monitoring of one the most restricted insect populations in the United States, *Megalagrion xanthomelas* (Selys-Longchamps), at Tripler Army Medical Center, Oahu, Hawaii (Zygoptera: Coenagrionidae). Odonatologica 30(3): 255-263.

Englund RA. 2002. The loss of native biodiversity and continuing nonindigenous species introductions in freshwater, estuarine, and wetland communities of Pearl Harbor, Oahu, Hawaiian Islands. Estuaries 25(3): 418-430.

Englund RA, and Polhemus DA. 2001. Evaluating the effects of introduced rainbow trout (*Oncorhynchus mykiss*) on native stream insects on Kauai Island, Hawaii. Journal of Insect Conservation 5: 265-281.

Englund RA, Wright MG, and Polhemus DA. 2007. Aquatic insect taxa as indicators of aquatic species richness, habitat disturbance and invasive species impacts in Hawaiian Streams. Biology of Hawaiian Streams and Estuaries (NL Evenhuis, ed). Bishop Museum Bulletin in Cultural and Environmental Studies 3: 207-232.

Hardy DE, and Delfinado MD. 1980. Insects of Hawaii Volume 13: Diptera: Cyclorhhapha III. University of Hawaii Press. 451 pp.

O’Grady PM and Pak N. 2016. Studies in Hawaiian Diptera III: New distributional records for Canacidae and a new endemic species of Procanace. Biodiversity Data Journal 4: e5611.

Rosenberg, DM, Resh, VH and King, RS. 2008. Chapter 7: Use of Aquatic Insects in Biomonitoring. An Introduction to the Aquatic Insects of North America, 4th Edition (Merritt, RW, Cummins, KW and Berg, MB, eds.). Kendall Hunt Publishing, Dubuque, IA.

Terrestrial Invertebrates

Long-legged flies
Order Diptera
Family Dolichopodidae

FAMILY INCLUDES:
17 Native Genera
282 Native Species
>280 Endemic Species

GENERAL INFORMATION: Genera with endemic species
Adachia: 6 spp.
Campsicnemus: >200 spp.
Conchopus: 6 spp.
Elmoia: 8 spp.
Eurynogaster: 24 spp.
Sigmatineurum: 11 spp.
Swezeyella: 7 spp.
Uropachys: 9 spp.
Arciellia, *Asyndetus*, *Diaphorus, Hydrophorus*, *Major*, *Medetera*, *Paraliancalus*: 1–3 spp. each
The long-legged flies are a highly diverse group in Hawai‘i. The largest genus is *Campsicnemus*, with over 200 species described to date. It is the second largest radiation of endemic flies in Hawai‘i, and the sixth largest overall. They are particularly notable for the modification and ornamentation of the male legs (usually the middle one), which is used in courtship. They are generalist predators of small arthropods such as springtails and mites and inhabit a variety of forest habitats. Color is correlated to general habitat preference: species found on leaf litter are typically dull brown, water skaters are shiny brown to black, and those that prefer live leaves are metallic green to blue. A complex of genera formerly lumped under *Eurynogaster*, including *Adachia*, *Arciellia*, *Elmoia*, *Major*, *Sigmatineurum*, *Swezeyella*, and *Uropachys* contains similar but larger species with less elaborate male ornamentation. Most are distributed generally in forests, but *Sigmatineurum* and *Major* are specialists in aquatic habitats, found at seeps, waterfalls, and cascades. In contrast, the species of *Conchopus* are found only at the coast, on wave-washed rocks, and *Hydrophorus* are found around brackish coastal and lowland ponds.

DISTRIBUTION: Long-legged flies are known from all the Main Hawaiian Islands except Ni‘ihau and Kaho‘olawe. The coastal *Hydrophorus* and *Conchopus* are also found in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Some species are common and abundant, while others are rarely seen and known from only a handful of specimens. Some of latter may be infrequently collected due specialized habitats rather than inherent rarity. Little is known about the habitat requirements of specific species, particularly for immature stages, and the loss of native habitats likely means that some species are declining.

LOCATION AND CONDITION OF KEY HABITAT: *Campsicnemus*, *Eurynogaster*, and related genera occur in a variety of terrestrial habitats, depending on the species. Some are typically found on leaf litter, others arboreally on leaves, and still others are specialized water skaters on puddles and still pools. *Sigmatineurum* and *Major* are specialists in aquatic habitats, found at seeps, waterfalls, and cascades. The species of *Conchopus* are found only at the coast on wave-washed rocks, and *Hydrophorus* are found around brackish coastal and lowland ponds.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants and wasps, prey on these flies.
- Competition. Non-native long-legged flies, water treaders, and other insects may compete for resources.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward long-legged flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Hardy DE, Kohn MA. 1964 Insects of Hawaii Volume 11: Diptera, Brachycera. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Terrestrial Invertebrates

Pomace flies
Order Diptera
Family Drosophilidae

Genera with endemic species
Drosophila: >500 spp.
Scaptomyza: >150 spp.

GENERAL INFORMATION: The Hawaiian Drosophilidae are perhaps the best-known native flies because of the scientific interest in the group's genetics and adaptive radiations. About a quarter of the world's known species of Drosophilidae are endemic to Hawai'i. Although well-separated in the rest of the world, *Scaptomyza* is the sister group to the Hawaiian *Drosophila* clade and the Hawaiian endemic subgenera are often difficult to unambiguously separate from *Drosophila*. Thus they are often treated as a single group, although it is unclear if they are derived from one or two introductions to Hawai'i. Unusually among Hawaiian taxa, *Scaptomyza* dispersed out of Hawai'i multiple times, and all non-Hawaiian groups are derived from Hawaiian ancestors. About 500 species of *Drosophila* and 150 species of *Scaptomyza* are described, hundreds more are known but not yet described, and many more await discovery. The total estimate of this group of flies is likely to be 800–1,000 species, the largest radiation of endemic species in Hawai'i. The large, conspicuous members of the Hawaiian *picture wing* species group are the most famous but represent only about 120 species.

DISTRIBUTION: Native drosophilids are known from all the Main Hawaiian Islands except Kaho'olawe and Ni'ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate for most species. However, the loss of native habitats likely means that many species within the family are declining. Many of the *picture wing* species can be surveyed non-lethally with fermented baits and because they can be identified by wing pattern, but most other species either are not attracted to baits, can only be identified with a microscope, or both. Members of the *modified mouthparts* species group and most *Scaptomyza* tend of be cryptic and are rarely collected except by rearing from their host material. Fourteen species of picture-wing *Drosophila* are listed as endangered, and many more are equally rare.

LOCATION AND CONDITION OF KEY HABITAT: Pomace flies occur mainly in wet to mesic forest, and breed in rotting plant material. A few species reach into subalpine areas or dry forest. Nearly all species are highly specific to one or a few host plants. The species groups of *Drosophila* are mainly divided based on host plant substrate: bark, leaves, and fungus. *Scaptomyza* often use more ephemeral substrates such as rotting flowers, and some utilize unusual breeding habitats such as decaying silversword seeds and the sticky resin of *Pisonia* seed pods. One group, subgenus *Titanochaeta*, are predators on spider eggs. The hosts of many species are unknown.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predators and parasitoids. Non-native species, including ants and wasps, prey on these flies.
- Competition. Non-native detritivores and herbivores, such as ambrosia beetles, crane flies, and isopods, use the same host substrates and can alter the environment making it unsuitable for breeding.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pomace flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Hardy DE. 1965. Insects of Hawaii: Volume 12 Diptera: Drosophilidae. Honolulu: University of Hawaii Press.

Magnacca KM, Foote D, O'Grady PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. Zootaxa 1728: 1–58.

Magnacca KM, Price DK. 2015. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). Molecular Phylogenetics and Evolution 92: 226–242.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Drosophila kikiko, Kaua‘i sister species of *D. aglaia*, nearly identical in appearance. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila aglaia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila aglaia* Hardy, 1965 is one of the most striking members of the *picture wing* species group of Hawaiian *Drosophila* pomace flies. The species is endemic to the Wai‘anae range of O‘ahu, occurring in diverse mesic forest gulches. Although it was never common, it was historically found widely throughout the range on the eastern and northern slopes. *D. agalia* is the namesake of the *aglaia* species subgroup, which consists of six extremely rare species. It is nearly identical to the recently discovered *D. kikiko* of Kaua‘i (pictured above), differing only in minor characters like the coloration of the side of the thorax and the front leg hairs of the male. Notably, the host plants are unknown for *D. agalia* and all but one member of the *agalia* subgroup. This uncertainty regarding their precise habitat makes surveys specifically targeting *D. aglaia* difficult.

DISTRIBUTION: Known only from the Wai‘anae range of O‘ahu, where it has historically been found at six sites from Mokulē‘ia, west of Ka‘ala, to Pu‘u Palikea at the southern end. The most recent record was in 1997 at Pu‘u Palikea, but intensive surveys from 2013–2022 have failed to recover it there. This species has not been seen since 1971 at other historically known sites. There are no records from the leeward side, including Wai‘anae and Makaha valleys, but these areas were not intensively sampled during the early collecting period (1966–1975).

ABUNDANCE: Unknown. The lack of any records for the past 18 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. Given that the most recent record was less than 20 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The host of *D. aglaia* is unknown. It was reported as *Touchardia sandwicensis* (as *Urera sandwicensis*) in earlier reports (Montgomery 1975, Kaneshiro and Kaneshiro 1995), but this was based on an erroneous identification of *D. kinoole*. Therefore, the precise habitat requirements of *D. aglaia* are unknown. However, at five of the six historic sites, native vegetation is declining in general (Pu‘u Palikea being the exception).

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila aglaia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Magnacca, KN, Price, DK. 2015. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). Molecular Phylogenetics and Evolution 92: 226–242.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila differens

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila differens* Hardy & Kaneshiro, 1975 is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kauaʻi representatives. Within the group, *D. differens* closely resembles the other species of the *planitibia* subgroup, *D. planitibia* of Maui, and *D. heteroneura* and *D. silvestris* of Hawaiʻi. It differs from *D. planitibia* only in having the face yellow rather than black, but laboratory experiments have shown that hybrid male offspring are sterile. The species is endemic to Molokaʻi, occurring in montane wet forest. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads.

DISTRIBUTION: *Drosophila differens* was historically known from several upper elevation sites on Molokaʻi, all within the Nature Conservancy's current Kamakou Preserve. Its true range is probably greater, but much of the area to the east is extremely difficult to access. There have been only two collections since 1977, one in 1983 and one in 1999. Surveys in 2005, 2007, and 2010 failed to recover it. However, it was rediscovered in Puʻu ʻAliʻi Natural Area Reserve in 2024.

ABUNDANCE: Unknown. The lack of recent records at historic sites suggests it has strongly declined. Native host plant lobeliads now occur at low abundance in these areas and other sites where *D. differens* was recently rediscovered. Other sites near the summit of Kamakou Peak where lobeliads are more common have not been surveyed.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila differens* is reported to breed in *Clermontia*, which continues to occur in the area it had been found, though it is relatively uncommon. *Cyanea* and *Trematolobelia* (also lobeliads) occur in the area, *Trematolobelia* is even abundant in some places. It is likely that these two genera of plants also serve as hosts for *D. differens*.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila differens* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila digressa. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila digressa

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Drosophila digressa* Hardy & Kaneshiro, 1968 is a medium-sized picture wing fly endemic to Hawai‘i Island. It is a member of the *lanaiensis* species subgroup, which consists of five species, all being rare. All members of this subgroup breed primarily in decaying branches and trunks of *Charpentiera* spp. (pāpala), and usually secondarily in *Pisonia* spp. (pāpala kēpau). Both of these have highly restricted distributions on Hawai‘i. The species occurs in mesic to wet forests where its host plants are found. Although always uncommon and sporadic, it was historically found at sites across the southern and western portions of the island.

DISTRIBUTION: *Drosophila digressa* is historically known from six sites: Moanuiahea on Hualālai, Pāpā and Manukā in South Kona, Kīpuka 9 along the Saddle Road, and Kīpuka Puaulu and ‘Ōla‘a in Hawai‘i Volcanoes National Park. Recent collections and observations have come only from Manukā, the nearby site of Honomalino, and ‘Ōla‘a; there are no host plants remaining at Moanuiahea or Kīpuka 9, and all picture wing flies disappeared from Kīpuka Puaulu several years ago (Pāpā has not been accessible for several years).

ABUNDANCE: Unknown. Based on repeated visits to the two known populations, numbers at the ‘Ōla‘a site appear to be low but consistent while rarely detectable at Manukā but may experience large booms. Both conditions are vulnerable to stochastic events, especially at Manukā where the forest is drying out and many canopy trees are dying.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. The known host of *D. digressa* is *Charpentiera* (Montgomery 1975, Kaneshiro and Kaneshiro 1995). Many species that typically use this tree can also utilize the more abundant *Pisonia* (Magnacca et al., 2008), and *D. digressa* has been found in areas of Manukā where only *Pisonia* is present. However, the long-term survival of the flies is unclear when *Charpentiera* is almost completely absent. ‘Ōla‘a and other wet forest areas formerly had very large *Charpentiera* trees that served as important hosts for *D. digressa* and other species, but most of these were dead by the late 1990s. The population at Honomalino occurs in a rare forest type with only a very small number of host plants and may not be viable.

THREATS:

- Habitat loss and degradation due to invasive plants, disturbance by non-native ungulates, and fire from nearby agricultural and residential activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila digressa* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.
- Conduct studies to determine if restoration of *Charpentiera* is possible or feasible.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Magnacca, KN, Foote, D, O'Grady, PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. Zootaxa 1728: 1–58

Magnacca, KN, Price, DK. In press. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). Molecular Phylogenetics and Evolution.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered species status for 15 species on Hawaii Island. Federal Register 78: 64638–64690.

Drosophila hemipeza. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila hemipeza

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila hemipeza* (Hardy, 1965) is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kauaʻi representatives. The unusual wing pattern is similar to the related *D. substenoptera* and the unrelated *D. pilipa*, but is otherwise distinctive. It can be distinguished from the partially sympatric *D. substenoptera* (also endangered) by having the two crossveins nearly in line rather than widely staggered, with the marks over them creating a single dark band across the wing. Both species have an unusual habit of both sexes frequently walking with the wings spread and facing forward, even when not displaying to another fly, possibly making them more vulnerable to predators. *D. hemipeza* is endemic to Oʻahu, occurring from diverse mesic to wet forest. Historically, *D. hemipeza* was found widely throughout both of Oʻahu's mountain ranges, but its distribution has dramatically contracted. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads, including *Cyanea* and *Lobelia*, but has also been reared from *Urera kaalae* (ʻōpuhe), an unusual host for this group.

DISTRIBUTION: *Drosophila hemipeza* was historically known from both the Koʻolau and Waiʻanae ranges of Oʻahu, but primarily the latter. However, the only two Koʻolau sites are at the opposite ends of the island (Pūpūkea and Pauoa Flats), suggesting it had a wide distribution there. In the Waiʻanae it was found widely, from Makaleha Valley, Mākaha Valley, ʻĒkahanui, Kaluaʻā Gulch, and several sites in the vicinity of Puʻu Palikea. Though always uncommon, the great majority of records are from Palikea, where it can still be regularly found. The only other known site today is Puʻu Hāpapa, above Kaluaʻā Gulch, where it is very rare and has not been seen since 2015. Lab-reared flies have been released into the wild at ʻĒkahanui in the Waiʻanae range and Mānoa Cliff in the Koʻolau range, but it is not yet clear if they have established self-sustaining populations.

ABUNDANCE: Unknown. During nine years of ongoing monthly monitoring from 2013–2022, the Oʻahu Army Natural Resources Program (OANRP) found a low but relatively consistent population of this species at Palikea, and only rare individual observations at Hāpapa (OANRP, 2014). While this indicates at least one stable population, it is probably also small enough to be vulnerable to stochastic events like droughts.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila hemipeza* is reported to breed in *Cyanea*, *Lobelia*, and *Urera*, which all occur at both present

sites. Since there is only one rearing record from each plant, it is unknown whether there is a preferred host; however, if there is it is likely to be for the lobeliads, which related species use exclusively. Both Palikea and Hāpapa are fenced to exclude feral ungulates and intensively managed for rare plants and snails, and habitat is generally improving at both sites.

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila hemipeza* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining the primary host plant and other habitat requirements.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila heteroneura.

Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila heteroneura

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
Designation of Critical Habitat for 12 Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila heteroneura* (Perkins, 1910) is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kauaʻi representatives. The species is endemic to Hawaiʻi, occurring in montane mesic to wet forest, where it cooccurs with *D. silvestris,* except in Kohala. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads. *Drosophila heteroneura* closely resembles other members of the subgroup including *D. differens* of Molokaʻi, *D. planitibia* of Maui, and *D. silvestris* of Hawaiʻi. However, *D. heteroneura* differs strikingly from all of these in having a broad head, particularly in the males which possess a distinct "hammerhead". Laboratory experiments have shown that they can produce viable hybrids with *D. silvestris,* and hybrid individuals have been detected in the wild. Combined with the relative ease of laboratory rearing, this has led to *D. heteroneura* being used extensively in genetics research.

DISTRIBUTION: *Drosophila heteroneura* is historically known from many collections at twelve sites across the island of Hawaiʻi except for Kohala. However, sometime after 1980, it underwent a serious decline, disappearing from sites in east Hawaiʻi where it had formerly been common. Since 1998, it has only been known from a small area in South Kona.

ABUNDANCE: Unknown. *Drosophila heteroneura* has been extirpated throughout nearly all of its historic range, including many sites where it was formerly regularly collected, indicating a population decline of over 95%. At the sites where it remains, it was sometimes moderately abundant during surveys conducted from 1998–2011. However, access is extremely limited, and much of the area has not been surveyed in many years. Some sites were resurveyed in 2022–2023 and found to have undergone a catastrophic decline in host plants compared to 2011, with no flies found.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The primary host of *D. heteroneura* is the bark of lobeliads, particularly larger trees of *Clermontia*. These are especially vulnerable to disturbance by feral ungulates and direct herbivory by rats and slugs. Most of the current range of *D. heteroneura* is not fenced from ungulates. The disappearance of *D. heteroneura* coincided with both the decline of an important host species, *Clermontia*

hawaiiensis, and the arrival of the western yellowjacket (*Vespula pensylvanica*), a major predator of native insects.

THREATS:

- Habitat loss and degradation due to invasive plants, invertebrates, and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila heteroneura* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila montgomeryi, courtship dance.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila montgomeryi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila montgomeryi* Hardy & Kaneshiro, 1971 is a member of the *vesciseta* species subgroup, which contains seven species of relatively uniform appearance – mostly yellow-brown, with few dark markings, and a similar pattern on the wings. They are among the smallest of the picture wings, and some individuals may even be smaller than non-picture wings. Each island has one species that breeds on *Pisonia* spp. (pāpala kēpau) and one on *Urera* spp. (ʻōpuhe), except that there is no *Pisonia* breeder known from Kauaʻi. The two groups appear similar, but the *Urera* breeding species can all be readily distinguished by having the median anterior mark on the wing longer than wide, rather than square. Other details of the coloration and male leg hairs, involved in courtship, serve to separate the species, all of which are rare. *Drosophila montgomeryi* is endemic to Oʻahu, occurring in diverse mesic forest where it breeds in *Urera*.

DISTRIBUTION: *Drosophila montgomeryi* was historically known mainly from the Waiʻanae range of Oʻahu, where it was recorded from three sites: Alaiheihe, Kaluaʻā, and ʻĒkahanui, with the majority coming from the last. There is a single historic record from the southeastern Koʻolau range, but it has not been adequately surveyed there. Since 2009, it has been found at a total of 10 sites in five populations, from Waiʻanae Valley, Schofield Barracks, Kaluaʻā and Hāpapa, Pualiʻi, and Puʻu Palikea. Lab-reared flies have been released into the wild at ʻĒkahanui in the Waiʻanae range and Mānoa Cliff in the Koʻolau range, but it is not yet clear if they have established self-sustaining populations.

ABUNDANCE: This species is still found in nearly its full historic range and some additional sites. However, it apparently can no longer be found at ʻĒkahanui, where it was historically most abundant. While the Kaluaʻā/Hāpapa and Waiʻanae populations consist of multiple sites with moderate numbers of flies and host plants, the other three sites have only small and ephemeral populations, with relatively few host plants available. In addition, the Waiʻanae sites have drastically declined in quality and abundance over the past 10 years. Nine years of ongoing monthly monitoring from 2013–2022 by the Oʻahu Army Natural Resources Program (OANRP) found a strong seasonal pattern to *D. montgomeryi* abundance at Kaluaʻā and Hāpapa, with high numbers from February through June and dropping to near zero between August and November (OANRP 2014). These observations, and the restricted distribution of *Urera*, suggest that it is primarily limited by the abundance of host plants.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. *Drosophila*

montgomeryi is documented as breeding in *Urera kaalae*, and is presumed to also breed in *U. glabra* since it occurs at sites where only the latter species is present. *Urera glabra* is still found at many sites and is long-lived and resilient, but suffers from low recruitment and few young plants are seen outside of heavily managed areas. Because broken branches root easily, many apparent individuals in a patch may be clones; since it is dioecious, this may result in all plants in the area being one sex. However, in recent years the invasive ambrosia beetle *Euwallacea* cf. *fornicatus* has been attacking damaged but living trees, causing their death rather than allowing them to regrow. On the other hand, *U. kaalae* is a relatively short-lived tree and has undergone a catastrophic decline over the past 40 years, with only a handful of wild plants remaining. Seedlings are especially vulnerable to slug predation. The loss of *U. kaalae* as a significant breeding host is probably responsible for the absence of *D. montgomeryi* from ʻĒkahanui, where both were formerly abundant. Palikea and Kaluaʻā/Hāpapa are fenced to exclude feral ungulates and intensively managed for rare plants and snails, and habitat is generally improving at both sites. The Waiʻanae sites cannot be fenced due to the likelihood of damage from falling rocks, which can also directly damage the host plants.

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila montgomeryi* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Outplant *Urera* spp. in protected areas to increase available breeding habitat, with the goal of creating self-sustaining populations of plants.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors, particularly limits on *Urera* reproduction.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila mulli. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila mulli

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Threatened
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila mulli* Perreira & Kaneshiro, 1990 is an unusual fly with no clear affinity to other picture wing species groups. It can be immediately distinguished from all others by the small size of the wing spots, nearly all yellow-brown color, and long hairs covering both the front tibia and tarsus of the male. It is endemic to Hawai‘i, occurring in lowland to montane wet forest. The breeding host of *D. mulli* is unclear. It is closely associated with native *Pritchardia* palms – adults have been found almost exclusively by collecting them from the undersides of *P. beccariana* leaves. However, it has never been reared and the breeding location is unknown. No other *Drosophila* are known to be associated with palms.

DISTRIBUTION: *Drosophila mulli* is known from three sites between 2500 and 3200 feet elevation: ‘Ōla‘a Forest Reserve (1985–86), Stainback Highway (1998), and Saddle Road (2013–14). It is probably more widely distributed than these records suggest; since it is apparently not attracted to baits, flies can only be collected from very short palm trees, which are rare.

ABUNDANCE: Unknown. *Drosophila mulli* is difficult to collect and may occur more abundantly than is recognized if taller palms could be searched.

LOCATION AND CONDITION OF KEY HABITAT: All known picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The uncertainty about the breeding host of *D. mulli* makes it difficult to ascertain the habitat quality. However, it is clear that it has a strong association with *Pritchardia* palms. Although *P. beccariana*, the only species on which *D. mulli* has been found, is surviving better than the other species on Hawai‘i, it still suffers from poor reproduction due to rat and beetle predation on the seeds, and the extinction of birds that formerly dispersed the fruit. The fungal disease Rapid ‘Ōhi‘a Death (ROD) has had a greater impact on the lower elevation forests where *D. mulli* occurs than the higher sites where most other picture wing flies are typically found. The Saddle Road site where it was last collected in 2013-2014 is now much more open and dry, and may not support *D. mulli* anymore despite the continued presence of *Pritchardia*.

THREATS:

- Habitat loss and degradation due to invasive plants, invertebrates, fungal pathogens, and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila mulli* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila musaphilia. Photo: Glenn Uemura.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila musaphilia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila musaphilia* Hardy, 1965 is a member of the *hawaiiensis* species subgroup, the second largest within the *grimshawi* group. As far as known, all members of the group breed in fermenting sap fluxes of native trees rather than bark as is typical for picture wing *Drosophila*. It is dark gray with a continuous band across the middle of the wing, generally similar in appearance to related species and the unrelated, sympatric *D. villosipedis*. It can be readily distinguished from all other species by the wing pattern, with the median band sinuate rather than straight and the mark on the dm-cu crossvein L-shaped, as well as by the details of the male front leg setation. *Drosophila musaphilia* is endemic to Kauaʻi, occurring in mesic to wet forest where it breeds in fermenting sap fluxes of *Acacia koa* (koa).

DISTRIBUTION: *Drosophila musaphilia* was historically known three sites: Mt. Kāhili (Alexander Reservoir) and two sites in Kōkeʻe State Park. It has been recently collected along the Nuʻalolo Trail and elsewhere along Kaunuohua Ridge in Kōkeʻe.

ABUNDANCE: Unknown. This species appears to have always been rare within historical collecting, compared to others that have undergone clear declines between the early collecting period (1966–1975) and today. While it can be found occasionally at certain locations, typically no more than one or two individuals are seen at a time; it does not appear to experience population booms as some other endangered *Drosophila* species do.

LOCATION AND CONDITION OF KEY HABITAT: The breeding host of *Drosophila musaphilia* is *Acacia koa*, where larvae feed in fermenting sap fluxes. *Acacia koa* is abundant and reproducing at all sites where *D. musaphilia* is found, suggesting that unlike other rare *Drosophila*, its numbers may not be strictly host-limited at the sites where it occurs. It appears to be extremely limited in range compared to the broad distribution of *Acacia koa*, suggesting limiting due to either non-host factors or in the extent of suitable conditions for sap fluxes. Introduced saprophagous invertebrates may also affect breeding habitat quality.

THREATS:

- Habitat loss and degradation due to invasive plants and insects, disturbance by non-native ungulates, and fire from nearby agriculture and recreational activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila musaphilia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila neoclavisetae

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila neoclavisetae* Perreira & Kaneshiro, 1990 is a member of the *adiastola* species group. The species is endemic to West Maui, occurring in montane wet forest. It is part of a closely related complex of species including *D. clavisetae* of East Maui and *D. neogrimshawi* of O‘ahu which all have an extra crossvein in the wing, a convergent character with the *planitibia* species group. Among these, *D. neoclavisetae* is distinguished by its wing pattern and details of the setation. The breeding host of *D. neoclavisetae* is not known for certain, but almost all other members of the *adiastola* group, including close relatives, breed in rotting bark of lobeliads, primarily *Clermontia* and *Cyanea*.

DISTRIBUTION: *Drosophila neoclavisetae* was historically known from only two collections, from 1969 and 1975, at upper elevation sites on West Maui along the Pu‘u Kukui Trail. Surveys in the same area in 2007 and 2009 failed to recover it there. Its true range is probably greater, but much of the West Maui mountain region is extremely difficult to access.

ABUNDANCE: Unknown. The lack of any records for the past 50 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. The sampling effort in the area has been relatively low for detecting rare species.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. Like its close relatives, *D. neoclavisetae* probably primarily breeds in *Clermontia*, which continues to occur in the area where these flies have been found in moderate abundance. The other lobeliad genera *Cyanea* and *Trematolobelia* also occur relatively frequently in the area, and it is likely that *D. neoclavisetae* breeds in these as well. Overall the habitat at Pu‘u Kukui is largely intact, and the reasons for the absence of *D. neoclavisetae* are not clear.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila neoclavisetae* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and critical habitats to better direct conservation measures.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila obatai. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing
Drosophila
Drosophila obatai

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila obatai* Hardy & Kaneshiro, 1972 is a member of the *orphnopeza* species subgroup, the largest within the *grimshawi* group. It is readily distinguished from most other species by the dusty gray appearance of the body and the small size of the wing spots, characters it shares with the related *D. sodomae* of Maui Nui. *Drosophila obatai* is endemic to Oʻahu, occurring in diverse mesic forest where it breeds in *Dracaena* spp. (halapēpē).

DISTRIBUTION: *Drosophila obatai* was historically known mainly from the Waiʻanae range of Oʻahu, where it was collected once from Makaleha Valley and twice from a site near Puʻu Pane, east of Kaʻala in 1970–1971. There are also two records from that period from the southeastern Koʻolau range (Wailupe and Waiʻalae Nui), but it has not been adequately surveyed for there. It was rediscovered at Manuwai Gulch in 2011 and has since been found at East Makaleha, near Puʻu Pane, and two sites in Pūleʻe Gulch in Schofield Barracks.

ABUNDANCE: Unknown. This species is still found in nearly its full historic range as well as some additional sites, though the Koʻolau sites have not been surveyed. However, repeated surveys from 2013–2022 by the Oʻahu Army Natural Resources Program (OANRP) have found that it is present regularly and in moderate numbers only at Manuwai; at all other sites it is rarely seen, and then only as single individuals. These observations, and the restricted distribution of *Dracaena*, suggest that it is primarily limited by the abundance of host plants.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. *Drosophila obatai* is reported to breed in *Dracaena* (=*Pleomele*). The species was not recorded in fly-rearing records, but it is known to breed in at least *Dracaena halapepe* since it occurs at sites where that host plant is the only species present. *Dracaena forbesii* is presumed to be a host since it is extremely morphologically similar to *Dracaena halapepe*, but *D. obatai* has not been definitively associated with it. Both plant species are widespread, long-lived, and resilient, but suffer from low recruitment and few young plants are seen outside of heavily managed areas. They typically occur as relictual patches of one to five trees, often separated from other patches by mostly non-native vegetation. Because broken branches root easily, many apparent individuals in a patch may be clones. Manuwai and Pūleʻe are fenced to exclude feral ungulates and Manuwai is

managed for rare plants, and habitat is generally improving at both sites. Other sites continue to degrade due to the presence of feral pigs and goats.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila obatai* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Continue rat control to allow reproduction of *Dracaena*.
- Outplant *Dracaena* in protected areas to increase available breeding habitat, with the goal of creating self-sustaining populations of plants.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors, particularly limits on *Dracaena* reproduction.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawai‘i. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila ochrobasis. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila
Drosophila ochrobasis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila ochrobasis* Hardy & Kaneshiro, 1968 is a member of the *adiastola* species group. The species is endemic to Hawai‘i, occurring in montane wet forest. It is part of the *adiastola* subgroup, which is characterized by having the wings largely dark with scattered clear spots. Among these, *D. ochrobasis* is distinguished by the males having the base of the wing mostly clear with only a few faint marks; females are almost indistinguishable from the sympatric *D. setosimentum*. The primary breeding host of *D. ochrobasis*, if it has one, is unclear. Nearly all members of the *adiastola* subgroup breed in *Clermontia* (with the exception of one small clade which has switched to *Touchardia*), including the sympatric sibling species *D. setosimentum*. The presence of two such closely related species may mean that *D. ochrobasis* has switched to a new host. It has been reared three times, each from a different host and part: *Clermontia* roots, *Marattia* (mulesfoot fern) rachis, and *Myrsine* leaves.

DISTRIBUTION: *Drosophila ochrobasis* is historically known from many collections at six sites between 1966 and 1975, from a Saddle Road kīpuka, Ka‘ū Forest Reserve, Hualālai, and Kohala. However, sometime after this period, it underwent a serious decline, with only a single collection from the Saddle Road in 1986 before it was rediscovered in Kohala in 2006. Since then it has been found consistently at a few sites in the Kohala area, but nowhere else.

ABUNDANCE: Unknown. *Drosophila ochrobasis* appears to be extirpated throughout nearly all of its historic range, including many sites where it was formerly regularly collected, indicating a population decline of over 95%.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The uncertainty about the breeding hosts of *D. ochrobasis* makes it difficult to ascertain the habitat quality. It is clear that *Clermontia* is nearly gone from some of the sites where *D. ochrobasis* previously occurred, while it is still abundant at Kohala. However, *D. ochrobasis* does not live in some areas with abundant *Clermontia* that should be within its range, such as South Kona, where *D. setosimentum* is common.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).

- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila ochrobasis* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila primaeva, externally identical sister species of *D. sharpi*. Photo: Karl Magnacca.

Terrestrial Invertebrates

Sharp's Drosophila
Drosophila sharpi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Drosophila sharpi* Hardy, 1965 is a basal member of the Hawaiian *Drosophila*. It and its sympatric sister species *D. primaeva* represent an ancient lineage that was one of the first to branch off during the evolution of the group and has few or no other living relatives. Although not a member of the picture wing clade, it is often treated with them due to its similar size and habits. It is a large, brown fly with only a few inconspicuous wing marks and generally lacking in ornamentation except for a sclerotized black rim on the labellum of the male, which is also found in the fungus-feeding *haleakalae* group and the similar but very poorly-known *rustica* group. Morphologically it can be separated from *D. primaeva* only by details of the genitalia, but they are significantly different in chromosomal banding pattern. It is endemic to Kauaʻi, occurring in mesic to wet forest.

DISTRIBUTION: *Drosophila sharpi* was historically known from two sites, Mt. Kāhili in the south and Kōkeʻe in the northwest. The last record from Kōkeʻe is from 1991, but due to close similarity to the more common *D. primaeva* it is possible that some individuals have been sighted since then but not collected. The first and last record from Kāhili was in 1968, but access is limited and few surveys have been conducted there recently.

ABUNDANCE: Unknown. The lack of any recent records means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after much longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods. Given that the most recent record was less than 25 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: The breeding host of *Drosophila sharpi* is unknown. Its sister species *D. primaeva* breeds in decaying bark of Araliaceae, *Cheirodendron* spp. and *Polyscias* (=*Tetraplasandra*) spp., and given their close similarity it is likely that *D. sharpi* does as well. *Cheirodendron* is abundant and reproducing at all sites where *D. sharpi* has been found, suggesting that unlike other rare *Drosophila*, its numbers may not be strictly host-limited at the sites where it occurs.

THREATS:

- Habitat loss and degradation due to invasive plants and disturbance by non-native ungulates.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila sharpi* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawai‘i. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; determination of endangered status for 48 species on Kauai and designation of critical habitat. Federal Register 75: 18960–19008.

Drosophila substenoptera. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing
Drosophila
Drosophila substenoptera

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila substenoptera* Hardy, 1969 is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kauaʻi representatives. The unusual wing pattern is similar to the related *D. hemipeza* and the unrelated *D. pilipa* but is otherwise distinctive. It can be distinguished from the partially sympatric *D. hemipeza* (which is also endangered) by having the two crossveins widely staggered rather than nearly in line, with the marks over them distinctly separate. Both species have an unusual habit of both sexes frequently walking with the wings spread and facing forward, even when not displaying to another fly, possibly making them more vulnerable to predators. The species is endemic to Oʻahu, occurring in wet forest. It was historically found widely throughout both mountain ranges of the island, but its range has dramatically contracted. Like other members of the *cyrtoloma* subgroup, it breeds in rotting bark of araliads, including *Cheirodendron* spp. (ʻōlapa and lapalapa) and *Polyscias* spp. (ʻohe mauka).

DISTRIBUTION: *Drosophila substenoptera* was historically known from five sites in the Koʻolau range (from the Castle Trail to Kaʻau Crater) and four in the Waiʻanae range (Puʻu Palikea and three sites around Kaʻala) of Oʻahu. In the latter, it can still be found at most of its historic sites – just below the summit of Kaʻala, along the crestline to Puʻu Kalena, and at Palikea. However, at all sites but Palikea, it is only seen as single individuals. In the Koʻolau range, it has declined more severely and only one site is known, from the middle Peʻahināiʻa Trail.

ABUNDANCE: During nine years of ongoing monthly monitoring from 2013–2022, the Oʻahu Army Natural Resources Program (OANRP) found a low but relatively consistent population of this species at Palikea, and only rare individual observations in the vicinity of Kaʻala and at Peʻahināiʻa (OANRP, 2014). While this indicates at least one stable population, it is probably also small enough to be vulnerable to stochastic events like droughts.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila substenoptera* breeds in Araliaceae, primarily *Cheirodendron* spp. and secondarily the rarer *Polyscias* (=*Tetraplasandra*) spp. *Cheirodendron* is abundant and reproducing at all sites where *D. substenoptera* is found, suggesting that, unlike other rare *Drosophila*, its numbers are not

strictly host-limited at the sites where it occurs. However, it appears to prefer the taller, slightly drier forest such as that at Palikea and Pe‘ahināi‘a rather than the stunted, boggy forest found at the summits of both Ka‘ala and the Koolau crest, where most *Cheirodendron* is now found.

THREATS:

- Habitat loss and degradation due to invasive plants, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila substenoptera* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Drosophila hexachaetae, sympatric sister species of *D. tarphytrichia*, nearly identical in appearance.

Terrestrial Invertebrates

Picture wing
Drosophila
Drosophila tarphytrichia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila tarphytrichia* Hardy, 1965 is one of the smallest members of the *picture wing* species group of Hawaiian *Drosophila* pomace flies. The species is endemic to Oʻahu, primarily in the Waiʻanae range (there is only a single record from the eastern Koʻolau range, from 1949), occurring in diverse mesic forest gulches. Although always uncommon, it was historically widely found throughout the range on the eastern and northern slopes. It is a member of the *lanaiensis* species subgroup, which consists of five species, all of which are rare. Uniquely among *picture wing* species, it is nearly identical to a sympatric sibling species, *D. hexachaetae* (pictured above), differing only in the front leg morphology of the male. These two species are strikingly different from their relatives, and superficially most closely resemble members of the *vesciseta* subgroup, which are also small with an unmarked thorax. All members of the subgroup breed primarily in decaying branches and trunks of *Charpentiera* spp. (pāpala), and usually secondarily in *Pisonia* spp. (pāpala kēpau). While the latter is still abundant even in disturbed areas, the former has declined significantly since the early 1970s when most specimens were collected.

DISTRIBUTION: Known mainly from the Waiʻanae range of Oʻahu, where it has historically been found at four sites in Honouliuli Forest Reserve: Kaluaʻā, Puʻu Kaua (ʻĒkahanui), Mauna Kāpū, and Puʻu Palikea. The type specimen was from Mānoa Falls in the Koʻolau range, but there have been no other records from that side of the islands since that one in 1949. The most recent record was in 1997 at Puʻu Palikea, but intensive surveys 2013–2022 have failed to recover it there. At other historic sites, it has not been seen since 1975. It is possible that the close similarity to *D. hexachaetae*, which is also rare, has led it to be undercounted when specimens are not collected – males can only be separated by examining the front legs with a high-powered lens or microscope, and females cannot be distinguished at all. However, with increased conservation concern for this species they have been checked regularly during recent surveys (2013–2022), and all have been *D. hexachaetae*.

ABUNDANCE: Unknown. The lack of any records for the past 28 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. Given that the most recent record was less than 30 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The known host of *D. tarphytrichia* is *Charpentiera* (Montgomery 1975, Kaneshiro and Kaneshiro 1995). Many species that typically use this tree can also utilize the more abundant *Pisonia* (Magnacca et al., 2008), but the long-term survival of the flies is unclear when *Charpentiera* is almost completely absent. Until the early 1970s the major gulches of Honouliuli, ʻĒkahanui and Kaluaʻā, were dominated by large trees of *Charpentiera tomentosa*. However, an unexplained outbreak of the native tip-boring moth *Mapsidius charpentierii* resulted in the death of most of the large trees, followed by invasion by alien canopy trees. While *Charpentiera* persists in the area, since that time the moths have kept all trees very small, reducing the amount of breeding material available.

THREATS:

- Habitat loss and degradation due to invasive plants, excessive damage by native insects, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila tarphytrichia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and critical habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to determine if restoration of *Charpentiera* is possible or feasible.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Magnacca, KN, Foote, D, O'Grady, PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. Zootaxa 1728:1–58

Magnacca, KN, Price, DK. In press. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). Molecular Phylogenetics and Evolution.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.

Terrestrial Invertebrates

Tiger flies
Order Diptera
Family Muscidae
Genus *Lispocephala*

GENUS INCLUDES:
>103 Endemic Species

GENERAL INFORMATION: *Lispocephala* is a genus of predatory tiger flies (subfamily Coenosiinae). They are large, bristly, and fast-flying, catching prey in flight and feeding with toothed mouthparts. The genus *Lispocephala* consists of about 180 species worldwide, but over 100 of these are endemic to Hawai‘i. Although they appear to be generalist predators, a high diversity of species often occurs in any given area, so they may specialize in particular prey or habitats. Many undescribed species are known as well. Some of their diversity may be due to variation in the larval stage, which is poorly known for most species. Some are known to prey on *Drosophila* larvae, while others live in streams feeding on the larvae of canaceids, chironomids, and other aquatic flies.

DISTRIBUTION: *Lispocephala* are known from all the Main Hawaiian Islands except Kaho‘olawe and Ni‘ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining. Many species are common and abundant within intact native forest, but others are very rare and many have not been collected in decades. Due to their rapid and active flight, they are not as easily collected as other native flies.

LOCATION AND CONDITION OF KEY HABITAT: *Lispocephala* mainly occur in mid to upper elevation mesic to wet forest. Larval habitat may be more important for their conservation, but is only known for a few species.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants, wasps, crustaceans, and fish, prey on these flies.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward tiger flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to asses their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Hardy DE. 1981. Insects of Hawaii: Volume 14 Diptera: Cyclorrhapha IV, Series Schizophora Section Calyptratae. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Coleotichus blackburniae. Photo: Will Haines.

Terrestrial Invertebrates

True bugs
Order Hemiptera
Suborder Heteroptera

SUBORDER INCLUDES:
14 Native Families
45 Native Genera
437 Native Species
>434 Endemic Species

GENERAL INFORMATION:
The Hawaiian Heteroptera consists of species found on the alpine summit of Mauna Kea to species that live in aquatic habitats. Their diets range from phytophagy to predatory to scavengers. Members of this suborder are known as true bugs, and the most familiar groups are assassin bugs (Reduviidae), stink bugs (Pentatomidae), and plant bugs (Miridae). The largest number of native species occurs in the families Lygaeidae (i.e., seed bugs) and Miridae (i.e., plant bugs), many of the latter of which are still poorly studied and understood.

As an example of the diversity of Hawai‘i’s true bugs, three genera of the family Miridae are briefly outlined here. Most species in the genus *Nesiomiris* are endemic to single islands. The 50 described native species are known from all the MHI and feed only on the host plants in the following genera: *Cheirodendron*, *Ilex,* and *Polyscias.* The 96 described species in the genus *Orthotylus* are endemic to single islands in the MHI chain. Most individual *Orthotylus* species depend on a single host plant or several closely related species, with plants in the Rubiaceae family being important hosts. All but one of the 40 described native species in the genus *Sarona* are also endemic to single main Hawaiian Islands, and most depend on a single host plant species, often in the genus *Melicope*.

DISTRIBUTION: True bugs are known from all the MHI and the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats and host plants likely means species within the suborder are declining. Populations occurring in dry and mesic forests are believed to be declining rapidly.

LOCATION AND CONDITION OF KEY HABITAT: True bugs occur in aquatic (both marine and freshwater) and terrestrial habitats, including high-elevation alpine areas.

THREATS:
- Loss or degradation of habitat, especially dry lowland habitats and coastal zones.
- Loss of host-specific plants.
- Insufficient information for species assessments.

- Predation by invasive non-native insects such as ants (Hymenoptera: Formicidae) and generalist egg predators.
- Predation by invasive vertebrates such as coqui frogs (*Eleutherodactylus coqui*)
- Parasitism of koa bugs (*Coleotichus blackburniae*) by *Trichopoda pennipes* (Diptera: Tachinidae) and *Trissolcus basalis* (Hymenoptera: Scelionidae).
- Parasitism by non-native invertebrates.
- Displacement by non-native congeners (e.g., invasive members of the family Lygaeidae, particularly *Nysius* spp.).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward true bugs should include:

- Control of fire in dry and mesic forest habitats.
- Outplant native plants, especially hosts of declining heteropteran species.
- Protect coastal strand habitats from off-road vehicles and excessive foot traffic in areas where native vegetation remains.
- Conduct surveys to document and determine the distribution and abundance of known true bugs.
- Conduct surveys and document non-native predators and parasitoids.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Orthotylus*, *Koanoa*, *Sulamita*, *Kalania*, and *Pseudoclerada*, all of which appear to have many undescribed species. Document the biology, habitat requirements, and life histories.
- Conduct systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny.
- Support specialized taxonomic work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

Asquith A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Museum Occasional Papers 40:1–81.

Gagne WC. 1997. Insular evolution, speciation, and revision of the Hawaiian genus *Nesiomiris*. Bishop Museum Bulletins in Entomology 7. Honolulu, (HI): Bishop Museum Press.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Polhemus DA. 2002. An initial review of *Orthotylus* in the Hawaiian Islands, with descriptions of twenty-one new species (Heteroptera: Miridae). Journal of the New York Entomological Society 110(3–4):270–340.

Polhemus DA. 2004. Further studies on the genus *Orthotylus* (Heteroptera: Miridae) in the Hawaiian Islands, with descriptions of thirty-four new species. Journal of the New York Entomological Society 112(4):227–333.

Usinger RL. 1942. The genus *Nysius* and its allies in the Hawaiian Islands (Hemiptera, Lygaeidae, Orsillini). Bernice P. Bishop Museum Bulletin 173:1–167.

Zimmerman EC. 1948. Insects of Hawaii: Volume 3, Heteroptera. Honolulu: University of Hawaii Press.

Nysius wekiukola. Photo: G. Heaton.

Terrestrial Invertebrates

Maunakea Wēkiu Bug
Nysius wekiucola

"Maunaloa Wēkiu Bug"
Nysius aa

GENERAL INFORMATION:
The Maunakea wēkiu bug, *Nysius wekiucola*, and the "Maunaloa wēkiu bug", *Nysius aa* (no accepted common name but some generally call both summit bugs "wēkiu bugs"), are micropterous seed bugs in the family Lyaeidae (Hemiptera: Heteroptera). *N. wekiucola* is only found on the summit of Muanakea while its apparent sister species, *N. aa*, can only be found on the upper slopes of Maunaloa. Both flightless species live under rocky ʻaʻā and cinder. Unlike most members of the Lygaeidae, these two species do not feed on plant tissue but are scavenger-predators that feed on dead and dying insects blown up the mountain from lower elevations.

DISTRIBUTION: Hawaiʻi Island

ABUNDANCE: Surveys and studies of *Nysius wekiucola* bug over 11 years showed populations are stable given current threats are minimized. Abundance of the *N. aa* bug remains unknown due to a lack of systematic surveys to determine population estimates.

LOCATION AND CONDITION OF KEY HABITAT: Cinder cones (puʻu) on the summit of Maunakea (*N. wekiucola*) and the summit of Maunaloa (*N*. aa), at elevations between 3415 and 4205m.

THREATS:
- Loss or degradation of habitat via human traffic and development of astronomy observatory facilities

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. Specific management directed toward *Nysius wekiucola* and *N. aa* should include:
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate surveys to determine abundance of *N. aa*

References:

Ashlock PD, Gagné WC. 1983. A remarkable new micropterous *Nysius* species from the aeolian zone of Mauna Kea, Hawai‘i Island (Hemiptera: Heteroptera: Lygaeidae). International Journal of Entomology 25(1): 47-55.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Polhemus, DA. 1998. *Nysius aa* (Heteroptera: Lygaeidae), a new species of micropterous wekiu bug from the summit of Mauna Loa Volcano, Hawaii. Proceedings fo the Entomological Society of Washington 100(1): 25-31.

Endangered and Threatened Wildlife and Plants; Candidate Removal of Wekiu bug (*Nysius wekiucola*); Proposed Rules, 76 Fed. Reg. 66377 (Octoberr 26, 2011), Docket No. FWS–R9–ES–2011–0061; MO–9221050083–B2.

Kamehameha lunalilo

Terrestrial Invertebrates

Plant bugs
Order Hemiptera
Family Miridae

FAMILY INCLUDES:
15 Native Genera
>222 Native & Endemic Species

GENERAL INFORMATION:
Genera with endemic species
Engytatus: 10 spp.
Nesiomiris: 50 spp.
Opuna: >5 spp.
Orthotylus: >95 spp.
Sarona: 40 spp.
Sulamita: >5 spp.
Astelianmiris, Hyalopeplus, Kalania, *Kamehameha*, *Koanoa*, *Loulucoris*, *Nesidiorchestes*, *Pseudoclerada*, *Trigonotylus*: 1–3 spp. each

Miridae is a large and diverse family, with a correspondingly large number of endemic lineages. Most species feed on plants, hence the common name plant bugs; however, some are predaceous, and for many natives the life history is unknown. There are three large radiations: *Nesiomiris*, *Orthotylus*, and *Sarona*. All three are highly host-specific, with each species restricted to single islands. *Nesiomiris* is unusual in that all 50 species are found only on a few hosts in Araliaceae (*Cheirodendron* spp. and *Polyscias* spp.) and Aquifoliaceae (*Ilex anomala*), with multiple species often found sympatrically. *Orthotylus* are found on a wide variety of host plants in at least 18 families; a few are found on multiple plants and may be predaceous. *Sarona* occur on a few of the same hosts as *Orthotylus*, but most are on different plants, especially *Melicope*. The remaining genera are much smaller and have varied habits; *Engytatus*, *Loulucoris*, and *Sulamita* are host-specific plant feeders, while the others are found in a variety of situations and may be generalists or predaceous. *Hyalopeplus pellucidus* is remarkable for an endemic insect in being a generalist herbivore found in a wide range of habitats from dry coastal strands to montane wet forests. *H. pelucidus* seems to be able to survive in the presence of invasive predatory ants, but this cannot be said for other native plant bugs. *Nesidiorchestes* is a peculiar group of flightless jumping bugs found in leaf litter. Undescribed species are known at least for *Kamehameha*, *Koanoa*, *Nesidiorchestes*, and *Sulamita*, but comprehensive revisions are required to determine exactly how many there are.

DISTRIBUTION: Leaf bugs are known from all the MHI except Kahoʻolawe. *Hyalopeplus* and *Kamehameha* are also found on Nihoa.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Most species are tightly associated with native plants, and their fate is tied to that of the plants. However, they may not be able to locate isolated populations of hosts such as in restoration areas.

LOCATION AND CONDITION OF KEY HABITAT: Mirids occur in a wide variety of terrestrial habitats, from the coast to high-elevation subalpine areas, but primarily in forests.

THREATS:

- Loss or degradation of habitat, especially lowland dry and mesic forests and coastal zones.
- Loss of host plants.
- Insufficient information for species assessments.
- Predation and parasitism by invasive non-native insects including ants (Formicidae), parasitoid wasps (Hymenoptera), and generalist egg predators.
- Displacement by non-native mirids.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leaf bugs should include:

- Control of fire in dry and mesic forest habitats.
- Outplanting of native plants, especially those that are hosts to declining species.
- Protect coastal strand habitats from off-road vehicles and excessive foot traffic in areas where native vegetation remains.
- Conduct surveys to determine the distribution and abundance of known true bugs and to document and identify new species.
- Prevent introduction of invasive ants to areas they do not already occur.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Kamehameha*, *Koanoa*, *Sulamita*, *Kalania, Opuna,* and *Pseudoclerada*, all of which appear to have many undescribed species. Work to identify and describe new species to science.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

Asquith A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Museum Occasional Papers 40: 1–81.

Gagne WC. 1997. Insular evolution, speciation, and revision of the Hawaiian genus *Nesiomiris*. Bishop Museum Bulletins in Entomology 7. Honolulu, (HI): Bishop Museum Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Polhemus DA. 2002. An initial review of *Orthotylus* in the Hawaiian Islands, with descriptions of twenty-one new species (Heteroptera: Miridae). Journal of the New York Entomological Society 110(3–4): 270–340.

Polhemus DA. 2004. Further studies on the genus *Orthotylus* (Heteroptera: Miridae) in the Hawaiian Islands, with descriptions of thirty-four new species. Journal of the New York Entomological Society 112(4): 227–333.

Nabis subrufus

Terrestrial Invertebrates

Damsel bugs
Order Hemiptera
Family Nabidae
Genus *Nabis*

GENUS INCLUDES:
>50 Native & Endemic Species

GENERAL INFORMATION: Damsel bugs are predaceous true bugs related to assassin bugs (Reduviidae). There are 25 described endemic species, with about as many documented but as yet undescribed species. Damsel bugs are generalist predators, but most species are microhabitat specialists. These are primarily the sites where they seek or ambush prey, such as moss mats, specific plants, or leaf litter. The majority of species have reduced wings and are flightless, with restricted geographic ranges.

DISTRIBUTION: Damsel bugs are known from all the Main Hawaiian Islands except Niʻihau and Kahoʻolawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining. Many species have not been collected in years.

LOCATION AND CONDITION OF KEY HABITAT: Damsel bugs occur in mid to upper-elevation dry to wet forests, into subalpine shrubland. The small range of many species makes them vulnerable to disturbance and small-scale habitat destruction such as fire.

THREATS:

- Loss or degradation of habitat, especially for flightless species and in dry and mesic forests.
- Loss of host plants and microhabitats, such as drying leading to loss of moss mats.
- Insufficient information for species assessments.
- Predation by invasive non-native insects including ants (Formicidae).
- Displacement by non-native relatives (e.g., invasive members of the family Reduviidae and alien *Nabis*).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward damsel bugs should include:

- Control of fire in dry and mesic forest habitats.
- Conduct surveys to determine the distribution and abundance of known damsel bugs and to document and identify new species.

- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies to document the biology, habitat requirements, and life history of understudied species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 3 Heteroptera. Honolulu: University of Hawaii Press.

Oechalia prob. *suehiroae*

Terrestrial Invertebrates

Predatory stink bugs
Order Hemiptera
Suborder Heteroptera
Family Pentatomidae
Genus *Oechalia*

GENUS INCLUDES:
14 Endemic Species

GENERAL INFORMATION: *Oechalia* species are members of the stink bug family (Pentatomidae)**,** of which most species are plant feeders. Unlike their phytophagous cousins, *Oechalia* belongs to the subfamily Asopinae, a subfamily known for its predatory behavior, feeding on soft-bodied insects like caterpillars. This group of endemic predatory stink bugs is very understudied and not much is known of their current status.

DISTRIBUTION: The *Oechalia* are known from six of the MHI: Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: The species of *Oechalia* occur mostly in the mid and upper-elevation forests.

THREATS:
- Loss or degradation of habitat
- Insufficient information for species assessments.
- Predation by invasive, non-native insects including ants (Formicidae) and generalist egg predators, and parasitism by non-native flies (Diptera) and wasps (Hymenoptera).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Oechalia* should include:
- Conduct surveys to determine the distribution and abundance of known true bugs and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:
- Initiate monitoring the status of populations to detect declines in native species,
- Monitor impacts from non-native parasitoids and predators.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life histories of these species.
- Initiate studies to determine current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Usinger RL. 1941. The genus *Oechalia* (Pentatomidae, Hemiptera). Proceedings of the Hawaiian Entomological Society 11(1): 59-93.

Usinger RL. 1942. A new species of *Oechalia* from Oahu (Pentatomidae, Hemiptera). Proceedings of the Hawaiian Entomological Society 11(2): 217-218.

Nesodyne sp.

Terrestrial Invertebrates

Leafhoppers, Planthoppers
Order Hemiptera
Suborder Auchenorrhyncha

ORDER INCLUDES:
33 Native Families
20 Native Genera
>353 Native & Endemic Species

GENERAL INFORMATION: The Hawaiian Auchenorryhncha suborder is particularly species-rich in Hawai‘i. All members of the suborder are phytophagous and feed on sap from plant tissue. The most specious families in Hawai‘i include: Cicadellidae, Cixiidae, and Delphacidae; undescribed species likely occur in each family. Unfortunately, even in these diverse families, the constituent species are generally represented by few specimens, and their life history is poorly known. As an example of the diversity of Hawai‘i’s leafhoppers and planthoppers, three endemic genera are outlined. The endemic genus *Nesophrosyne* (Cicadellidae) is comprised of 72 described species and subspecies with many more remaining undescribed. Most species depend on a narrow range of host plants. Eighty-five described species and subspecies comprise the endemic genus *Nesosydne* (Delphacidae). Many species are endemic to individual islands, and most species depend on a narrow range of host plants. The endemic genus *Oliarus* (Cixiidae) is comprised of 87 described species and subspecies, most of which are endemic to a single island. Unlike the previous genera, members of this genus are not dependent on specific host plants.

DISTRIBUTION: Members of the suborder Auchenorrhyncha are found on all the MHI except Kaho‘olawe

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents any population estimate. However, the loss and degradation of native habitats, especially the loss of native host plants, likely means that species within the order are declining. Species that are dependent on plant species of dryland forests, as in the genus *Dictyophorodelphax*, are believed to be declining because of the almost total loss of native dry forests and their specific host plants (endemic *Euphorbia* spp.). The most abundant species appear to be found in the genus *Nesophrosyne* and their tolerance to invasive ants (Formicidae) likely explains their abundance.

LOCATION AND CONDITION OF KEY HABITAT: Auchenorrhyncha is a very ecologically diverse group and occurs in most terrestrial habitats including lava tubes. Key habitat requirements of individual species are poorly known.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.

- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predatory invasive ants.
- Natural enemies of invasive cicadellids including the two-spotted leafhopper (*Sophonia rufofascia*) and glassy-winged sharpshooter (*Homalodisca vitripennis*) may have the potential to adversely affect native cicadellid species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward Auchenorrhyncha should include:

- Conduct surveys to determine distribution and abundance of known Auchenorryhncha and to document and identify new species.
- Outplant native host plants that support rare Auchenorryhncha.
- Control of invasive non-native invertebrates.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations to detect declines in native species and to detect new non-native species.

RESEARCH PRIORITIES:

- Initiate studies of species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of natural enemies on species in the family Cicadelliade.
- The genus *Nesophrosyne* (Cicadellidae), comprised of many undescribed species that depend on rare native host plants, should be reviewed and revised as appropriate.
- Conduct systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Bennett GM, O'Grady PM. 2013. Host–plants shape insect diversity: Phylogeny, origin, and species diversity of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). Molecular Phylogenetics and Evolution 65:705–717.

Giffard WM. 1925. A review of the Hawaiian *Cixiidae*, with descriptions of species. Proceedings of the Hawaiian Entomological Society 6: 51–171.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Osborn, H. 1935. Cicadellidae of Hawaii. Bernice P. Bishop Museum Bulletin 134: 1–62.

Zimmerman EC. 1948. Insects of Hawaii: Volume 4, Auchenorhyncha. Honolulu: University of Hawaii Press.

Nesophrosyne sp.

Terrestrial Invertebrates

Leafhoppers
Order Homoptera
Family Cicadellidae

FAMILY INCLUDES:
6 Native Genera
>266 Native & Endemic Species

GENERAL INFORMATION:
Genera with endemic species
Balclutha: 9 spp.
Nesophrosyne: >250 spp.
Balolina, *Kirkaldiella*, *Nesolina*, *Nesophryne*: 1–3 spp.

Leafhoppers are jumping insects that suck sap from the leaves of plants. The endemic genus *Nesophrosyne* is by far the largest group of native species. It currently contains 72 described species and subspecies, but the bulk of the diversity remains undescribed, with at least 150 undescribed species known in collections. All are endemic to individual islands, sometimes to one volcano, and are host-specific to one native plant genus. This enormous undescribed diversity presents challenges for identification and monitoring for conservation. However, many are already documented by DNA barcodes and associated photos. The other genera are much smaller, rarer, and more restricted in distribution. *Kirkaldiella* and *Nesophryne* are related to *Nesophrosyne* and have similar habits, feeding on dicots in mesic and dry forests. *Balclutha*, *Balolina*, and *Nesolina* belong to a different lineage and feed on grasses.

DISTRIBUTION: Leafhoppers are found on all the MHI except Niʻihau and Kahoʻolawe, from the coast to high-elevation forests.

ABUNDANCE: Some species may be seasonally abundant, especially those that feed on more common plants. They often become rare or completely disappear during the drier summer and fall months.

LOCATION AND CONDITION OF KEY HABITAT: Because these leafhoppers produce honeydew, an attractive food for ants, *Nesophrosyne* have been noted to be better able to survive in the presence of non-native ant (Formicidae) populations than most native insects which are not adapted to these non-native predators. However, these leafhoppers can only survive where their host plants do. It is unknown how well they are able to disperse naturally to find new populations of host plants, such as restoration sites. The grass-feeding groups are particularly affected by the loss of native host plants.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native predatory wasps (Crabronidae) and parasitoids (various Hymenoptera) may adversely affect some species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leafhoppers should include:

- Conduct surveys to determine distribution and abundance of known leafhopper species and to document and identify new species.
- Outplanting of native host plants that support rare species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations to detect declines in native species and to detect new non-native species.

RESEARCH PRIORITIES:

- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of introduced arthropods on species in the family Cicadellidae.
- *Nesophrosyne* should be reviewed and revised as appropriate.

References:

Bennett GM, O'Grady PM. 2013. Host–plants shape insect diversity: Phylogeny, origin, and species diversity of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). Molecular Phylogenetics and Evolution 65:705–717.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 4 Homoptera: Auchenorrhyncha. Honolulu, HI: University of Hawaii Press.

Dictyophorodelphax mirabilis

Terrestrial Invertebrates

Planthoppers
Order Hemiptera
Family Delphacidae

FAMILY INCLUDES:
7 Native Genera
>144 Native & Endemic Species

GENERAL INFORMATION:
Genera with endemic species
Aloha: 9 spp.
Dictyophorodelphax: 5 spp.
Emoloana: 6 spp.
Leialoha: 12 spp.
Nesosydne: >83 spp.
Nesothoe: 23 spp.
Nesodryas, *Nesorestias*, *Nothorestias*: 2 spp. each

Planthoppers in the family Delphacidae are a large and diverse group worldwide. They are easily distinguished from other families by the large moveable spur at the apex of the hind tibia. The endemic genera have diverse habits; almost all are strongly host-plant specific. *Emoloana* belongs to a different subfamily from the other genera and feeds on native grasses. *Dictyophorodelphax* is a striking endemic genus with a long horn on the head; all species feed on native ʻakoko (Euphorbiaceae: *Euphorbia*). The two species of *Nesodryas* feed on monocots. The remaining genera feed on a wide variety of wet to mesic forest trees and shrubs, with a high diversity of hosts within each. *Nesosydne* is by far the most diverse genus, with many undescribed species.

DISTRIBUTION: Delphacids are known from all the Main Hawaiian Islands except Niʻihau and Kahoʻolawe. Several species of *Emoloana* are also known from Laysan in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the family are declining with populations occurring in dry and mesic forests are believed to be declining rapidly. A large number of species of *Nesosydne* have not been collected in many years and may be very rare or extinct. *Emoloana* is especially vulnerable as it is restricted to native grasses which are increasingly rare.

LOCATION AND CONDITION OF KEY HABITAT: Delphacid planthoppers occur widely from lowland dry habitats to mesic and wet forests and subalpine areas. Lowland and drier habitats are particularly threatened.

THREATS:

- Loss or degradation of habitat, especially dry lowland habitats.
- Loss of host plants.
- Insufficient information for species assessments.
- Predation and parasitism by invasive non-native insects including ants (Formicidae), parasitoid wasps (Hymenoptera), and generalist egg predators.
- Displacement by non-native competitors (e.g., invasive members of the superfamily Fulgoroidea).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward planthoppers should include:

- Control of fire in dry and mesic forest habitats.
- Outplanting of native plants, especially those that are hosts to declining species.
- Conduct surveys to determine the distribution and abundance of planthoppers and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Nesosydne* and *Nesothoe*, which appear to have many undescribed species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

Asche, M. 2000. A review of the systematics of Hawaiian planthoppers (Hemiptera: Fulgoroidea). Pacific Science 51(4):366–376.

Goodman KR. 2010. Emerging biodiversity: Diversification of the Hawaiian *Nesosydne* planthoppers. PhD dissertation, University of California, Berkeley.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 4 Homoptera: Auchenorrhyncha. Honolulu: University of Hawai'i Press.

Phyllococcus oahuensis galls on a *Urera glabra* leaf

Terrestrial Invertebrates

Psyllids, Mealybugs, and Scale Insects
Order Hemiptera
Suborder Sternorrhyncha

ORDER INCLUDES:
3 Native Families
23 Native Genera
>108 Native & Endemic Species

GENERAL INFORMATION: Ninety-seven percent of the described 108 endemic species of Sternorrhyncha are within the families Triozidae (Psylloidea) and Pseudococcidae (Coccoidea). Compared with the diverse and numerous invasive Sternorrhyncha recorded in Hawai‘i, the endemic species are outnumbered by more than three to one. All members of the suborder are phytophagous feeders on the phloem of plant tissue. All endemic species are extremely host-specific, most having only a single host plant species. More than thirty-five species of *Pariaconus* (Triozidae) are specific to *Metrosideros polymorpha.* Endemic Hawaiian mealybugs and psyllids have evolved closely with their host plants and some exhibit remarkable gall-forming habits.

DISTRIBUTION: Members of the suborder Sternorrhyncha are found on all the MHI except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: As a group unknown. Most species are rare and have not been recorded for decades. A lack of systematic surveys prevents any population estimate. However, the loss of these species’ obligate host plants, often rare or threatened endemic plant species, means the inevitable decline of many endemic Sternorrhyncha.

LOCATION AND CONDITION OF KEY HABITAT: Sternorrhyncha are found in remnant native and mixed mesic forests where host plants still exist.

THREATS:

- Habitat loss and degradation due to urbanization, agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants and invertebrates.
- Loss of obligate endemic host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Insufficient taxonomic work on describing new species and reviewing groups with taxonomic uncertainty.
- Non-native parasitoids (Hymenoptera), and predators such as ladybeetles (Coleoptera: Coccinellidae).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby

reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward endemic Sternorrhyncha should include:

- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.
- Conduct surveys to document and identify non-native predators and parasitoids.
- Outplant native host plants specific to rare taxa.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:

- Initiate monitoring the status of populations to detect declines in native species and new non-native species. Monitor impacts from non-native parasitoids and predators.
- Initiate monitoring of rare host plant species.

RESEARCH PRIORITIES:

- Initiate studies to determine species' current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Percy DM. 2017a. Making the most of your host: the *Metrosideros*-feeding psyllids (Hemiptera, Psylloidea) of the Hawaiian Islands. ZooKeys 649: 1-163.

Zimmerman EC. 1948. Insects of Hawaii: Volume 5, Homoptera, Sternorhyncha. Honolulu: University of Hawaii Press.

Swezeyana atra

Terrestrial Invertebrates

Psyllids
Order Hemiptera
Suborder Sternorrhyncha
Superfamily Psylloidea
Family Triozidae

FAMILY INCLUDES:
11 Native Genera
>73 Native & Endemic Species

GENERAL INFORMATION: The Hawaiian Triozidae are extremely specialized psyllids, most being single-island endemic species. All but one of the 9 genera are specialized to just one host plant species or host plant genus. Listed below are the known endemic genera, the number of described species, and their known host plants. Many species remain undescribed, and more are being collected every day.

Cerotrioza: 2 species (*Xylosma hawaiiensis*)
Crawforda: 1 species (*Polyscias hawaiensis*)
Hemischizocranium: 2 species (*Zanthoxylum dipetalum*)
Hevaheva: 8 species (*Melicope*)
Kuwayama: 6 species (*Pisonia sandwicensis*, *Sideroxylon polynesicum*)
Megatrioza: 5 species (*Pritchardia*)
Pariaconus: 36 species (*Metrosideros*)
Paurotriozana: 1 species (*Cryptocarya oahuensis*)
Stevekenia: 2 species (*Nothocestrum longifolium, N. peltatum*)
Swezeyana: 9 species (*Planchonella sandwicensis*)
Trioza: 1 species (*Cryptocarya mannii*)

Several of these genera (*Hevaheva*, *Megatrioza*, *Pariaconus*, and *Swezeyana*) illustrate the amazing adaptive radiations between the endemic psyllids and their host plants in the Hawaiian Islands. The *Pariaconus* genus contains 36 described species, all specific to a single host plant, *Metrosideros polymorpha.* These species have extraordinary biological and morphological diversity, also shown in their diverse galling biology. There are likely additional species which have not yet been discovered.

DISTRIBUTION: Members of the family Triozidae are found on all the MHI except Kahoʻolawe and Niʻihau.

ABUNDANCE: A lack of systematic surveys prevents any population estimate. However, the loss and degradation of native habitats, especially the loss of rare endemic host plants, likely means species within the order are declining. The species-specific nature of the Triozidae highlights the dependence on host plant abundance and distribution. While *Metrosideros polymorpha* is the most widespread of the known hosts, there have been huge losses of *M.*

polymorpha trees due to the spread of *Ceratocystis lukuohia* and *C. huliohia* (causal agents of Rapid ʻŌhiʻa Death) in forested areas where *Pariaconus* are known.

LOCATION AND CONDITION OF KEY HABITAT: Key habitats are host plant-dependent but range from wet bogs to lowland mesic forest.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of obligate endemic host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native parasitoid wasps (Hymenoptera)
- Predation by non-native lady beetles (Coleoptera: Coccinellidae)

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward Triozidae should include:

- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.
- Conduct surveys to document and identify non-native predators and parasitoids.
- Outplant endemic host plants specific to rare taxa.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:

- Initiate monitoring the status of populations to detect declines in native species and new non-native species. Monitor impacts from non-native parasitoids and predators.
- Initiate monitoring of rare host plant species.

RESEARCH PRIORITIES:

- Initiate studies to determine species' current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate and support taxonomic specialists to describe species new to science.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Percy DM. 2017a. Making the most of your host: the *Metrosideros*-feeding psyllids (Hemiptera, Psylloidea) of the Hawaiian Islands. ZooKeys 649: 1-163.

Percy DM. 2017b. A new endemic psyllid genus, *Stevekenia* gen. nov. (Hemiptera: Psylloidea, Triozidae), from the Hawaiian Islands with two new and rare species on threatened host plants in the endemic genus *Nothocestrum* (Solanaceae). Zootaxa 4286, 3(3).

Percy DM. 2018. Revision of the Hawaiian psyllid genus *Swezeyana*, with descriptions of seven new species (Hemiptera, Psylloidea, Triozidae). ZooKeys 758: 75-113.

Zimmerman EC. 1948. Insects of Hawaii: Volume V. Homoptera: Sternorhyncha. Honolulu, HI: University of Hawaii Press.

Nesodynerus scoriaceus. Photo: Karl Magnacca.

Terrestrial Invertebrates

Bees and wasps
Order Hymenoptera

ORDER INCLUDES:
14 Native Families
42 Native Genera
>800 Native Species
>800 Endemic Species

GENERAL INFORMATION: The order Hymenoptera is large and diverse, and is best known because of the social behavior of ants, bees, and wasps. Hawai‘i’s native Hymenoptera fauna, however, is comprised of non-social bees and wasps and does not include any native ants. The most speciose genus is *Sierola* (Bethylidae) with 278 described and an estimated 400–500 total species. Several species in each of the genera *Hylaeus* (Colletidae), *Ectemnius* (Sphecidae), and *Nesodynerus* (Vespidae), including *H. difficilis*, *H. pubescens*, *E. nesiotes*, *E. polynesialis*, *N. peles*, and *N. scoriaceus,* are common and relatively abundant. However, the status of many other species in these genera, as well as species in the genera *Enicospilus* (Ichneumonidae), *Sclerodermus* (Bethylidae), *Sierola* (Bethylidae), is unknown. As elsewhere, Hawaiian bees and wasps have important ecosystem functions including pollinating native plants and keeping other insects, particularly herbivorous species, in check. The native *Hylaeus,* or yellow-faced bees, are important pollinators for many native plants. Most of the native wasps are arthropod predators or parasites, often specific to particular taxa. For example, species in the family Mymaridae parasitize small insects and insect eggs; species in the family Encyrtidae are parasitoids of mealybugs (Hemiptera); species in the family Figitidae lay their eggs on fly (Diptera) pupae, and species in the families Vespidae and Bethylidae prey on Lepidoptera caterpillars. A large radiation in the family Pteromalidae is largely unstudied, but is believed to parasitize native beetle grubs.

As an example of the diversity of Hawai‘i’s hymenopterans, two genera are briefly outlined. The 64 species in the bee genus *Hylaeus* occur on all the Main Hawaiian Islands (MHI) and Nihoa. They nest in hollow stems, holes in trees, under bark, in crevices, or in burrows in soil. Potential threats include non-native bees (*Ceratina* spp.) found in the native coastal habitats used by *Hylaeus* species and competition with the European honeybee (*Apis mellifera*) for nectar and pollen. Confirmed threats include introduced ants (Formicidae) which compete with *Hylaeus* for nesting sites, and the big-headed ant (*Pheidole megacephala*) and Argentine ant (*Linepithema humile*) which prey on the native bees. Since *Hylaeus* bees pollinate native plants, their loss would be detrimental to the recovery of native plants.

Wasps in the genus *Sierola* are found throughout the Indo-Pacific region, but over 2/3 of the known species are endemic to Hawai‘i. They are small, black wasps found primarily in wet and mesic forests. At present 156 species are known from O‘ahu and 108 from the island of Hawai‘i, with the other islands almost totally unexplored. Hundreds of species remain to be described, and it is not uncommon to find more than ten morphospecies (i.e., species established solely on morphological characteristics) at a single site. These species are difficult to collect, and many

morphospecies are found in very low numbers; this may be an artifact of collection methods or due to their rarity. Similar to other wasps, females find a Lepidoptera larva, sting and paralyze it, and lay an egg on it. Once the egg hatches the larva feeds on the caterpillar.

DISTRIBUTION: Native Hymenoptera are found on all the MHI and Laysan and Nihoa in the Northwestern Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Hymenopterans occur in most terrestrial habitats.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects.
- Loss or degradation of habitat, especially the loss of native host plants for bees.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known hymenopterans and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawai‘i Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. University of Hawai’i Press, Honolulu.

Magnacca KN. 2020. Review of Sierola Cameron (Hymenoptera: Bethylidae) of the Hawaiian Islands. Part 1: O‘ahu. Bishop Museum Bulletin in Entomology 14:1:311.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Takumi RL. 1999. A Systematic Review of the Ectemnius (Hymenoptera: Sphecidae) of Hawai‘i, University of California Press, Berkeley.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. University of Hawai‘i Press, Honolulu.

Flat wasps
Order Hymenoptera
Family Bethylidae
Genus *Sierola*

GENUS INCLUDES:
>400 Native and Endemic Species

GENERAL INFORMATION: *Sierola* is a group of small parasitoid wasps widely distributed in the Austro-Pacific region. They are very diverse in Australia and representatives are found on nearly all Pacific islands, but about half or more of the world's known species are endemic to Hawai‘i. Over 400 species have been documented from the islands, with Maui Nui poorly collected. They attack caterpillars of microlepidoptera, particularly the families Cosmopterigidae, Gelechiidae, Gracilariidae, and Tortricidae. The hosts of most *Sierola* species are unknown, however, the species are differentiated mainly by characters used to access concealed hosts (such as head shape and mandible form), so it is presumed that most are relatively specialized on particular host taxa. Although they do not make nests, females sometimes guard paralyzed hosts on which their larvae are developing. A few species are common, but the large majority are very rare, often known from only one or a few specimens. Many are found primarily or exclusively in the forest canopy and are rarely collected even if they may not be rare in the environment. At least one O‘ahu species apparently adapted to alien sugarcane-feeding moths; it was only ever collected in cane fields. Its native host is unknown, probably a native grass-feeding moth, and it has not been collected since the end of large-scale sugar cultivation.

DISTRIBUTION: *Sierola* are found on all the MHI except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining.

LOCATION AND CONDITION OF KEY HABITAT: *Sierola* occur in most terrestrial habitats. Most are found in lowland and montane forests, but a few are coastal.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects (direct predation and predation of their hosts).
- Loss or degradation of habitat, especially the loss of native host plants for host caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:
- Conduct systematic and taxonomic assessments for Kauaʻi, Maui, Molokaʻi, and Lānaʻi.
- Conduct studies to document the biology, habitat requirements, and life history.
- Refine methods for conducting quantitative surveys.

References:

Fullaway DT. New species of *Sierola* with explanatory notes. Bishop Museum Occasional Papers 7(7):57-159.

Magnacca KN. 2020. Review of *Sierola* Cameron (Hymenoptera: Bethylidae) of the Hawaiian Islands. Part 1: Oʻahu. Bishop Museum Bulletin in Entomology 14:1–311.

Magnacca KN. 2024. Review of *Sierola* Cameron (Hymenoptera: Bethylidae) of the Hawaiian Islands. Part 2: Hawaiʻi. Bishop Museum Bulletin in Entomology 16:1–203.

Terrestrial Invertebrates

Yellow-faced bees
Order Hymenoptera
Family Colletidae
Genus *Hylaeus*

GENUS INCLUDES:
64 Native & Endemic Species

GENERAL INFORMATION: The yellow-faced bees (*Hylaeus*) are the only bees native to Hawai‘i. The 64 species evolved from a single ancestor in the subgenus *Nesoprosopis*, which is found throughout east and southeast Asia. They nest in hollow stems, holes in trees, under bark, crevices, cavities in rocks, or burrows in soil, and are important pollinators for many native plants. Aside from the coastal tree heliotrope, they rarely visit alien plants. Non-native bees including small carpenter bees (*Ceratina* spp.), sweat bees (*Lasioglossum* spp.), and the alien yellow-faced bee *Hylaeus strenuus* are competitors for both floral resources and nest sites. The European honeybee (*Apis mellifera*) and some ants such as the Argentine ant (*Linepithema humile*) also compete for nectar and pollen. Other introduced ants such as the big-headed ant (*Pheidole megacephala*) and yellow crazy ant (*Anoplolepis gracilipes*) are major predators and often exclude native bees entirely. Since *Hylaeus* bees pollinate native plants, their loss would be detrimental to the recovery of native plants. Five species have evolved to be cleptoparasites (cuckoo bees), laying their eggs in the nests of other species. While this habit is found in many groups of bees, these are the only cleptoparasitic species in the family Colletidae worldwide. Despite the apparent decline of many species, new undescribed species continue to be found.

DISTRIBUTION: Yellow-faced bees are found on all the MHI and Nihoa in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining. Numbers of many species appear to have declined significantly since the last large-scale surveys in 2002 and 2011. A few species, such as *H. difficilis* in dry shrubland and *H. unicus* in wet forest, are relatively common, but the majority are rare and some are only known from one or two specimens.

LOCATION AND CONDITION OF KEY HABITAT: Yellow-faced bees occur in most terrestrial habitats including coastal strands, dry shrublands, wet forests, and alpine stone deserts. Coastal and lowland habitats are highly limited due to the presence of ants. Some montane dry forests that have been invaded by ants and myoporum thrips have greatly reduced bee abundance and diversity, and some species that were restricted to that habitat may now be extinct.

THREATS:

- Competition with non-native bees (particularly honeybees), other non-native wasps such as yellowjackets, alien *Hylaeus*, and non-native ants.
- Predation by non-native insects, mainly ants.
- Loss or degradation of habitat, especially the loss of native host plants.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward yellow-faced bees should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawai‘i Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. University of Hawai’i Press, Honolulu.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus anthracinus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus anthracinus* (F. Smith, 1853) is a medium-sized bee found on all the main islands except Kauaʻi and Niʻihau, where the closely related *H. flavifrons* occurs. It lives primarily in coastal areas, sometimes extending up into lowland dry forest on Maui, with one record from montane dry forest on Hawaiʻi. The island populations form three highly genetically distinct clusters which may be cryptic species: Hawaiʻi, Maui + Kahoʻolawe, and Molokaʻi + Oʻahu (there are no recent records from Lānaʻi). Therefore, it is important to conserve all island populations. This and other coastal species are the only native bees that regularly visit flowers of an introduced plant, the tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*). With the loss of most of the native coastal vegetation, tree heliotrope is now a critical floral resource. Other important plants visited for pollen and nectar include naupaka (*Scaevola taccada*), ʻilima (*Sida fallax*), ʻōhai (*Sesbania tomentosa*), naio (*Myoporum sandwicense*), and ʻakoko (*Euphorbia* spp.).

DISTRIBUTION: *Hylaeus anthracinus* is found from Hawaiʻi to Oʻahu and was formerly one of the most widely distributed native bees. While it is still known to occur on all islands in that range except Lānaʻi, the loss of native coastal vegetation has caused the occupied area to contract dramatically. It can still be found along several long stretches of coastline on the northwest coast of Hawaiʻi in South Kohala and North Kona, sometimes in extremely high densities. Elsewhere on the island, it is known only from a single, very small population near South Point, and from a reintroduced population at Puʻuhonua O Hōnaunau National Historical Park in South Kona (there is one high-elevation record at Pōhakuloa from 2004, but it has not found there since and it is unknown if there is a breeding population there). On Maui and Molokaʻi, it has been found at only two sites, though much of the coast is unexplored. Three sites are known for Oʻahu, where population numbers have seriously declined since 2011 with the spread of an alien yellow-faced bee from India, *Hylaeus strenuus*.

ABUNDANCE: Unknown. *Hylaeus anthracinus* may occur in extremely high densities in the south Kohala and north Kona areas, but elsewhere it is generally found in low numbers. At nearly all sites, it is restricted to narrow stretches of coastal strand less than 30 meters (98 feet) wide, and sometimes only a single row of trees or shrubs. The former largest population on Oʻahu, at Kaʻena Point, has virtually disappeared since 2011 for unknown reasons and is currently small and highly fragmented.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees

are only found in marginal habitat that is too dry for ants to live in. Native *Hylaeus* do not visit introduced plants except for tree heliotrope, and observations suggest they cannot survive on naupaka (the most common coastal shrub) alone. Current populations of *Hylaeus anthracinus* are widely scattered so they are unlikely to disperse these large distances on their own to sites where vegetation restoration is carried out. The recently introduced alien bee *Hylaeus strenuus* appears to be a major competitor in coastal and lowland dry habitats, and has displaced native *Hylaeus* from several sites on Oʻahu. It has already been detected on Kauaʻi and will likely spread to the other islands as well.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus anthracinus* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Determine if species status is warranted for the three genetic populations.
- Conduct studies on captive rearing for reintroduction to establish new populations.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). Honolulu: University of Hawaiʻi Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaiʻi, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on Oʻahu and Hawaiʻi Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawaiʻi, Honolulu, Hawaiʻi. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus assimulans

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus assimulans* (Perkins, 1899) lives primarily in coastal areas, often extending up into lowland dry forests. Each island population is genetically distinct, but they do not form divergent clusters of potential cryptic species. It is much larger than related species, and its size may be an adaptation to eating the large pollen of ʻilima (*Sida fallax*), with which it is closely associated and visits more often than other species. Other important plants visited for pollen and nectar include naupaka (*Scaevola taccada*), pāʻū o Hiʻiaka (*Jacquemontia ovalifolia*), and nehe (*Lipochaeta* spp.).

DISTRIBUTION: *Hylaeus assimulans* was historically found from Maui to Oʻahu. The loss of native coastal vegetation has caused its range to contract dramatically. It has not been collected from Oʻahu since at least the 1930s, and surprisingly there are no recent records for Molokaʻi where there is extensive coastal habitat. It is currently known from only one to three sites on each island. On Maui, it is found at scattered localities on West Maui and in the Makena area. On Lānaʻi, it has been found on both the east and northwest slopes in mostly alien vegetation, and there is a single record from Kahoʻolawe.

ABUNDANCE: Unknown. *Hylaeus assimulans* is generally found in very low numbers where it occurs. It is subject to extreme population fluctuations due to the dry conditions of its habitat and episodic blooming of its preferred flowers, particularly on Lānaʻi. The Maui population is the most widely distributed, and the difficulty of accessing sites on West Maui may be preventing a better assessment of its range.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation and dry forest have declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. Current populations of *Hylaeus assimulans* are widely scattered so they are unlikely to disperse these long distances on their own to sites where vegetation restoration is carried out. ʻIlima is one of relatively few native plants that can regrow vigorously after fire, but repeated fires will convert a shrubby ʻilima understory into grass.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants

(primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus assimulans* specifically, management needs include:
- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal and dry forest habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:
- Survey for new populations in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

No photo available

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus facilis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus facilis* (F. Smith, 1879) is a medium-sized bee found on Oʻahu and Maui Nui. It has a broad habitat range, from the coast through lowland and montane dry to mesic shrubland and open forest. Once the most abundant and widely collected of Hawaiian bee species, it is now exceedingly rare. The reasons for its decline all across its range are unclear, as other related species continue to thrive in the same habitats on at least some islands. Its floral hosts probably include the same ones used by related species in the same habitat, including naupaka (*Scaevola taccada*), ʻilima (*Sida fallax*), and the introduced tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*) at the coast, and ʻaʻaliʻi (*Dodonaea viscosa*), pūkiawe (*Leptecophylla tameiameiae*), and ʻōhiʻa lehua (*Metrosideros polymorpha*) in upland areas.

DISTRIBUTION: *Hylaeus facilis* was historically found from Maui to Oʻahu, though there are no records from Kahoʻolawe. It prefers the drier leeward areas, from the coast to about 1,524 meters (5,000 feet) elevation.

ABUNDANCE: Unknown. While it was common on all islands through the 1930s, sometime between then and when intensive collecting resumed in 1998 it experienced a severe collapse in numbers. There are only four records from the past 50 years, each of single individuals: two from Oʻahu in 1969 and 1975, one from Maui in 1993, and one from Molokaʻi in 2005.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Dry shrubland is also highly degraded and rare on Oʻahu and Maui Nui, except for subalpine areas of East Maui above 2000 m where *H. facilis* was never found. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, native bees are often found in marginal habitat. Some suitable areas appear to exist, but *H. facilis* has not been found in them. In some of these areas, other native *Hylaeus* that were historically collected in company with *H. facilis* are still present. Thus, *H. facilis* may have specialized habitat requirements that are currently unknown. The closely related *H. simplex* of Hawaiʻi was also formerly abundant but has completely disappeared and is probably extinct.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants

(primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus facilis* specifically, management needs include the following:
- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:
- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). University of Hawai‘i Press, Honolulu.

Magnacca KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca KN, and King CBA. 2013. Assessing the Presence and Distribution of 23 Hawaiian Yellow-faced Bee Species on Lands Adjacent to Military Installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Hylaeus hilaris. Photo: Karl Magnacca.

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus hilaris

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus hilaris* (F. Smith, 1879) is a medium-sized bee found on Maui Nui. It is one of the most beautiful native bees, as well as one of the rarest known to be recently extant, and lives exclusively in coastal areas. Unlike most other native bees, it is a cleptoparasite or cuckoo bee; rather than constructing a nest, the female enters the nest of another species and lays an egg inside the cell. The cleptoparasite larva then hatches and consumes the provisions, either killing the host larva directly or leaving it to starve. Adults visit flowers occasionally to feed themselves, but females do not collect pollen for a nest. While this strategy is common in general (about a quarter of all bees are cleptoparasites), *H. hilaris* and its four relatives among the Hawaiian *Hylaeus* are the only members of the family Colletidae to have evolved this trait.

DISTRIBUTION: *Hylaeus hilaris* was historically found on Maui, Molokaʻi, and Lānaʻi. The loss of native coastal vegetation has caused the occupied area to contract dramatically, as its host species have declined. Since the 1930s, it is known from only two collections (1990 and 1999) from Moʻomomi Preserve on Molokaʻi, each of a single individual.

ABUNDANCE: Unknown, but the population is undoubtedly very low. *Hylaeus hilaris* is exceedingly rare and its long-term survival is unlikely unless there are more populations or the abundance of hosts is significantly increased. The hosts of *H. hilaris* are *H. anthracinus* and *H. longiceps*, which are themselves listed endangered species.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees are only found in marginal habitat that is too dry for ants to live in. The single current population of *H. hilaris* is widely separated from other suitable areas so they are unlikely to disperse these long distances on their own to new sites. The recently introduced alien bee *H. strenuus* appears to be a major competitor in coastal and lowland dry habitats and has displaced native *Hylaeus* from several sites on Oʻahu. However, it could potentially serve as a host for the native cleptoparasitic species.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.

- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly or indirectly (via the host bees) compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus hilaris* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

No photo available

Yellow-faced bee
Hylaeus kuakea

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus kuakea* is a medium-sized bee endemic to Oʻahu. Unlike most of the native *Hylaeus*, the face mark of the male is ivory-colored rather than yellow. It lives in lowland dry to mesic forest, in association with various understory shrubs. It was only discovered in 1997, and little is known of its habits.

DISTRIBUTION: *Hylaeus kuakea* is restricted to the Waiʻanae range of Oʻahu. There are only three records of the species, each of a single individual: one from Schofield Barracks South Range in 1997, one from Mākaha Valley in 2009, and one from Waiʻanae Valley in 2014.

ABUNDANCE: Unknown. *Hylaeus kuakea* is apparently extremely rare, as more than one has never been found at any given site. Like many *Hylaeus*, it may prefer spending time in the canopy, which could make it more difficult to observe.

LOCATION AND CONDITION OF KEY HABITAT: Mid-elevation dry and mesic forests have declined dramatically, and only a tiny fraction of their original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. While upper elevation wet habitat remains relatively intact, alien plants invading from below in the aftermath of ungulate disturbance have seriously impacted the habitat favored by *H. kuakea*.

THREATS:
- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes* and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus kuakea* specifically, management needs include the following:
- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Hylaeus longiceps. Photo: Karl Magnacca.

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus longiceps

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus longiceps* (Perkins, 1899) is a medium-sized bee found on Oʻahu and Maui Nui. It lives primarily in coastal areas, sometimes extending up into lowland dry forest on Lānaʻi. The island populations form two genetic clusters, with Oʻahu individuals distinct from those on Maui, Molokaʻi, and Lānaʻi. Therefore, it is important to conserve all island populations. This and other coastal species are the only native bees that regularly visit flowers of an introduced plant, the tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*). With the loss of most of the native coastal vegetation, tree heliotrope is now a critical floral resource. Other important plants visted for pollen and nectar include naupaka (*Scaevola taccada*), ʻilima (*Sida fallax*), ʻōhai (*Sesbania tomentosa*), naio (*Myoporum sandwicense*), and ʻakoko (*Euphorbia* spp.).

DISTRIBUTION: *Hylaeus longiceps* is found from Maui to Oʻahu. While it still occurs on all islands in that range except Kahoʻolawe, the loss of native coastal vegetation has caused the occupied area to contract dramatically. It is currently known from only two or three sites on each island. On Maui, it is found at relictual dune sites east and west of Kahului on the north shore. On Molokaʻi, it is known only from the Nature Conservancy's Moʻomomi Preserve and Molokaʻi Land Trust's Anapuka Preserve, but much of the coast is unexplored. Two sites were known Oʻahu. *Hylaeus* have all but disappeared from Kaʻena Point after 2011 but a small population is currently being monitored in the Kahuku area.

ABUNDANCE: Unknown. *Hylaeus longiceps* is generally found in very low numbers where it occurs. At most sites, it is restricted to narrow stretches of coastal strand less than 30 m wide, and sometimes only a single row of trees or shrubs. One site on Maui is a small dune with a patch of native vegetation at the top, surrounded by a golf course, and is probably unsustainable in the long term. The former largest population on Oʻahu, at Kaʻena Point, has virtually disappeared since 2011 for unknown reasons. The Lānaʻi population is the most widely distributed, but the island is often subject to drought conditions and no surveys have been conducted for *Hylaeus* there since 1999.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees are only found in marginal habitat that is too dry for ants to live in. Native *Hylaeus* do not visit introduced plants except for tree heliotrope, and observations suggest they cannot survive on naupaka (the most common coastal shrub) alone. Current populations of *Hylaeus longiceps* are

widely scattered making it difficult for them to disperse these long distances on their own to sites with suitable coastal vegetation and areas where restoration has occurred. In 2023, private landowners near the single O‘ahu population site cleared a vast stretch of key habitat with native coastal vegetation this species is dependent on. The recently introduced alien bee *Hylaeus strenuus* appears to be a major competitor in coastal and lowland dry habitats, and has displaced native *Hylaeus* from several sites on O‘ahu. It has already been detected on Kaua‘i and will likely spread to the other islands as well.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus longiceps* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Conduct studies on captive rearing for reintroduction to establish new populations.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian Hylaeus (Nesoprosopis) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, Hylaeus (Nesoprosopis) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Hylaeus mana. Photo: Karl Magnacca.

Terrestrial Invertebrates

Yellow-faced bee
Hylaeus mana

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus mana* is one of the smallest native bees. It is endemic to Oʻahu, where it lives in lowland mesic forest and is mainly found in association with sandalwood or ʻiliahi (*Santalum freycinetianum*). This makes it one of the few native *Hylaeus* to show signs of ecological specialization. It was only discovered in 2002, and little else is known of its habits. It has an unusual amount of coloration in the female, which makes both sexes immediately identifiable in the field.

DISTRIBUTION: *Hylaeus mana* is restricted to the Koʻolau range of Oʻahu. While it occurs relatively widely on leeward ridges from Mauʻumae (Olympus) in the southeast to Mānana in the north, it is restricted to the narrow zone around 450–520 m (1500–1700 feet) elevation where ʻiliahi is found. Below this elevation, the vegetation is either predominantly alien or shrubland, and above it becomes wetter.

ABUNDANCE: Unknown. *Hylaeus mana* is generally found in low numbers where it occurs. The highest number of individuals that have been observed or collected at a site at once is three.

LOCATION AND CONDITION OF KEY HABITAT: Mid-elevation dry and mesic forests have declined dramatically, and only a tiny fraction of their original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. While upper elevation wet habitat remains relatively intact, alien plants invading from below in the aftermath of ungulate disturbance have seriously impacted the habitat favored by *H. mana*. In addition, ʻiliahi was heavily logged in the early 19th century for the sandalwood trade, greatly reducing its abundance. As a result, *H. mana* is restricted to small ridgetop patches, often isolated by broad and deep gulches dominated by alien plants. This habitat is also seasonally dry and highly susceptible to fire; several large remnant stands of ʻiliahi have been destroyed by fires in recent years.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes* and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.

- Stochastic events. Events such as droughts are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus mana* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of key habitats and associated plants.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus (Nesoprosopis)* Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus (Nesoprosopis)* (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Terrestrial Invertebrates

Photo: Bow Tyler

Square-headed wasps
Order Hymenoptera
Family Crabronidae
Genus *Ectemnius*

GENUS INCLUDES:
21 Native & Endemic Species

GENERAL INFORMATION: Square-headed wasps (*Ectemnius*) are generalist predators of flies (Diptera). They particularly attack large calyptrates such as blow flies and flesh flies, and often appear at a carcass before the flies themselves do. However, they will take any suitably sized fly, and Hawaiian species are known to use fruit flies (Tephritidae), big-headed flies (Pipunculidae), and others, including non-native species. The genus is cosmopolitan; the 21 endemic species occur on all the Main Hawaiian Islands (MHI) except Niʻihau and Kahoʻolawe, where lowland or coastal species may have occurred in the past. Unlike most native insects, many of the species are found on more than one island; only 12 are single-island endemics. They are well-studied taxonomically and it is unlikely more new species will be discovered. They nest in hollow stems, holes in trees, under bark, in crevices, or in burrows in soil.

DISTRIBUTION: Native *Ectemnius* are found on all the MHI except Niʻihau and Kahoʻolawe.

ABUNDANCE: Unknown. Anecdotal data from general observations suggests most species have declined over the past 30 years, but evidence is lacking. It is difficult to conduct systematic surveys for them due to their sporadic occurrence, and none have been attempted which prevents any population estimate.

LOCATION AND CONDITION OF KEY HABITAT: *Ectemnius* occur in most terrestrial habitats, from coastal strand to montane dry shrubland and wet forest.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects, particularly ants (Formicidae) which directly predate nests.
- Loss or degradation of habitat, especially the loss of native land snails which are hosts for endemic blow flies.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known hymenopterans and to document and identify new species.

- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Determine threats and causes of decline.
- Refine methods for conducting quantitative surveys.

References:

Takumi RL. 1999. A Systematic Review of the *Ectemnius* (Hymenoptera: Sphecidae) of Hawai‘i, University of California Press, Berkeley.

Terrestrial Invertebrates

Potter wasps
Order Hymenoptera
Family Vespidae
Subfamily Eumeninae

SUFAMILY INCLUDES:
113 Native & Endemic Species

GENERAL INFORMATION:
Euodynerus: 4 spp.
Nesodynerus: 109 spp.

Nesodynerus is an endemic genus of potter wasps restricted to the Hawaiian Islands. With 109 species, it is the second largest radiation of native Hymenoptera. They are predators, provisioning their nests with caterpillars. The nesting habits are varied; some dig holes, others make free-standing mud nests (from which the common name of the larger group is derived), but the majority use pre-existing cavities, such as beetle tunnels, human-made holes, and old nests of other wasps. A few species are relatively common and can sometimes be abundant, but the majority are very rare and many have not been collected in over 100 years. The genus as a whole is poorly studied, and some species may be restricted to particular niches rather than rare per se. Little is known about the drivers of diversity or how the various species may be adapted to particular prey species or habitats.

The four species of *Euodynerus* are derived from a separate colonization event. Unlike *Nesodynerus*, they did not diversify much; two species are endemic to Kauaʻi, one to Oʻahu, and the fourth, *E. nigripennis*, is widespread across all the larger islands. A generalist species found from the coast up to 1200 m elevation, it was widespread and abundant, even in cane fields and urban areas, up until the 1960s. Since then it and its relatives have disappeared even from higher elevation, intact forests where *Nesodynerus* are found.

DISTRIBUTION: *Nesodynerus* and *Euodynerus* are found on all the MHI except Kahoʻolawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats and abundance of alien competitors likely means that species in the group are declining. All of the *Euodynerus* species have apparently not been seen for decades.

LOCATION AND CONDITION OF KEY HABITAT: *Nesodynerus* and *Euodynerus* occur in most terrestrial habitats, from the coast to montane wet forest. They are now mostly restricted to higher-elevation forests.

THREATS:

- Competition with non-native wasps and ants, particularly the keyhole wasp *Pachodynerus nasidens*.
- Predation by non-native insects, both direct on nests and indirect, reducing the population of hosts.
- Loss or degradation of habitat, especially the loss of native plants for host caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Nesodynerus* and *Euodynerus* should include the following:

- Conduct surveys to determine distribution and abundance and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Carpenter JM. 2008. Review of Hawaiian Vespidae (Hymenoptera). Bishop Museum Occasional Papers 99:1–18.

Perkins RCL. 1899. Hymenoptera Aculeata: Eumenidae. Fauna Hawaiiensis 1(1):30–75.

Eupithecia sp. Photo: W. Haines.

Terrestrial Invertebrates

Moths and Butterflies
Order Lepidoptera

ORDER INCLUDES:
23 Native Families
66 Native Genera
>1013 Native Species
>1010 Endemic Species

GENERAL INFORMATION: The beauty and popularity of many species of butterflies and moths makes Lepidoptera perhaps the best known insect order. Hawai‘i supports over 1013 described native species of moths, but only two native butterfly species: Blackburn’s blue (*Udara blackburni*; Lycaenidae), and Kamehameha butterfly (*Vanessa tameamea*; Nymphalidae). The latter is Hawai‘i’s state insect. This disparity in numbers is likely the result of the fact that many moths are generalists, while most butterflies are dependent on specific host plants, making it unlikely that they would establish in the islands unless their host plant was already here. Most native moths are very small, with most only having a wingspan of one centimeter (0.4 inches) or less, and most are poorly known. Approximately 363 species of native moths are in the genus *Hyposmocoma*, and many more are likely undescribed. *Hyposmocoma* is the second most diverse animal lineage in Hawai‘i (after flies in the family Drosophilidae). These moths inhabit a wide range of habitats, although some species are restricted to single stream or river drainages. As a genus they are mostly herbivorous, feeding on plant debris and lichens, though some species are carnivorous, feeding on snails. Less than one percent of the world’s known moths and butterflies are predaceous, but in Hawai‘i, predaceous behavior has evolved independently in two lineages (*Hyposmocoma* and *Eupithecia*).

DISTRIBUTION: Lepidopterans are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining. Recent surveys and reviews of museum specimens estimated that about a third of native Lepidopterans have not been collected in over 50 years and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Butterflies and moths occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native plants, lichens, algae, and fungi. Some species feed only in the decaying wood of particular plant species.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.

- Loss of obligate native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native species, such as ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and social wasps (Vespidae), especially *Vespula* spp.
- Parasitism by non-native flies (Diptera) and wasps (Hymenoptera).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward moths and butterflies should include:

- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known moths and butterflies and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species to science.
- Systematic review of the order.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Austin K., Rubinoff D. 2024. Towards a conservation assessment of the endemic Hawaiian moths and butterflies. Hawaii Conservation Conference. Oral presentation.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Rubinoff D, Haines W. 2005. Web-spinning caterpillar stalks snails. Science 309:575.

Zimmerman EC. 2001. Insects of Hawai'i: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Hyposmocoma kahamanoa

Terrestrial Invertebrates

Cosmet Moths
Order Lepidoptera
Family Cosmopterigidae
Genus *Hyposmocoma*

GENUS INCLUDES:
>500 Native & Endemic Species

GENERAL INFORMATION: *Hyposmocoma* is a Hawaiian endemic genus of small to minute moths, also known as Hawaiian fancy-cased caterpillars. Approximately 360 species are described (Nishida, 2002), and hundreds more remain undescribed, making them the second largest endemic radiation in Hawai‘i (flies in the family Drosophilidae being the largest). The group is divided into two subgenera, *Hyposmocoma sensu stricto*, where the caterpillars make cases (205 species), and *Euperissus*, where the caterpillars live freely (158 species; Zimmerman, 1978). As caterpillars they are mostly herbivorous, feeding on leaves, ferns, plant debris, and lichens. However, some species are predatory on insects and even snails, which is extremely rare among Lepidoptera (Rubinoff and Haines, 2005). They inhabit a wide range of habitats, from the coast to montane wet forests and barren lava flows. Some are aquatic or semi-aquatic, grazing on moss and algae on rocks of permanent or intermittent streams. Due to the large size of the group, small size of individual specimens, and many cryptic species, identification is often difficult, especially without both the larval case and the adult.

DISTRIBUTION: *Hyposmocoma* are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates, and their small size, large number of undescribed species, and lack of literature resources make the species difficult to identify. The loss of native habitats likely means that species within the genus are declining, particularly those that inhabit specialized niches. However, at least some of the case-making species are able to persist at disturbed lowland sites with few other native species.

LOCATION AND CONDITION OF KEY HABITAT: *Hyposmocoma* occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native plants, lichens, algae, and mosses. Some species are predatory on insects or snails.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.

- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*) and Argentine ant (*Linepithema humile*), and parasitic wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward moths and butterflies should include:

- Conduct surveys to determine the distribution and abundance of known *Hyposmocoma* species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate efforts to locate and identify new species.
- Systematic review of the genus to create an identification framework.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Rubinoff D, Haines W. 2005. Web-spinning caterpillar stalks snails. Science 309:575.

Zimmerman EC. 1978. Insects of Hawai'i: Volume 9 Microlepidoptera Part II. Honolulu: University of Hawai'i Press.

Omiodes monogramma. Photo: W. Haines.

Terrestrial Invertebrates

Crambid snout moths and grass moths
Order Lepidoptera
Family Crambidae

FAMILY INCLUDES:
11 Native Genera
137 Native Species
136 Endemic Species

GENERAL INFORMATION: The family Crambidae includes 137 described native species which feed on a variety of native plants. The most species-rich crambid genus is *Eudonia*, containing more than 60 described species, and likely many more undescribed species. Caterpillars of many *Eudonia* species feed on mosses and lichens and can be common, even in relatively disturbed areas. Other large lineages in this family include *Udea* (44 spp.), *Mestolobes* (34 spp.), and *Omiodes* (23 spp.). Caterpillars of *Udea* and *Mestolobes* feed on a variety of native plants, while most *Omiodes* feed on monocots, including grasses, sedges, palms, and lilies. Most crambid moths are nocturnal, but many *Mestolobes* are active during the day, and are frequently seen visiting flowers. Crambid moths, like other native lepidoptera, are likely important pollinators for native plants.

DISTRIBUTION: Crambid moths are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining. Several species of *Omiodes* have not been seen in over 100 years and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Crambid moths occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native flowering plants, mosses, and lichens.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward crambid moths and butterflies should include:

- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known crambid moths and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

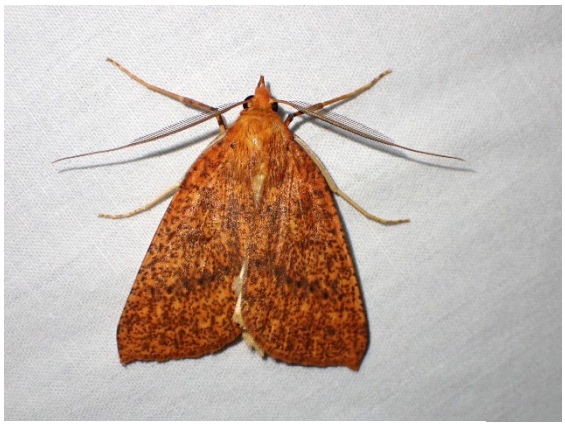
RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of genera within the family.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1958. Insects of Hawaii: Volume 8 Lepidoptera: Pyraloidea. Honolulu: University of Hawaii Press.



Scotorythra sp. Photo: W. Haines.

Terrestrial Invertebrates

Geometer moths
Order Lepidoptera
Family Geometridae

FAMILY INCLUDES:
7 Native Genera
82 Native & Endemic Species

GENERAL INFORMATION: The family Geometridae, or geometer moths, is fairly well represented in the Hawaiian fauna, including 82 recognized species within seven genera. Caterpillars of geometrid moths are often referred to as inchworms, due to the way they move in a stepwise fashion, reaching forward with their front legs, grasping the substrate, then bringing the back half of their body up to meet the front. Geometrid caterpillars lack prolegs (leg-like abdominal appendages) along most of their abdomen, possessing them only on the last segments. The largest genera of native geometrid moths are *Scotorythra* (44 spp.) and *Eupithecia* (22 spp.). Caterpillars of *Scotorythra* moths feed on the vegetation of native plants. Some species are specialists, feeding on only one genus or species of native plant; others, such as *S. rara*, are generalists, able to feed on many different types of plants. The koa looper, *S. paludicola,* sometimes has population explosions, defoliating koa forests on Maui and Hawai‘i. The genus *Eupithecia* includes some of the most unique native animals; most of the Hawaiian species have evolved a predatory lifestyle. Their caterpillars situate themselves along the edge of a leaf and wait for unsuspecting insects to stumble upon them. They have backward-pointing trigger hairs at the tip of their abdomen, allowing them to sense when small insects come into contact with them. They then snap backward and grab prey with their well-developed, grasping forelegs. These are among the only ambush predator caterpillars in the entire world.

DISTRIBUTION: Geometer moths are known from all the main Hawaiian Islands except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: As a group, unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Geometer moths occur in all types of native habitats from sea level to alpine deserts. Host material includes a wide variety of native plants, though many *Eupithecia* species are entirely carnivorous.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.

- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward geometrids should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of genera in the family, including description of undescribed species.
- Characterization of pheromones of *Scotorythra* spp. to facilitate monitoring of outbreaking species such as the koa looper.

References:

Haines WP, Heddle ML, Welton P, Rubinoff D. 2009. A recent outbreak of the Hawaiian koa moth, *Scotorythra paludicola* (Lepidoptera: Geometridae), and a review of outbreaks between 1892 and 2003. Pacific Science 63(3): 349-369.

Heddle AL. 2003. Systematics and phylogenetics of the endemic genus *Scotorythra* (Lepidoptera: Geometridae) in the Hawaiian Islands. Dissertation, University of California at Berkeley. 310 pp.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawai'i: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Philodoria splendida. Photo: K. Magnacca.

Terrestrial Invertebrates

Painted leaf miners
Order Lepidoptera
Family Gracillariidae
Genus *Philodoria*

GENUS INCLUDES:
52 Endemic Species

GENERAL INFORMATION: *Philodoria* is an endemic genus in the leaf-mining moth family Gracillariidae. Aside from the questionably-native *Caloptilia mabaella*, *Philodoria* species are the only native representatives of the large and widespread Gracillariidae family, which includes a number of agricultural pests. The flattened caterpillars feed in between the top and bottom surface of leaves, forming mines that may be serpentine or contiguous (blotch) depending on the species. All are host plant specific at least to family, often to species. Adults are minute, often with bright or metallic patterns.

DISTRIBUTION: *Philodoria* are known from all the MHI except Niʻihau and Kahoʻolawe, and one widespread species is also found on Nihoa in the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the genus are declining, and some may be extinct. Mines of some species that have not been recovered recently have been found in herbarium specimens of their host plants.

LOCATION AND CONDITION OF KEY HABITAT: *Philodoria* occur in all native habitats from sea level to alpine deserts. They feed in a wide variety of plants, from common species such as *Metrosideros polymorpha* (ʻōhiʻa lehua) and *Pipturus albidus* (māmaki) to endangered ones such as *Argyroxiphium grayanum* and *Hesperomannia* spp.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) prey on both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Philodoria* should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known leaf miners and to document and identify new species.
- Conduct outplanting of native host plants within or near existing moth populations.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of the genus.

References:

Kobayashi S, Johns CA, and Kawahara AY. 2021. Revision of the Hawaiian endemic leaf-mining moth genus *Philodoria* Walsingham (Lepidoptera: Gracillariidae): its conservation status, host plants and descriptions of thirteen new species. Zootaxa 4944(1): 1–175.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 1978. Insects of Hawaii: Volume 9 Microlepidoptera. Honolulu: The University Press of Hawaii.

Udara blackburni (left) and *Vanessa tameamea* (right).

Photos: W. Haines.

Terrestrial Invertebrates

Butterflies
Order Lepidoptera
Superfamily
Papilionoidea

SUPERFAMILY INCLUDES:
2 Native Families
2 Native Genera
2 Native & Endemic Species

GENERAL INFORMATION: Hawai‘i supports about a thousand native moth species, but only two native butterflies: Blackburn’s blue (*Udara blackburni*; Lycaenidae), and the Kamehameha butterfly (*Vanessa tameamea*; Nymphalidae). The latter is Hawai‘i’s state insect. Both are larval food specialists. Caterpillars of the Kamehameha butterfly feed on native plants in the nettle family (Urticaceae), primarily māmaki (*Pipturus* spp.) but also ‘akolea (*Boehmeria grandis*), ‘olonā (*Touchardia latifolia*) and ‘ōpuhe (*T. sandwicensis*), while those of Blackburn’s blue feed on koa (*Acacia koa*) and ‘a‘ali‘i (*Dodonaea viscosa*). Using only koa and ‘a‘ali‘i as host plants is somewhat unusual for insects since these plants are unrelated. Interestingly, though, koa and ‘a‘ali‘i are also the two host plants of the koa bug (*Coleotichus blackburniae*).

DISTRIBUTION: The Kamehameha butterfly is known from all of the Main Hawaiian Islands except Kaho‘olawe. Blackburn’s blue is known from all of the Main Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that the species are declining. The Kamehameha butterfly has been increasingly less abundant over the past 30 years, particularly on O‘ahu where it is rarely seen in the Ko‘olau range. Captive rearing and reintroductions of the Kamehameha butterfly were attempted by DLNR-DOFAW from 2016 to 2020 in the southern Ko‘olau Range of O‘ahu but were not successful due to high predation rates on caterpillars. Blackburn’s blue appears to be fairly common but has not been studied as much.

LOCATION AND CONDITION OF KEY HABITAT: Both butterflies occur in native dry to wet forests.

THREATS:
- Habitat loss and degradation due to conversion for agriculture, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and parasitism by several species of parasitic flies (Diptera)

and wasps (Hymenoptera) that attack eggs and larvae. Introduced birds, particularly red-vented bulbuls and Japanese white-eyes, also prey on caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward butterflies should include:

- Conduct surveys to determine the distribution and abundance of both species to assess current conservation status.
- Preserve, maintain, and restore habitats supporting existing populations.
- Encourage planting of host plants in natural areas and in nearby residential areas.

MONITORING:

- Support and expand existing monitoring efforts.
- Determine if declines are occurring and target affected areas for conservation actions.

RESEARCH PRIORITIES:

- Conduct studies on life history, distribution, and critical habitats to better direct conservation measures.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Terrestrial Invertebrates

Blackburn's Sphinx Moth
Manduca blackburni

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic
NatureServe Heritage Rank G1 - Critically imperiled
Recovery Plan for the Blackburn's Sphinx Moth (*Manduca blackburni*) - USFWS 2005
Designation of Critical Habitat for the Blackburn's Sphinx Moth: Final Rule – USFWS 2003

SPECIES INFORMATION: Blackburn's sphinx moth is one of Hawai'i's largest native insects (Family: Sphingidae) with a wing span of up to 12 centimeters (5 inches). Adults are overall gray with black bands across the top of their wings and five orange spots on each side of their abdomen. Caterpillars are large and populations contain two distinct color morphs, bright green or purple/gray. Both morphs have scattered white speckles across their back and a horizontal white stripe on the side of each segment. Caterpillars feed on plants in the nightshade family (Solanaceae), especially native trees in the genus *Nothocestrum,* but also on non-native solanaceous plants such as tree tobacco (*Nicotiana glauca)*, commercial tobacco (*N. tabacum*), eggplant (*Pseudomonas solanacearum*), tomato (*Lycopersicon esculentum*), and Jimson weed (*Datura stramonium*). Adults have been observed feeding on the nectar of koaliawa (*Ipomea indica)*. Additional likely adult nectar sources include other species of *Ipomea*, maiapilo (*Capparis sandwichiana)*, and 'ilie'e (*Plumbago zeylancia*); it is believed that the moth pollinates these species, but further study is necessary. Development from egg to adult may be as short as 56 days, but pupae may aestivate (i.e., remain dormant during hot or dry conditions) in the ground for as long as a year. Moths are found year-round but may be most active between January and April and, again, between September and November, especially after rains.

DISTRIBUTION: Originally distributed across all the Main Hawaiian Islands (MHI), the species was believed to be extinct in the late 1970s. In 1984, it was rediscovered on East Maui. Additional populations have recently been found on Kaho'olawe and the island of Hawai'i. Blackburn's sphinx moth can be found across a broad elevational gradient from sea level to 1,540 meters (5,000 feet), though it does not breed in all locations where the adults might be found.

ABUNDANCE: Unknown. The species' short life span as an adult, rarity, and mobility makes estimating population sizes difficult. Despite this, it is believed that populations have declined over the past 100 years since the moth no longer occurs on several islands on which it had been recorded. Currently, the largest populations reside on Maui and Hawai'i. Historical accounts and museum specimens suggest the species was widespread and common on most of the MHI.

LOCATION AND CONDITION OF KEY HABITAT: Historical records indicate that Blackburn's sphinx moth mostly occurred in coastal, lowland, and dry forests in areas receiving less than 127 centimeters (50 inches) of rain per year. Human modification of Hawaiian landscapes has greatly reduced these communities; for example, more than 90 percent of Hawai‘i's dry forests have been destroyed. Depending on the location and elevation, the composition of the plant species in moth habitat varies considerably. However, some common native plants found in areas where the species occurs include lama (*Diospyros sandwicensis*), ‘ohe (*Polyscias sandwicensis*), hao (*Raovolfia sandwicensis*), ‘āla‘a (*Planchonella sandwicensis*), āulu (*Pisonia sandwicensis*), ‘a‘ali‘i (*Dodonaea viscosa*), naio (*Myoporum sandwicense*), and wiliwili (*Erythrina sandwicensis*). The populations on Maui and Hawai‘i are primarily associated with non-native tree tobacco and native ‘aiea (*Nothocestrum* spp.) trees. Perhaps the largest stand of ‘aiea trees in the State is located on Maui in the Kanaio Natural Area Reserve. On Moloka‘i, potential moth habitat consists of mixed-species mesic and dry forests with both native and non-native plants (see below)**.** On Kaho‘olawe, caterpillars currently feed on the non-native tree tobacco. Although the species will feed on non-native plants, primary constituent elements of critical habitat as designated by the USFWS (see below; critical habitat) include the endemic larval host plant species *N. latifolium* and *N. breviflorum*, and native nectar sources for adults including koaliawa, other species of *Ipomoea*, maiapilo, and ‘ilie‘e. These species are likely superior to non-natives in that they are more persistent, especially during drought conditions.

THREATS: Historically, habitat loss and degradation due to ranching, introduced plants and animals, human development, and wildfire reduced the quantity and quality of native habitats. In 2003, 40,420 hectares (99,433 acres) of critical habitat was designated by the USFWS on the islands of Hawai‘i, Maui, Moloka‘i, and Kaho‘olawe. Current threats include non-native ants, especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies and wasps. Although little documentation exists of direct predation, in areas where big-headed ants occur, native insects have been eliminated. Several alien wasp species have been documented parasitizing the Blackburn's sphinx moth. All species of host *Nothocestrum* are declining. Because of development, competition from non-native species, browsing by cattle and feral goats, and wildfire, the larval host plant, *N. breviflorum* on the island of Hawai‘i, and the potential host plant, *N. peltatum* on Kaua‘i, are federally listed as endangered. Given that the species inhabits dry habitats, natural variation in rainfall can result in reduced food availability and negatively affect moth populations.

CONSERVATION ACTIONS: The Kanahā Pond Sanctuary dune restoration project on Maui is planting native host plants in response to observations of caterpillars on plants in the restoration area. In addition to common statewide and island conservation actions, specific management directed toward Blackburn's sphinx moth should include:

- Restoration of habitat (e.g. dry and mesic shrubland and forests) and increased protection of currently occupied habitats, especially those supporting host plants.
- Support cultivation and restoration of *Nothocestrum* species.
- Restore *Nothocestrum* on Kaho‘olawe to support moth populations.
- Re-establish moth populations throughout their historic range.
- Prevent introduction of non-native invertebrates that may pose a risk to existing moth populations.

MONITORING:

- Continue surveys of populations in known and potential habitats.
- Continue monitoring of *Nothocestrum* species.
- Monitor non-native plant and animal populations in known as well as potential moth habitat.

RESEARCH PRIORITIES:

- Evaluate the species' habitat needs, population status, and life history.
- Evaluate limiting factors on the species, possibly through controlled release trials. This should be geared towards establishing additional populations across the former range of the species.

References:

U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn's Sphinx Moth: final rule. Federal Register 68: 34710-34766.

U.S. Fish and Wildlife Service. 2005. Recovery plan for the Blackburn's Sphinx Moth (Manduca blackburni). Portland, Oregon.

U.S. Fish and Wildlife Service. 2009. Blackburn's Sphinx Moth (Manduca blackburni) 5-Year Review: Summary and Evaluation. Pacific Islands Fish and Wildlife Office. Honolulu, Hawaii.

Terrestrial Invertebrates

Fabulous Green Sphinx
Order Lepidoptera
Family Sphingidae
Tinostoma smaragditis

GENERAL INFORMATION: *Tinostoma smaragditis*, known as the "fabulous green sphinx of Kauaʻi," is one of the largest and most enigmatic Hawaiian native insects. It was long known from a single specimen collected in the 1890s by a member of the Gay family (owners of Makaweli), and failure to obtain any more specimens combined with the lack of any other relatives led some to believe that it was not actually a Hawaiian species, either having been mislabelled or a one-off accidental import. However, it was rediscovered in 1961, and since then a series of specimens have been found in diverse mesic forest in the Kōkeʻe and Kalalau areas. The most recent sighting was in 2000, and further searches in the Kōkeʻe and Wailua River areas have not found any more. The host plant is unknown; one female caught in 1992 laid several eggs before dying, but the caterpillars that hatched did not feed on any of the plants offered.

DISTRIBUTION: *Tinostoma smaragditis* is known only from Kauaʻi, primarily in the northwest corner of the island.

ABUNDANCE: Extremely rare; known only from about 15 specimens total, and not seen for 25 years.

LOCATION AND CONDITION OF KEY HABITAT: Based on the location of collections, *Tinostoma smaragditis* appears to inhabit diverse mesic forest. There are still some significant stands of this habitat type remaining, but since its specific host plant is unknown, the primary factor in assessing habitat status is missing.

THREATS:

- Habitat loss and degradation due to disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) probably attack eggs and larvae.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Tinostoma smaragditis* should include:

- Conduct surveys to determine its distribution and abundance.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.

RESEARCH PRIORITIES:

- Conduct studies to determine the host plant and other key life history traits.

References:

Heddle MR, Wood KR, Asquith A, Gillespie RG. 2000. Conservation status and research on the fabulous green sphinx of Kauaʻi, *Tinostoma smaragditis* (Lepidoptera: Sphingidae), including checklists of the vascular plants of the diverse mesic forests of Kauaʻi, Hawaiʻi. Pacific Science 54(1): 1–9.

Zimmerman EC. 1958. Insects of Hawaii: Volume 7 Macrolepidoptera. Honolulu: University of Hawaii Press.

Mantua fulvosericea. Photo: K. Magnacca.

Terrestrial Invertebrates

Leaf-roller moths
Order Lepidoptera
Family Tortricidae

FAMILY INCLUDES:
13 Native Genera
>90 Native & Endemic Species

GENERAL INFORMATION: The family Tortricidae is a large, diverse group worldwide. The family is commonly known as leaf-roller moths, although some have other habits such as feeding in seeds or fruit. The native Hawaiian fauna is notable for the high number of colonists, with each genus derived from a separate introduction event. As a result, while there are several moderately large radiations, many groups have only a few species. The most diverse genera are *Pararrhaptica* and *Spheterista*, each with over 20 species, and *Cydia* and *Eccoptocera* each with at least 15. Some, such as *Bactra straminea* and *Cryptophlebia illepida*, appear to be highly variable and widespread species but are probably actually cryptic species complexes in the process of rapid evolution.

DISTRIBUTION: Tortricids are known from all the MHI and the genus *Crocidosema* is also found on many of the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the family are declining. Recent surveys have found fewer of many species than in the past; many others have not been collected in 50 years or more and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Tortricids occur in all native habitats from sea level to alpine deserts. Most feed on the leaves or seeds of native plants. Some species have adapted to feed on alien grasses.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and wasps (Hymenoptera) parasitize and prey on larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leaf-roller moths should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known tortricids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of the family.

References:

Austin KA, and Rubinoff D. 2024. Nine new species of Hawaiian leaf-roller moths (Lepidoptera: Tortricidae), including one probably extinct species. Proceedings of the Hawaiian Entomological Society 56: 29–59

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1978. Insects of Hawaii: Volume 9 Microlepidoptera. Honolulu: University of Hawaii Press.

Micromus swezeyi. Photo: Brendan Wang.

Terrestrial Invertebrates

Lacewings and Antlions
Neuroptera

ORDER INCLUDES:
3 Native Families
5 Native Genera
50 Endemic Species and subspecies

GENERAL INFORMATION:
Family Chrysopidae- 22 speices and subspecies
Family Coniopterygidae- 1 species
Family Hemerobiidae- 25 species and subspecies
Family Myrmeleonidae- 2 species and subspecies

Lacewings and antlions are predators, feeding on other insects in both their immature and adult stages. Most adult species in the genus have four large, net-veined, wings. Species in the Chrysopidae are bright green and colorful, while species in the Hemerobiidae are mostly brown. A few species are flightless (e.g., *Micromus lobipennis* and *M. haleakalae*). The largest number of Hawaiian endemic species are found in the genera *Anomalochrysa* (Chrysopidae) and *Micromus* (Hemerobiidae). Many native species of brown lacewings (Hemerobiidae: *Micromus*) are relatively common, but others – particularly those with highly modified or reduced wings – are rare. The native antlions (Myrmeleontidae: *Distoleon*) are rare and very poorly known; it is unclear if there are multiple endemic species present, or if they are indigenous variants of the widespread *D. bistrigatus*.

DISTRIBUTION: Neuropterans are known from all the MHI except for Kahoʻolawe and Niʻihau. Members of this order also are known from the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mostly unknown. However, lacewings and antlions appear to occur in a wide range of habitats.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward lacewings and antlions should include:

- Conduct surveys to determine the distribution and abundance of known lacewings and antlions and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1957. Insects of Hawaii: Volume 6, Ephemeroptera-Neuroptera-Trichoptera and Supplement to Volumes 1 to 5. Honolulu: University of Hawaii Press.

Anax strenuus. Photo: Karl Magnacca.

Terrestrial Invertebrates

Damselflies and dragonflies
Odonata

ORDER INCLUDES:
3 Native Families
4 Native Genera
29 Native Species
27 Endemic Species

GENERAL INFORMATION: Dragonflies and damselflies are among the most common and easily recognized aquatic insects. All members of the order are predaceous, both as immatures and adults. All dragonflies and damselflies have an aquatic immature form (naiad). Adults have large compound eyes, two pairs of large membranous wings, and a long, thin abdomen. The order consists of two suborders, one (Anisoptera) containing the dragonflies and the other (Zygoptera) the damselflies. Dragonflies are very strong fliers, soaring for long distances, and at rest holding their wings spread. Damselflies generally do not fly long distances, and at rest hold their wings together above the body. Because of the diversity and extensive adaptive radiation, the native damselfly genus *Megalagrion* is particularly well-studied. Many *Megalagrion* species are endemic to single islands or ridges, and at least ten of the 23 species in the genus are considered at risk. *Megalagrion oahuense* is one of the few truly terrestrial damselflies in the world. Several other species are semi-terrestrial, the naiads living in tiny amounts of water held by the rosette-forming native plants *Astelia* and *Freycinetia*. The endemic green darner dragonfly, *Anax strenuus*, is one of our largest native insects with a wingspan of up to 14 cm (5.5 inches). Six endemic damselflies (*Megalagrion leptodemas*, *M. nesiotes*, *M. nigrohamatum nigrolineatum*, *M. oceanicum*, *M. pacificum*, and *M. xanthomelas*) are federally listed as endangered.

DISTRIBUTION: Dragonflies and damselflies are known from all the Main Hawaiian Islands except for Kahoʻolawe. The widespread indigenous globe skimmer dragonfly (*Pantala flavescens*) is also found in the NWHI.

ABUNDANCE: Most of the native dragonflies remain relatively common, although the endemic clubtail *Nesogonia blackburni* is somewhat rare. However, many species of *Megalagrion* are rare, and their abundance and distribution has declined dramatically over the past 100 years.

LOCATION AND CONDITION OF KEY HABITAT: Larvae and adults occur in or near a wide range of aquatic habitats (e.g., streams, plunge pools, reservoirs, anchialine pools, lowland swamps and marshes), montane forests and bogs, and lowland habitats, many of which are threatened by habitat change and loss. In particular, the introduction of mosquitofish and topminnows (Poeciliidae) for control of mosquitoes has eliminated *Megalagrion* damselflies from many streams. Bullfrogs (*Rana catesbeiana*) also prey on naiads and can spread from stream to stream across land.

THREATS:

- Habitat loss or degradation caused by water diversions, pollution, and disturbance by feral ungulates.
- Predation of naiads by non-native invasive invertebrates, fish, and frogs.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward dragonflies and damselflies should include the following:

- Identify and protect streams currently free of non-native species and human alterations, particularly in lowland areas.
- Conduct surveys to determine distribution and abundance of known dragonfly and damselfly populations and to document and identify new species.
- Enhance protection of key watersheds.
- Support captive breeding and relocation/translocation of endangered *Megalagrion* species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring of known populations to assess population trends.
- Survey for additional, new populations.
- Conduct surveys for species believed to be extinct.

RESEARCH PRIORITIES:

- Determine the cause(s) of decline of stream-breeding species, particularly on O‘ahu.
- Conduct studies to determine life history factors for conservation.
- Assess potential haplotype differences among island populations of widespread species to determine the importance of protecting populations on individual islands.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Polhemus DA. 1993. Damsels in distress: a review of the conservation status of Hawaiian *Megalagrion* damselflies. Aquatic Conservation: Marine and Freshwater Ecosystems 3:343-49.

Polhemus DA. 2004. Critical species of Odonata in the Hawaiian Islands. International Journal of Odonatology 7(2):133-138.

Polhemus DA, Asquith A. 1996. Hawaiian damselflies: a field identification guide. Honolulu, (HI): Bishop Museum Press.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77:57648–57862.

Megalagrion leptodemas.

Terrestrial Invertebrates

Crimson Hawaiian damselfly
Megalagrion leptodemas

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion leptodemas* (Perkins, 1899) is a small, relatively slender damselfly. Males are predominantly bright red except on the posterior half of the abdomen, and females are greenish. Despite the coloration of the males, their small size and shy habits make them inconspicuous when flying about. Adults are found along stream corridors near standing pools or slow-moving stream sections that serve as breeding sites, usually not straying far from the stream. Along with *M. oceanicum*, it is among the rarest Oʻahu species known to be extant.

DISTRIBUTION: Endemic to Oʻahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Waiʻanae range. In the Koʻolau range, it occurs in only three isolated locations in the upper reaches of streams: Moanalua, North Halawa, and Maʻakua.

ABUNDANCE: Unknown. The total population is extremely small due to the highly constrained habitat available and few remaining populations.

LOCATION AND CONDITION OF KEY HABITAT: The naiads inhabit still pools and slow-flowing sections of streams. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. As a result, it is now restricted to upper elevations in streams where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. This species has not been reared in captivity. For *Megalagrion leptodemas* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Develop captive rearing methods for the species.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.
- Develop captive rearing methods for the species.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.

Megalagrion nesiotes. Photo: Dan Polhemus, USFWS.

Terrestrial Invertebrates

Flying earwig
Hawaiian damselfly
Megalagrion nesiotes

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion nesiotes* (Perkins, 1899) is a large damselfly, distinguished from other Hawaiian species by the blue and black color pattern and enlarged terminal appendages of the male. Females are brown with black stripes on the thorax. As a dark-colored, weak-flying species that occurs in forests, it is relatively inconspicuous and difficult to observe. Never very common, this species had not been seen since the 1930s before it was rediscovered along a stream on Maui in the early 1990s.

DISTRIBUTION: Historically this species was known from windward East Maui and Hawai‘i, mostly below 914 meters (3,000 feet) elevation. The last collections from Hawai‘i were made in the 1930s, and intensive surveys at historical sites in Puna and Volcano have not recovered it. However, its coloration and habits may mean it has been overlooked. The only known population site is on the north slope of Haleakalā, where the species was rediscovered in the 1990s after a gap of 75 years.

ABUNDANCE: Unknown. The sole known population is small and vulnerable to stochastic events, and no individuals have been observed during recent visits. The species was last sighted in 2005, and several damselfly surveys of the area between 2009 and 2022 failed to detect the species.

LOCATION AND CONDITION OF KEY HABITAT: The breeding habitat is unknown. Based on its behavior and relationships, it is thought to breed in terrestrial or semiterrestrial habitat, such as uluhe mats, damp leaf litter, or wet banks. Because these are not associated with the introduced aquatic predators that have cause the decline of most *Megalagrion* species, the main driver of this species’ decline is unclear.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, and alien aquatic plants.
- Predation. Non-native predators, including invasive invertebrates, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion nesiotes* specifically, management needs include the following:

- Conduct surveys around the known population to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census the population in order to assess stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith, AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; listing the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly as endangered throughout their ranges. Federal Register 75: 35990–36012.

U.S. Fish and Wildlife Service. 2023. Flying earwig Hawaiian damselfly (*Megalagrion nesiotes*) 5-year Review 2023. Available at https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/4698.pdf (accessed 17 Dec 2024).

Photo: W. Haines

Terrestrial Invertebrates

Blackline Hawaiian damselfly
Megalagrion nigrohamatum nigrolineatum
SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion nigrohamatum nigrolineatum* (Perkins 1899) is a moderate-sized damselfly, immediately distinguishable from all other Hawaiian species by the greenish to blue color of the lower half of the face and eyes. Males and females are sexually dimorphic in color pattern, with males reddish on the side of the thorax and females yellow to light blue. Adults are found along stream corridors in the vicinity of the pools and slow-moving stream sections that serve as breeding sites.

DISTRIBUTION: Endemic to Oʻahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Waiʻanae range. In the Koʻolau range, it occurs in scattered locations along streams of the central and northern regions, on both the windward and leeward sides. Approximately 20 populations are currently known.

ABUNDANCE: Numbers are drastically reduced due to the highly constrained area of habitat available. The population is estimated to be about 800 to 1,000 individuals in total, with approximately 50 individuals at each site.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in pools and slow sections of perennial montane streams. Like most native damselflies, this species is impacted by nonnative fish, though it does overlap in range with mosquito fish and smallmouth bass in some streams and appears to be somewhat more resilient to predation than other *Megalagrion* species. Although it historically occurred close to sea level, it is now restricted to upper elevations where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. Captive rearing of this species began in 2021 and reintroductions have been attempted to a limited degree, but methods are in need of refinement.

For *Megalagrion nigrohamatum nigrolineatum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Develop and refine captive rearing methods.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.

Megalagrion oceanicum.
Photo: Dan Polhemus, USFWS.

Terrestrial Invertebrates

Oceanic Hawaiian damselfly
Megalagrion oceanicum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion oceanicum* (McLachlan, 1883) is a large, relatively robust damselfly. Like its relatives *M. heterogamias* of Kauaʻi and *M. blackburni* of Hawaiʻi, males are predominantly red except near the tip of the abdomen, while females have a dull greenish thorax and a dark abdomen. The size and the predominantly red coloration of the males make them conspicuous when flying about. Adults are found along stream corridors around fast-moving stream sections that serve as breeding sites; they are strong fliers and may also be found in adjacent forests.

DISTRIBUTION: Endemic to Oʻahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Waiʻanae range. In the Koʻolau range, it occurs in scattered locations along streams on the windward side of the central and northern regions. Twelve populations were known when the species was listed as endangered, but recent surveys failed to detect the species in many of these locations, and its range is likely quite restricted, making it among the rarest damselflies endemic to Oʻahu.

ABUNDANCE: Unknown. The population is thought to be relatively small due to the highly constrained habitat available.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in fast-flowing sections of perennial montane streams, but may come out of the water to forage on mossy banks and rocks. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. Although it historically occurred close to sea level and in all habitable streams, it is now restricted to upper elevations in streams where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion oceanicum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.

Megalagrion pacificum. Photo: Hank Oppenheimer.

Terrestrial Invertebrates

Pacific Hawaiian damselfly
Megalagrion pacificum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion pacificum* (McLachlan, 1883) is a moderate-sized damselfly, readily distinguished from all other Hawaiian species by the red and black color pattern of the male. Females are similar, with the abdomen predominantly black and the thorax marked with light green instead of red. Males can also be recognized by having the lower pair of terminal appendages much longer than the upper; in most species, the upper pair is longer. Once considered one of the most common and widespread species of Hawaiian damselfly, it is now extirpated from most of its range and restricted to a handful of sites. Adults are found around the seepage-fed side pools of stream corridors that serve as breeding sites.

DISTRIBUTION: Historically this species was found in the lowlands of all the main islands except Niʻihau and Kahoʻolawe. It apparently disappeared from Oʻahu first, around 1910, and later from Kauaʻi and Lānaʻi. Recent surveys have found it at seven streams on Molokaʻi (with possibly more that are unsurveyed), fourteen on Maui, and only one on Hawaiʻi.

ABUNDANCE: Unknown. Numbers are drastically reduced due to the highly constrained area of habitat available.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in seepage-fed side pools off of main streams. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. Formerly, *M. pacificum* was found in other lentic habitats such as marshes and taro ponds, but these are now almost all invaded by alien fish. It is now restricted to sites where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion pacificum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith, AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; listing the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly as endangered throughout their ranges. Federal Register 75 :35990–36012.

Megalagrion xanthomelas

Terrestrial Invertebrates

Orangeblack
Hawaiian damselfly
Megalagrion xanthomelas

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion xanthomelas* (Selys-Longchamps, 1876) is a small, relatively slender damselfly. Males are red on the head, thorax, and tip of the abdomen, and black across most of the abdomen; females are patterned similarly but with pale brown instead of red. Adults are found around standing pools or slow-moving stream sections that serve as breeding sites, usually not straying far from the breeding habitat. It occurs primarily in lowland areas and is one of the most adaptable native damselflies, capable of breeding in brackish anchialine ponds, basal spring wetlands, pools in slow-moving streams, and artificial water bodies.

DISTRIBUTION: The most widely distributed species of native damselfly, *M. xanthomelas* has been documented from all the main islands except Kahoʻolawe. However, it has apparently been extirpated from Kauaʻi and Lānaʻi (the Niʻihau population is unknown). On Oʻahu it was formerly widespread, including in basal spring wetlands around Pearl Harbor and the vicinity of Honolulu, but the alteration of wetlands and near-ubiquitous presence of alien fish and frogs reduced them to a single small population on the grounds of Tripler Army Medical Center. This population appears to have been extirpated, with the last sighting in April 2023, and the Oʻahu population currently exists only in captivity and at reintroduction sites. There are a few small, widely scattered populations on West and East Maui. Molokaʻi and Hawaiʻi have several significant populations, dwelling in both streams and anchialine ponds near the coast. In November 2019, surveys of previously known populations on Lānaʻi failed to locate any extant populations. Most of the locations had been infested with mosquito fish. As of 2024, plans are underway to attempt reintroduction of the species to Lānaʻi.

ABUNDANCE: Unknown. The Molokaʻi and Hawaiʻi populations are thought to be relatively large, though the anchialine ponds on the Kona coast of Hawaiʻi are under threat from development, pollution, and introduction of fish. Maui populations are relatively small and fragmented. The Oʻahu wild population is extremely small and vulnerable to extirpation.

LOCATION AND CONDITION OF KEY HABITAT: The naiads inhabit still pools and slow-flowing sections of streams. Unlike most other species that occur in similar habitat, *M. xanthomelas* can live in many types of this form of water body, provided introduced fish and frogs are absent. As a result, they have persisted in what would be considered degraded sites, including drainage ditches, leaking pipes, and golf course water hazards.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by development, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. For *Megalagrion xanthomelas* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Continue captive rearing to maintain rare populations.
- Continue reintroduction efforts to expand its range.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends. Regularly monitor any reintroduction sites.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

Polhemus, D.A., W. Haines, and K. Bustamente. 2020. Field survey report: Lanai inland waters assessment, native damselfly baseline survey- Endangered Species Act. 36 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.

U.S. Fish and Wildlife Service. 2021. Orangeblack Hawaiian Damselfly (*Megalagrion xanthomelas*) 5-Year Review Summary and Evaluation https://ecos.fws.gov/docs/tess/species_nonpublish/3400.pdf (accessed 17 Dec 2024).

Prognathogryllus sp.

Terrestrial Invertebrates

Crickets and Katydids
Order Orthoptera

ORDER INCLUDES:
3 Native Families
10 Native Genera
269 Native Species

268 Endemic Species

GENERAL INFORMATION: Crickets and katydids are well-known because of their jumping and singing abilities. In general, members of the order are herbivores, but many species are omnivores. Some of the best examples of cryptic coloration and mimicry are found in this group, with some species being shaped like leaves or colored to match their background. The number of endemic Hawaiian cricket species is twice the number known from the entire continental United States, yet only four of the major Orthopteran groups (tree crickets, sword-tail crickets, katydids, and grasshoppers) are represented. The largest number of endemic species by far is found in the sword-tail crickets, Trigonidiidae, primarily the genera *Nudilla* (formerly *Laupala*, 37 species) and *Zudella* (formerly *Paratrigonidium*, 133 species). They are often abundant in forests, sometimes even in disturbed areas, and species are difficult to distinguish. Unlike most crickets, many species sing during the day. Another genus, *Caconemobius* (~13 species) consists of species found in rocky areas including shorelines, cliffs, lava flows, and caves. The cave species are very variable and probably in the process of speciating.

The tree crickets (Oecanthidae) are divided into two major groups: *Prognathogryllus* (37 species) are large, robust, and sing, while *Leptogryllus* (28 species) and *Thaumatogryllus* (5 species) are more slender with tiny wings, courting via scent instead of singing. Because they live higher in trees, they are much more often heard than seen. Katydids (Tettigoniidae) are represented by a single small radiation, the endemic flightless genus *Banza* (11 species), as well as the enigmatic long-winged *Conocephaloides remotus*. The latter is known from only six specimens, the last from 1941, and is likely extinct.

DISTRIBUTION: Crickets and katydids are known from all the MHI except for Niʻihau. There are also two species endemic to Nihoa in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Tree crickets are difficult to survey due to their habit of staying close to the canopy, and others tend to be cryptic and difficult to catch despite their songs. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Crickets and katydids occur in a wide range of habitats including mesic and wet forests, rocky shores and lava flows, and caves. Cave habitats are highly sensitive to disturbance and changes in temperature and humidity, and are

dependent on tree roots growing through the roof of the cave. A number of introduced crickets inhabiting forests, lava flows, and shorelines have arrived in recent decades.

THREATS:

- Loss or degradation of habitat.
- Non-native invasive predators, parasitoids, and competing cricket species.
- Habitat-modifying non-native plants.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward crickets and katydids should include:

- Conduct surveys to determine distribution of known crickets and katydids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Determine monitoring methods for assessing taxa not amenable to standard methods.
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to determine the effects of non-native predators and parasitoids on species.
- Conduct systematic and taxonomic assessments of poorly known taxa.
- Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Otte D. 1994. The Crickets of Hawaii. Philadelphia: Orthopterists' Society.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2, Apterygota to Thysanoptera Inclusive. Honolulu: University of Hawaii Press.

Terrestrial Invertebrates

Harrisoniella densa. Photo: Liliana Tobar.

Lice
Order Phthiraptera

ORDER INCLUDES:
2 Native Families
25 Native Genera
57 Native Species
5 Endemic Species

GENERAL INFORMATION: Lice are wingless external parasites of birds or mammals. Unlike other parasites, lice cannot live long if removed from their host. Eggs or nits are glued directly to the feathers or hair of hosts. Most lice rely on a single species to serve as a host. Lice are poorly known in Hawai‘i.

DISTRIBUTION: Lice are known from the islands of Hawai‘i, Maui, and O‘ahu, as well as the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Poorly understood. However, since Hawaiian lice are typically bird parasites, those habitats that support healthy populations of various bird species should support lice populations.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward lice should include:
- Conduct surveys to determine the distribution and abundance of known lice and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Kilauella sp. Photo: Brendan Wang.

Terrestrial Invertebrates

Bark lice
Order Psocoptera

ORDER INCLUDES:
6 Native Families
7 Native Genera
>93 Native Species
>90 Endemic Species

GENERAL INFORMATION: Most bark lice are scavengers or feed on lichen found on woody vegetation. Bark lice are an important food source for native birds and other insectivores. The largest number of endemic species occurs within the genera *Ptycta*, *Palistreptus*, and *Kilauella*. The first two genera have been revised and contain 60 and 20 taxa respectively; however *Kilauella* is still largely unknown, and a large number of undescribed species are present.

DISTRIBUTION: Bark lice are known from all the MHI except for Niʻihau and Kahoʻolawe. One unusual species is only known from Laysan in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Found mostly on woody vegetation. They are more abundant in some locations than others, but the habitat requirements of the native taxa are poorly studied.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward bark lice and psocids should include:
- Conduct surveys to determine the distribution and abundance of known bark lice and psocids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Thornton IWB. 1981. The Psocoptera of the Hawaiian Islands. Parts I and II, Introduction and the nonendemic fauna. Pacific Insects 23(1–2):1–49.

Thornton IWB. 1985. The Psocoptera of the Hawaiian Islands. Part III The endemic Ptycta complex (Psocidae): Systematics, distribution, and evolution. International Journal of Entomology 26(1–2):1–128.

Thornton IWB. 1990. The Psocoptera of the Hawaiian Islands. Part IV. The endemic genus *Palistreptus* (Elipsocidae): systematics, distribution, and evolution. Bishop Museum Bulletins in Entomology 4:1–57.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Photo not available

Terrestrial Invertebrates

Fleas
Order Siphonaptera

ORDER INCLUDES:
1 Native Family
1 Native Genus
1 Native Species
1 Endemic Species

GENERAL INFORMATION: Fleas are typically parasites feeding on the blood of their vertebrate hosts. Larvae are free-living and feed on organic matter. One native species is known in the Hawaiian Islands. *Parapsyllus laysanensis*, a seabird parasite, was described from Laysan albatross nest material and has also been found in wedge-tailed shearwater nests. This order is poorly known in Hawai‘i.

DISTRIBUTION: Hawai‘i’s single native species of flea is known only from Laysan Island in NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. However, habitats supporting breeding colonies of seabirds are likely key to this species’ survival.

THREATS:
- Loss of hosts and degradation of habitat for host species.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Parapsyllus laysanensis* should include:
- Conduct surveys to determine distribution of known *P. laysanensis* populations and to document and identify new species of Siphonaptera.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:
- Conduct studies to document the biology, habitat requirements, and life history of this endemic species.

References:
Davies RG. 1988. Outlines of entomology. New York, (NY): Chapman and Hall. 408 pp.

Haas GE, Wilson N, Tomich PQ. 1972. Ectoparasites of the Hawaiian Islands, I. Siphonaptera. Contributions of the American Entomological Institute 8(5): 1-76.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Neurisothrips saki. Photo: S. Chun.

Terrestrial Invertebrates

Thrips
Order Thysanoptera

ORDER INCLUDES:
2 Native Families
~7 Native Genera
3 Endemic Genera
~26 Native Species
~21 Endemic Species

GENERAL INFORMATION: Thrips are herbivorous, fungivorous, or predaceous, preying on insects and mites. Most species in Hawai‘i are herbivores, feeding on the tissues of living plants, however, understanding true reproductive host plants of species is very difficult. Some species are parthenogenic, capable of producing young without mating. Metamorphosis is intermediate and thrips rarely exceed four millimeters (0.2 inches). Some thrips are gregarious and found in large colonies. This order is poorly known and understudied in Hawai‘i. The genus *Neurisothrips*, with 14 species, is the only endemic thrips genus in Hawai‘i that has significantly radiated. Seven other genera in the family Phlaeothripidae have between one and five species considered to be native, but their true status is unclear and they may be introduced species that are unrecognized in their native range.

DISTRIBUTION: Thrips are recorded from all the MHI except for Ni‘ihau and Kaho‘olawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining. Several native species have not been collected since their original description decades ago.

LOCATION AND CONDITION OF KEY HABITAT: Thrips occur in a variety of habitats ranging from dry, lowland areas to wet, high-elevation forests. Fungivores are more likely to occur in wetter habitats. Individuals are often found in flowers, on branches, on leaves, under bark, in leaf litter, and in other well-protected locations.

THREATS:
- Loss or degradation of habitat.
- Loss of host-specific plants.
- Predation or parasitism.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward thrips should include:
- Conduct surveys to determine the distribution and abundance of known thrips and to document and identify new species.

- Control of invasive predators, such as ants.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct systematic and taxonomic assessments of poor known and understudied taxa; review and revise taxa in need of scrutiny.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of natural enemies on native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Mound L, Nakahara S, Tsuda DM. 2017. Thysanoptera-Terebrantia of the Hawaiian Islands: an identification manual. ZooKeys 549:71-126.

Mound LA. 2020. Diversity in the Hawaiian endemic genus *Neurisothrips* (Thysanoptera, Thripidae). Zootaxa 4779(2):215-229.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2. Honolulu: University of Hawaii Press. 475 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.

Photo: Gordon Smith, USFWS

Terrestrial Invertebrates

Kaua‘i Cave Arthropods
Adelocosa anops
(Kaua‘i Cave Wolf Spider)

Spelaeorchestia koloana
(Kaua‘i Cave Amphipod)

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
NatureServe Heritage Rank G1 - Critically imperiled
Draft Recovery Plan for the Kaua‘i Cave Arthropods: the Kaua‘i Cave Wolf Spider *Adelocosa anops*) and the Kaua‘i Cave Amphipod (*Spelaeorchestia koloana*) – USFWS 2004
Final Rule: Designation of Critical Habitat for the Kaua‘i Cave Wolf Spider and Kaua‘i Cave Amphipod Critical Habitat – USFWS 2003

SPECIES INFORMATION: Both the Kaua‘i cave wolf spider and the Kaua‘i cave amphipod were discovered in 1971, and both are known from less than a dozen caves on the island of Kaua‘i. Although a few wolf spider species (order Araneae, family Lycosidae) have reduced eyes, the Kaua‘i cave wolf spider has completely lost all vestiges of eyes; this trait justifies the species placement in the monotypic genus *Adelocosa*. Adult spiders are between 12 and 19 millimeters (0.5 to 0.75 inches) in length and are overall reddish brown in color. The species’ life history is poorly known. Like all spiders, the Kaua‘i cave wolf spider is a predator and actively stalks its prey using its sense of touch or chemoreceptors. The species likely feeds on the Kaua‘i cave amphipod and non-native arthropods. Unlike other wolf spiders, the fecundity of the Kaua‘i cave wolf spider is low.

Compared to other terrestrial amphipods (order Amphipoda, family Talitridae), the Kaua‘i cave amphipod has unusual morphological attributes which justifies its placement in the monotypic genus *Spelaeorchestia*. Like the Kaua‘i cave wolf spider, the Kaua‘i cave amphipod is blind, although it does possess eyes. Adults are seven to ten millimeters (0.25 to 0.4 inches) in length and have a translucent appearance. The species is a detritivore and has been observed feeding on rotting roots, plant material washed into the caves, and frass (i.e., arthropod fecal material). Little is definitively known about the species’ life history.

DISTRIBUTION: Found only on Kaua‘i. Both are restricted to caves found in a 10.5 square kilometer (four square mile) lava flow. The Kaua‘i cave wolf spider has been documented in six caves, but only regularly observed in one. The Kaua‘i cave amphipod has been documented in nine caves, but only regularly observed in two. The amphipod also occurs in a limestone cave formed on top of the lava flow.

ABUNDANCE: Unknown. Currently, no survey methods exist to accurately estimate the population of either species. However, counts have never documented more than 30 spiders or 80 amphipods.

LOCATION AND CONDITION OF KEY HABITAT: Caves in a single exposed lava flow in the Koloa Basin with very rocky to extremely rocky soils, and free from erosional sediments. Both species are restricted to dark, moist areas of larger caverns and smaller subterranean spaces. The latter may be the primary habitat for both the spider and amphipod. Both species appear to require very high humidity.

THREATS:

- All the land supporting these species is privately owned. Activities associated with development and agriculture (e.g., removal of native vegetation, filling, and grading) degrade the delicate environments supporting the Kaua‘i cave wolf spider and Kaua‘i cave amphipod. Removal of vegetation results in a reduction of organic material that the amphipod feeds on and affects the humidity levels in the caves. Filling and grading increase the rate at which sediments fill the caves.
- Non-native competitors and predators.
- Droughts could alter the high-humidity environment that is required by the species and that also limits the establishment of non-native cave fauna.
- Human disturbance or visitation to the caves and the use of pesticides are serious threats to both species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. Both species were listed as endangered in 2000. In 2003, the USFWS designated 106 hectares (272 acres) as critical habitat for both species. In addition to common statewide and island conservation actions, specific management directed toward Kaua‘i cave arthropods should include:

- Protect habitat from further loss or degradation, including above-cave habitats.
- Habitat enhancement or restoration including outplanting with native species to stabilize cave environments and increase food resources for cave fauna.
- Prevent the establishment of additional non-native invertebrate species and control existing non-native species that potentially limit cave arthropod populations.
- Conduct public outreach to increase public understanding of and support for both species.

MONITORING:

- Continue monitoring the status of known populations to better understand the abundance and distribution of both species.

RESEARCH PRIORITIES:

- Develop methods to survey populations that are accurate and minimize damage to fragile cave environments.
- Conduct surveys or initiate studies to determine local population sizes and movements of individuals.
- Identify additional populations of both species.

- Conduct studies to determine the most appropriate plants to restore above-cave habitats.
- Conduct studies to determine the factors that regulate cave humidity levels and how variation in humidity affects both species.
- Assess the feasibility of translocating individuals to suitable, but unoccupied caves.

References:

U.S. Fish and Wildlife Service. 2003. Final Rule: designation of Critical Habitat for the Kauai cave wolf spider and Kauai cave amphipod. Federal Register 68(68): 17430–17470.

U.S. Fish and Wildlife Service. 2004. Draft recovery plan for the Kauaʻi cave arthropods: the Kauaʻi cave wolf spider (*Adelocosa anops*) and the Kauaʻi cave amphipod *(Spelaeorchestia koloana*). Portland, (OR): U.S. Fish and Wildlife Service. 55 pp.

Ligia hawaiiensis

Terrestrial Invertebrates

Pillbugs, Sowbugs, Woodlice, Isopods
Order Isopoda

ORDER INCLUDES:
5 Native Families
10 Native Genera
25 Native Species
24 Endemic Species

GENERAL INFORMATION: Pillbugs, sowbugs, woodlice, and isopods have a variety of feeding habits. They can be carnivores, herbivores, or scavengers. Females carry eggs until they hatch, and larvae are not pelagic. This order is poorly understood in Hawai‘i.

DISTRIBUTION: Pillbugs, sowbugs, woodlice, and isopods occur on all the MHI with the exception of Ni‘ihau, and on all the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial members of this order occupy a wide range of habitats including marine littoral zones, rain forests, and caves.

THREATS:
- Competition from non-native species.
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pillbugs, sowbugs, woodlice, and isopods should include:
- Conduct surveys to determine the distribution and abundance of known isopods and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Brusca R. 1997. Tree of life project [Internet]. Available at: http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida.

Terrestrial Invertebrates

Cave Lithobiomorpha (undetermined species).
Photo: Mike Slay/TNC

Centipedes
Order Geophilomorpha
Order Lithobimorpha

ORDERS INCLUDE:
5 Native Families
10 Native Genera
~9 Native Species
~8 Endemic Species

GENERAL INFORMATION: Centipedes (Class Chilopoda) have elongated and segmented bodies. Worldwide, there are five divergent orders of centipedes; only two occur in Hawai‘i (Geophilomorpha and Lithobimorpha). Species in the order Geophilomorpha hatch with the full complement of adult legs and segments (i.e., epimorphic growth), females care for eggs and young, and individuals move very slowly. In contrast, species in the order Lithobiomorpha obtain additional segments and legs with each molt (i.e., anamorphic growth), females do not care for eggs or young, and individuals move very rapidly. Both orders are poorly understood in Hawai‘i. While around eight species considered possibly endemic to Hawai‘i, at least four have questionable origins and may be indigenous or possibly even adventive.

DISTRIBUTION: Centipedes are known from Kaua‘i, O‘ahu, Moloka‘i, Maui, and the island of Hawai‘i as well as the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the orders are declining.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. However, centipedes occur in diverse Hawaiian habitats from lava tubes to the summit of Maunakea.

THREATS:
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward centipedes should include:
- Conduct surveys to determine the distribution and abundance of known centipedes and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Bonato L, Foddai D, Minelli JA. 2004. The centipede order Geophilomorpha in the Hawaiian Islands (Chilopoda). Bishop Museum Occasional Papers 78: 13-32.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Shelley RM. 1999. Centipedes and millipedes with emphasis on North America fauna. The Kansas School Naturalist 45(3). Available at: http://www.emporia.edu/ksn/v45n3-march1999/intro.htm.

Nannolene sp. (undescribed). Photo: Mike Slay

Terrestrial Invertebrates

Millipedes

Orders Polyxenida, Spirostreptida

ORDER INCLUDES:
2 Native Families
2 Native Genera
>16 Native Species
>16 Endemic Species

GENERAL INFORMATION: Most millipedes (Class Diplopoda) are detritivores (i.e., feeding on decaying organic material) and play a role in breaking down decaying plant material. A few species are carnivorous, and a few others eat moist, living plant material. Millipedes hatch from eggs and molt as they grow, obtaining more segments and legs with each molt (i.e., anamorphic growth). Millipedes do not bite, but many will emit poisonous or foul-smelling substances to deter predators. Of the 15 orders of millipedes found worldwide, only two are found in Hawai‘i, and both are poorly known.

DISTRIBUTION: Millipedes are known from all the MHI except for Ni‘ihau. An undescribed cave-adapted species has been found in lava tubes on Hawai‘i.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the orders are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mostly unknown. Several blind species inhabit caves. Other species occur along shorelines.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward millipedes should include:

- Conduct surveys to determine distribution of known millipedes and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Shelley RM. 1999. Centipedes and millipedes with emphasis on North America fauna. The Kansas School Naturalist 45(3).

PLANTS

SPECIES OF GREATEST CONSERVATION NEED
WORKHORSE SPECIES and IMPORTANT INTERACTIONS

SPECIES INFORMATION: The plant species listed below are important components of the native plant communities that provide habitat for native wildlife. They are also important plant species for post-fire rehabilitation, ecosystem restoration, pollinator habitat, and coastal hardening.

DISTRIBUTION: These species are indigenous or endemic to Hawai‘i and have broad distributions across the state and throughout most ecosystems from sea level to sub-alpine habitats.

ABUNDANCE: These plant species are relatively abundant compared to rare species. They are not listed as Threatened or Endangered and are not targets for the Plant Extinction Prevention Program. Instead, they are important foundations for plant communities and are moderately abundant. Some taxa are locally-abundant in remnant native habitat, but otherwise absent from developed and degraded areas.

THREATS:

- Browsing and habitat destruction by feral animals;
- Herbivory and/or seed predation by small vertebrate pests;
- Competition from invasive non-native plants;
- Landslides, hurricanes, wildfire, or other geologic events;
- Human disturbance;
- Disease;
- Damaging herbivory by invasive non-native invertebrate pests;
- Loss of native pollinators or other mutualists;

CONSERVATION ACTIONS:

- Monitor known locations for population trends, phenology, and threats;
- Protect important populations on each island from ongoing threats;
- Establish secure *ex-situ* collections to provide adequate and appropriate plant materials for restoration projects and post-fire rehabilitation;
- Create seed source orchards where seeds and other propagules can be harvested and stored in bulk to furnish restoration and reforestation projects statewide.

RESEARCH PRIORITIES:

- Determine causes of decline in abundance and/or distribution;
- Develop proper horticultural protocols and pest management;
- Determine optimal *ex situ* storage methods;

- Conduct pollination biology and seed dispersal studies;
- Develop adequate threat control strategies and technology;
- Map genetic diversity to guide future reintroduction and augmentation efforts;
- Identify optimal translocation sites in protected habitat.

REFERENCES:

Wagner, W.L., Herbst, D.R., and Sohmer, S.H. 1999. Manual of the Flowering Plants of Hawai′i-Revised Edition. Honolulu, HI: University of Hawaii Press and Bishop Museum Press. 1853p.

Wagner, W. L., D. R. Herbst, and D. H. Lorence. 2024. Flora of the Hawaiian Islands website. https://naturalhistory2.si.edu/botany/hawaiianflora/index.htm.

Abutilon incanum
Acacia koa
Acacia koaia
Achyranthes splendens var. splendens
Alphitonia ponderosa
Alyxia stellata
Antidesma platyphyllum var. platyphyllum
Antidesma pulvinatum
Argemone glauca var. glauca
Astelia menziesiana
Athyrium microphyllum
Bacopa monnieri
Bidens spp.
Bobea brevipes
Bobea elatior
Boehmeria grandis
Bolboschoenus maritimus
Canavalia hawaiiensis
Capparis sandwichiana
Carex alligata
Carex meyenii
Carex wahuensis subsp. herbstii
Carex wahuensis subsp. wahuensis
Ceodes brunoniana
Ceodes umbellifera
Charpentiera obovata
Charpentiera spp.
Cheirodendron platyphyllum
Cheirodendron trigynum
Chenopodium oahuense
Cibotium chamissoi
Cibotium glaucum
Cibotium menziesii
Cibotium nealiae
Cladium jamaicense
Claoxylon sandwicense
Clermontia clermontioides
Clermontia fauriei
Clermontia spp.
Coleus australis
Coprosma elliptica
Coprosma ernodeoides
Coprosma foliosa
Coprosma kauensis
Coprosma menziesii
Coprosma montana
Coprosma ochracea
Coprosma pubens
Coprosma rhynchocarpa
Coprosma spp.
Cordia subcordata
Cryptocarya mannii
Cyanea spp.
Cyclosorus interruptus
Cyperus laevigatus
Cyperus polystachyos
Cyrtandra halawensis
Cyrtandra spp.
Deschampsia nubigena
Dianella sandwicensis
Dicranopteris linearis
Diospyros hillebrandii
Diospyros sandwicensis
Diplazium sanwichiananum
Dodonaea viscosa
Dracaena aurea
Dryopteris spp.
Dryopteris tetrapinnata
Dubautia arborea
Dubautia paleata
Dubautia raillardioides
Dubautia spp.
Elaeocarpus bifidus
Elaphoglossum spp.
Eragrostis grandis
Eragrostis monticola
Eragrostis variabilis
Erythrina sandwicensis
Euphorbia olowaluana
Euphorbia spp.
Freycinetia arborea
Gahnia lanaiensis
Geranium tridens
Gossypium tomentosum
Heliotropium anomalum var. argenteum
Heliotropium curassavicum
Heteropogon contortus
Hibiscus arnottianus subsp. arnottianus
Hibiscus kokio subsp. kokio
Hibiscus kokio subsp. saintjohnianus
Hibiscus tiliaceus
Hydrangea arguta
Ilex anomala
Ipomoea indica
Isachne distichophylla
Jacquemontia sandwicensis
Kadua affinis
Labordia waialaeale
Leptecophylla tameiameiae
Lepturus repens
Lipochaeta spp.
Lobelia spp.
Lysimachia spp.
Machaerina angustifolia
Melicope anisata
Melicope clusiifolia
Melicope cruciata
Melicope macropus
Melicope spp.
Metrosideros macropus
Metrosideros polymorpha
Metrosideros rugosa
Metrosideros tremuloides
Metrosideros waialealae
Myoporum sandwicense subsp. lanaiense
Myoporum sandwicense subsp. sandwicense
Myoporum stellatum
Myrsine lessertiana
Myrsine sandwicensis
Myrsine spp.
Nama sandwicensis
Notelaea sandwicensis
Nothocestrum longifolium
Nothocestrum spp.
Nototrichium sandwicense
Oreobolus furcatus
Osteomeles anthyllidifolia
Pandanus tectorius
Panicum spp.
Paratrophis pendulina
Perrottetia sandwicensis

Pipturus albidus
Pittosporum hosmeri
Pittosporum spp.
Pittosporum terminalioides
Planchonella spathulata
Plumbago zeylanica
Polyscias hawaiensis
Polyscias sandwicensis
Polyscias spp.
Pritchardia beccarriana
Psychotria spp.
Psydrax odorata
Pyschotria hawaiiensis
Racomitrium lanuginosum
Rauvolfia sandwicensis
Rhynchospora chinensis subsp. spiciformis
Rockia sandwicensis
Rubus hawaiensis
Rumex giganteus
Sadleria cyatheoides
Santalum ellipticum
Santalum freycinetianum
Sapindus oahuensis
Sapindus saponaria
Scaevola glabra
Scaevola procera
Scaevola spp.
Scaevola taccada
Schoenoplectus tabernaemontani
Senna gaudichaudiana
Sesuvium portulacastrum
Sida fallax
Sideroxylon polynesicum
Smilax melastomifolia
Solanum americanum
Sophora chrysophylla
Sporobolus virginicus
Stenogyne macrantha
Stenogyne purpurea
Stenogyne rugosa
Stenogyne scrophularioides
Syzygium sandwicensis
Touchardia latifolia
Touchardia sandwicensis
Vaccinium calycinum
Vaccinium dentatum
Vaccinium reticulatum
Vigna marina
Vitex rotundifolia
Waltheria indica
Wikstroemia monticola
Wikstroemia oahuensis
Wikstroemia oahuensis
Wikstroemia phillyreifolia
Wikstroemia sanwicensis
Wilkesia gymnoxiphium
Xylosma hawaiiense
Zanthoxylum kauaense

SPECIES OF GREATEST CONSERVATION NEED PLANT EXTINCTION PREVENTION PROGRAM TARGETS

SPECIES INFORMATION: The plant species listed below have fewer than fifty individuals remaining in the wild and are targets for the Hawai'i Plant Extinction Prevention Program (PEPP). Although they are critically rare and on the verge of extinction, they are not yet listed as Threatened or Endangered by the U.S. Fish and Wildlife Service or the State of Hawai'i. Five of the taxa on the PEPP list are still under investigation and have not yet described (Lysimachia sp. nov. (Wainiha, Kauai), Lysimachia sp. nov. (Pohakea, Kauai), Myrsine sp. nov. (Kauai), Polysicas sp. nov. (Koiae, Kauai), Tetramolopium sp. nov. 2 (Mauna Kahalawai)). The following threats, conservation actions, research priorities apply to all species on the list.

THREATS:

- Browsing and habitat destruction by feral animals;
- Herbivory and/or seed predation by small vertebrate pests;
- Competition from invasive non-native plants;
- Landslides, hurricanes, wildfire, or other geologic events;
- Human disturbance;
- Disease;
- Damaging herbivory by invasive non-native invertebrate pests;
- Loss of native pollinators or other mutualists;

CONSERVATION ACTIONS:

- Monitor known locations for population trends, phenology, and threats;
- Protect important populations on each island from ongoing threats;
- Establish secure *ex-situ* collections to provide adequate and appropriate plant materials for restoration projects and post-fire rehabilitation;
- Create seed source orchards where seeds and other propagules can be harvested and stored in bulk to furnish restoration and reforestation projects statewide.

RESEARCH PRIORITIES:

- Determine causes of decline in abundance and/or distribution;
- Develop proper horticultural protocols and pest management;
- Determine optimal *ex situ* storage methods;
- Conduct pollination biology and seed dispersal studies;
- Develop adequate threat control strategies and technology;
- Map genetic diversity to guide future reintroduction and augmentation efforts;

- Identify optimal translocation sites in protected habitat.

REFERENCES:

Wagner, W.L., Herbst, D.R., and Sohmer, S.H. 1999. Manual of the Flowering Plants of Hawai′i-Revised Edition. Honolulu, HI: University of Hawaii Press and Bishop Museum Press. 1853p.

Wagner, W. L., D. R. Herbst, and D. H. Lorence. 2024. Flora of the Hawaiian Islands website. https://naturalhistory2.si.edu/botany/hawaiianflora/index.htm.

PEPP Target Taxon Name
Argyroxiphium virescens
Charpentiera ovata var. niuensis
Clermontia grandiflora subsp. maxima
Coprosma kawaikiniensis
Cryptocarya oahuensis
Cyanea hardyi
Cyanea heluensis
Cyanea konahuanuiensis
Cyperus prescottianus
Cyrtandra kohalae
Euphorbia arnottiana
Euphorbia remyi var. hanaleiensis
Hibiscadelphus stellatus
Lipochaeta populifolia
Lobelia dunbariae subsp. dunbariae
Lysimachia ovoidea
Lysimachia sp. nov. (Pohakea, Kauai)
Lysimachia sp. nov. (Wainiha, Kauai)
Melicope nealae
Melicope oppenheimeri
Melicope stoneii
Melicope wailauensis
Myoporum degeneri
Myrsine sp. nov. (Kauai)
Neraudia kauaiensis
Peperomia degeneri
Phyllostegia electra
Phyllostegia glabra var. glabra
Phyllostegia macrophylla
Polysicas sp. nov. (Koiae, Kauai)
Portulaca molokiniensis
Pritchardia gordonii
Scaevola hobdyi
Schiedea haakoaensis
Schiedea pentandra
Sicyos hillebrandii
Stenogyne calycosa
Stenogyne kaalae subsp. kaalae
Tetramolopium sp. nov. 2 (Mauna Kahalawai)
Tetramolopium stemmermanniae
Viola kauaensis var. hosakae

Freshwater Fishes

‘O‘opu ‘akupa
Sandwich Island sleeper
Eleotris sandwicensis

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: ‘O‘opu ‘akupa or Sandwich Island sleeper (*Eleotris sandwicensis)* is an amphidromous fish species that inhabits freshwater streams. It has a robust body, a blunt head, and a grayish-brown coloration with dark bands. Juveniles migrate from marine to freshwater environments during their life cycle. It is Hawai‘i’s only endemic eleotrid. Adult ‘o‘opu ‘akupa are ambush predators that feed on a variety of invertebrates and fishes, including other native adult and post-larval gobies and some exotic fishes. One study shows that they are also opportunistic feeders. It can grow to 33 centimeters (13 inches) in length. Unlike Hawai‘i’s native gobies, its pelvic fins are not fused into a disc. Without this sucking disc, they are unable to hold on to substrates and are not good climbers. Spawning occurs in freshwater; nests are made in crevices at the stream bottom. Eggs hatch within a day and are washed to the sea where they spend a few months as oceanic plankton. Post-larvae, or hinana, recruit to streams indiscriminately, and they depend on waves and currents to bring them inshore. This recruitment occurs year round but is most prevalent in the spring and usually takes place during nighttime hours. ‘O‘opu ‘akupa usually stay hidden, but can be seen darting and diving into leaf litter or mud or searching for shelter in rocks. There are two head morphs of the species.

DISTRIBUTION: Endemic to the Hawaiian Islands.Historically, ‘o‘opu ‘akupa were found on all the Main Hawaiian Islands in streams and estuaries across most of the main Hawaiian Islands.Today, they also are found on all the Main Hawaiian Islands in the lower reaches of streams and in estuaries below all man-made obstructions. Post-larvae are found in oceanic waters, but little is known of its oceanic distribution, but post-larvae do not show natal stream fidelity.

ABUNDANCE: Most common on O‘ahu. One study shows that ‘o‘opu ‘akupa are present in Pelekunu stream but rare in Waikolu stream, which are adjacent streams on Moloka‘i. ‘O‘opu ‘akupa populations are stable in both altered and unaltered streams. Observed in low densities in suitable stream habitats.

LOCATION AND CONDITION OF KEY HABITAT: ‘O‘opu ‘akupa are found only in estuaries and the lower reaches of streams preferring slow-moving pools and deeper sections of streams with clean, oxygen-rich water.Juveniles rely on estuarine environments for early development before migrating upstream.Their feeding habitat is primarily on the bottom of these streams and estuaries. Although they prefer clear, cool streams like the other gobies, they are better adapted than most gobies to live in degraded habitat. They can often be found living

in cans and other trash items at the bottom of streams. Condition of key habitat varies depending on whether streams flow through protected or forested areas versus urban areas, but ʻoʻopu ʻakupa populations are stable in both altered and unaltered streams. For specific information on stream biota, the Division of Aquatic Resources of the Department of Land and Natural Resources has a database of surveyed streams. Oceanic waters are important to the survival of post-larvae, but little is known of its oceanic distribution or habitat requirements.

THREATS:

- Habitat degradation: Resulting from water diversion, stream channelization, dams, pollution, the introduction of exotic species and parasites, and climate change. Water diversion, stream channelization, and dams result in habitat degradation through altered stream flows, which also causes a loss of riparian vegetation, shelter and erosion control; higher water temperatures; and lower dissolved oxygen levels. Because of their higher tolerance to stress, ʻoʻopu ʻakupa are not as threatened by altered streams as other Hawaiian gobies. However, reduced water flows can still limit larvae from reaching the ocean and recruitment back into streams;
- Non-point source water pollution: Including nutrients, sedimentation, and chemicals may threaten ʻoʻopu ʻakupa; however, the consequence of these pollutants is relatively unknown and needs to be further studied;
- Introduction of exotic species, diseases and parasites: such as tilapia are significant threats to ʻoʻopu ʻakupa. Historical introductions of game fish and more recent unwanted exotic fish from the aquarium trade are both problems. These exotic fish species prey on native fish, they compete native fish for food, and spread parasites and diseases;
- Fishing: for ʻoʻopu ʻakupa occurs today and it is used as bait. In conjunction with the above threats, overfishing could become a threat in the future.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Past actions to restore fish populations have consisted of a ban on gill, drag, draw, and seine netting; stream clean-up efforts, and public outreach. In addition to common state-wide and island conservation actions, specific actions include:

- Improve altered or diverted streams;
- Modify or remove gratings or diversions to allow for instream passage of fish;
- Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
- Remove alien species;
- Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Work to clean streams with significant pollution;
- Continue developing GIS database and making it web-accessible;
- Use science-based management of recreational fishing;
- Increase education and outreach efforts, particularly on issues of fishing related life history, water pollution, and how to deal with unwanted aquarium pets;
- Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships.

MONITORING:

- Monitor number of returning hinana
- Population Surveys: Regular assessments of population density and distribution. Monitor the number of fish taken in recreational fishing each year. Monitor number of returning hinana.
- RESEARCH PRIORITIES:Stream Health: Monitoring water quality and habitat conditions.
- Juvenile Recruitment: Tracking migration and survival rates of juveniles.
- Threat Impact Studies: Evaluating the effects of habitat loss, pollution, and invasive species.

RESEARCH PRIORITIES:

- Population Dynamics: Understanding life history, reproduction, and population trends. Initiate research to study source-sink population structure.
- Habitat Connectivity: Studying migration pathways and barriers to upstream movement.Better understand the role of estuaries in species ecology.Continue researching effects of stream channelization and diversion-specifically how this goby is able to have high numbers in altered streams.
- Impact of Climate Change: Assessing how changing environmental conditions affect the species.
- Invasive Species Interaction: Investigating competitive and predatory effects on native populations. Research impacts and methodologies to deal with alien species.
- Conservation Effectiveness: Evaluating the success of restoration and protection measures. Research effect of fishing on total population size and distribution.

CULTURAL INFORMATION:

- Other historical names of the ʻOʻopu ʻakupa also include ʻoau, ʻōkuhe, ʻapohā, and kuhe. Called ʻoau on Oʻahu and Maui. Called ʻōkuhe on Kauaʻi. The name ʻōkuhekuhe is defined as a young ʻōkuhe, after the hinana stage.
- Hawaiians believed that the ʻoʻopu belonged to the great moʻo family. To anyone who had a moʻo, or lizard, as an ʻaumakua, or family god or guardian, the eating of the ʻoʻopu was kapu, or taboo. The markings of this species in particular resemble those of the lizard and it is probably for this reason that the Hawaiians were especially averse to eating this species, owing to the awe and fearful reverence with which they regard the moʻo family.
- This ʻoʻopu is known for its very aggressive nature and will eat anything smaller than itself, including other ʻoʻopu.
- An ʻōlelo noʻeau, or Hawaiian proverb, that pertains to this ʻoʻopu says: "He ʻoʻopu ʻapohā". A black, large-mouthed goby fish. [A term of derision for a very dark-skinned person.]
- An article from a Hawaiian newspaper, *Ko Hawaiʻi Pae ʻĀina*, May 4, 1878 that mentions this ʻoʻopu says: "he lawaiʻa no ke kai pāpaʻu, he haʻilima ka loa o kāna wahi aho, a he paoʻo a he ʻōkuhe ka iʻa e loaʻa iā ia", a fisherman of the shallow, with his fishing line the length of a haʻilima (a Hawaiian measurement, from the elbow to the fingertips), will catch the paoʻo and ʻōkuhe fish.

References:

Brasher AM. 1997. Habitat use by fish (‘o‘opu), snails (hihiwai), shrimp (‘opae) and prawns in two streams on the island of Moloka`i. Technical Report. Honolulu HI: Cooperative National Park Resources Studies Unit University of Hawaii at Manoa. Report no 116. 92 pp.
Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

Hau S. 1996. Post-larval migration of three native gobies (Lentipes concolor, Awaous guamensis, and Sicyopterus stimpsoni) in Iao stream on the island of Maui. Proceedings of the October 1994 Hawaii Stream Restoration Symposium; 1994; Hawai‘i. State of Hawai‘i,

Hawai‘i Division of Aquatic Resources (DAR). (2023). Native Stream Fishes of Hawai‘i. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). Eleotris sandwicensis. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Kido, M. H. (1996). Ecological Monitoring of Hawaiian Streams. Bishop Museum Press.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams.

McDowall, R. M. (2004). Amphidromy in Freshwater Fishes. Fish and Fisheries, 5(2), 75–85.

Nature Conservancy Hawai‘i Program. (2023). Freshwater Conservation in the Hawaiian Islands. Retrieved from https://www.nature.org

Tate DC. 1997. The role of behavioral interactions of immature Hawaiian stream fishes (Pisces: Gobiodei) in population dispersal and distribution. Micronesica 30 (1): 51-70.

Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Yamamoto M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Fishes
‘O‘opu ‘alamo‘o
Lentipes concolor

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: The endemic ‘o‘opu ‘alamo‘o (*Lentipes concolor*) is an amphidromous fish species known for its distinctive ability to climb waterfalls and steep stream sections using its pelvic fins. It has a slender body with variable coloration, often displaying red and blue hues in males during the breeding season. It is one of five endemic gobies in Hawaiian streams. It can be distinguished from Hawai‘i’s other endemic gobies by their extraordinary abilities to climb vertical waterfalls. Male ‘o‘opu ‘alamo‘o can be distinguished from females by their displays of striking sexual dimorphism with a range of color patterns that depend on its activities. Additionally, males are territorial, while females are not. ‘O‘opu ‘alamo‘o are omnivores, feeding on algae and small aquatic animals. Adults feed primarily on small aquatic animals including atyid shrimps and may graze on microalgae while they move. Juveniles feed more on plant material. Additionally, they will swim through the water column to collect drift particles or insects. ‘O‘opu ‘alamo‘o breed in upstream areas from late fall to early spring and are cued by freshets. Nests are made under rocks and in crevices away from the main river channel. Eggs hatch within two to three days of being laid and are carried to the ocean with the current. They have four days to reach the ocean or the larvae will not survive. Postlarvae or hinana remain part of the oceanic plankton for a few months and then recruit indiscriminately to a freshwater source with the incoming tide, usually after sunrise. This recruitment occurs year round but is most prevalent in the spring. They swim directly upstream spending no longer than one day in an estuary. ‘O‘opu ‘alamo‘o travel at speeds of 90 meters (295 feet) per hour. Although they cannot swim up through flowing water and must use a substrate, they are very able climbers using their suction discs to hold on to the surface and their pectoral fins to move them upwards.

DISTRIBUTION: Endemic to the Hawaiian Islands.‘O‘opu ‘alamo‘o has been found in streams on all main islands historically. They are currently found in streams on the island of Hawai‘i, Kaua‘i, Maui, Moloka‘i, and in seven streams on O‘ahu. Although not as common, it is very likely that ‘o‘opu ‘alamo‘o exist in more streams on O‘ahu, in areas of high elevation and where habitat is not affected as a result of human population growth and pollution. Previously thought only to be located on windward streams, ‘o‘opu ‘alamo‘o recently has been discovered in the upper reaches of leeward perennial streams as well. They also can be found above Akaka Falls on the island of Hawai‘i. Dams and stream obstructions can limit their presence in upper reaches that they previously occupied.
Larvae spend time in the ocean as plankton, but not much is known of their oceanic distribution.

ABUNDANCE: Restricted to Hawai‘i; population trends are declining due to habitat degradation.

Abundance throughout the islands is unknown; however, populations are decreasing on Oʻahu and Maui.

LOCATION AND CONDITION OF KEY HABITAT: ʻOʻopu ʻalamoʻo do best in unobstructed, cool, fast-moving streams. They spend the majority of their life in freshwater in the upper reaches of streams. ʻOʻopu ʻalamoʻo are very well suited to the naturally variable characteristics of Hawaiʻi's streams. However, where natural stream habitat has been altered, including decreases in forest cover, ʻoʻopu ʻalamoʻo populations have decreased. The majority of already degraded key habitat is located on Oʻahu, although 58 percent of the 366 perennial streams in the State have been altered in some way. Interestingly, the amount of plant cover within a stream affects the location of ʻoʻopu ʻalamoʻo in a stream, with fish density being the highest where plant cover is the lowest. For more information on specific stream biota, the Division of Aquatic Resources of the Department of Land and Natural Resources has a database of surveyed streams. Oceanic waters are important to the survival of post-larvae, but little is known of its oceanic distribution or habitat requirements.

THREATS:

- Habitat degradation results from water diversion, stream channelization, dams, pollution, the introduction of exotic species and parasites, and climate change. Water diversions, stream channelization, and dams result in habitat degradation through altered stream flows that lead to: the destruction of key water characteristics such as freshets, riffles and runs; higher water temperatures; and lower dissolved oxygen levels. The reduced water flows from water diversions and dams also can limit larvae from reaching the ocean and recruiting back into streams. Channelization leads to a decrease in riparian vegetation that causes a loss of shelter and erosion control;
- Non-point source water pollution such as nutrients, sedimentation, and chemicals may threaten ʻoʻopu ʻalamoʻo; however, the consequence of these pollutants is relatively unknown and needs to be further studied;
- Exotic species such as tilapia are another important threat to the ʻoʻopu ʻalamoʻo. Historical introductions of game fish and more recent unwanted exotic fish from the aquarium trade are both problems. These exotic fishes prey on native fish species, out compete native fishes for food, and spread parasites and diseases.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Past actions to restore fish populations have consisted of a ban on gill, drag, draw, and seine netting; stream clean-up efforts, and public outreach. In addition to common statewide and island conservation actions, specific actions include:

- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage of fish;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Remove alien species;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Collaborate with the Commission on Water Resources Management and the Land Board

to ensure adequate Instream Flow and biological integrity of riparian areas;
    - Work to clean streams with significant pollution;
    - Continue developing GIS database and making it web-accessible;
    - Use science-based management of recreational fishing;
    - Increase education and outreach efforts, particularly on issues of water pollution and how to deal with unwanted aquarium pet
    - Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships.

MONITORING:

- Population Assessments: Monitoring distribution, abundance, and recruitment rates. Monitor number of returning hinana.
- Water Quality: Regular testing for pollutants and sediment levels.
- Habitat Connectivity: Evaluating barriers to migration such as dams and culverts.
- Threat Mitigation: Tracking the effectiveness of conservation measures.

RESEARCH PRIORITIES:

- Determine effects of pollution on population;
- Better understand the role of estuaries in species ecology;
- Continue research efforts on marine life stage;
- Initiate research to study source-sink population structure;
- Research impacts and methodologies to deal with alien species;
- Continue researching effects of stream channelization and diversion.

CULTURAL INFORMATION:

- Other historical names of the ʻoʻopu ʻalamoʻo also include hiʻu ʻula and hiʻu kole. Moʻo means "lizard-like" referring to the appearance of the head of this ʻoʻopu. The hiʻu, or tail, of the ʻoʻopu is likened to the color of the ring around the eye of the kole fish. The words ʻula and kole also mean red, referring to the orange tail of the male fish. A rare name is ʻailehua, used in old moʻolelo (stories) of Hawaiʻi island.
- The hiʻukole, or red tail, was said to bring bad luck in the net, since it keeps other fish away. If one was taken, it should be thrown out with an exclamation of disgust in order that the fisherman may have a successful catch.
- An ʻōlelo noʻeau, or Hawaiian proverb, that pertains to this ʻoʻopu says: "Hoʻi ka ʻoʻopu ʻai lehua i ka māpunapuna". The lehua-eating ʻoʻopu has gone back to the spring. [Said of one who has gone back to the source.]
- An article from a Hawaiian newspaper, *Ka Nūpepa Kūʻokoʻa*, December 3, 1892 that mentions this ʻoʻopu says: "i hiki aku ka hana e kapalili mai ana ka ʻamaʻama o Waipiʻo, ka ʻoʻopu ʻailehua, ka ʻōpae kalaʻole a me ke kalo huluhulu o Kūnaka", when we arrived, the ʻamaʻama of Waipiʻo, the ʻoʻopu ʻailehua, the ʻōpae kalaʻole, and the kalo of Kūnaka were fluttering about.

Waipiʻo is one of a few places in all of Hawaiʻi that still has ʻoʻopu alamoʻo, also known as hiʻukole, where the alamoʻo climb Hiʻilawe, the famous 1,450 foot waterfall.

References:

Brasher AM. 2003. Impacts of human disturbances on biotic communities in Hawaiian streams. BioScience 53 (11): 1052-1060.

Devick WS, Fitzsimons JM, Nishimoto RT. 1995. Threatened fishes of the world: *Lentipes concolor* Gill, 1860 (Gobiidae). Environmental Biology of Fishes 44: 325-326.

Fitzsimons, J. M., & Nishimoto, R. T. (1990). Behavior and Ecology of Amphidromous Gobies in Hawaiian Streams. *Environmental Biology of Fishes*, 27(1), 1–15.

Hau S. 1996. Post-larval migration of three native gobies (*Lentipes concolor, Awaous guamensis,* and*Sicyopterus stimpsoni*) in Iao stream on the island of Maui. Proceedings of the October 1994 Hawaii Stream Restoration Symposium; 1994; Hawai‘i. State of Hawai‘o‘opu‘ alamo‘o i, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Native Stream Fishes of Hawai‘i. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). *Lentipes concolor*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Keith P. 2003. Biology and Ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal of Fish Biology 63: 831-847.

Kido, M. H. (1996). Ecological Monitoring of Hawaiian Streams. *Bishop Museum Press*.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams.

McRae MG. Louisiana State University. Personal communication.

Nature Conservancy Hawai‘i Program. (2023). Freshwater Conservation in the Hawaiian Islands. Retrieved from https://www.nature.org

Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Way CM et al. 1998. Reproductive Biology of the Endemic Goby, *Lentipes concolor*, from Malamaka‘o‘opu‘ alamo‘o ole Stream, Maui and Waikolu Stream, Moloka‘o‘opu‘ alamo‘o i. Environmental Biology of Fishes 51: 53-65.

Yamamoto M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Courtesy Annette Tagawa

Freshwater Fishes
‘O‘opu nākea
Awaous stamineus

SPECIES STATUS:

IUCN Red List – Least Concern
Endemic

SPECIES INFORMATION: The endemic ‘o‘opu nākea (*Awaous stamineus)* is an amphidromous fish species that thrives in freshwater streams. It is characterized by its elongated body, broad head, and grayish to brown coloration. The species is capable of climbing steep stream gradients and is integral to native Hawaiian aquatic ecosystems.
It is the largest of Hawai‘i’s endemic gobies, reaching a length of up to 36 centimeters (14 inches). It is also the most common. They are omnivores feeding on benthic algae, aquatic insects and insect larvae, worms, and crustaceans, but not fishes. They may feed on suspended food particles in the water column as well. ‘O‘opu nākea display sexual dimorphism and elaborate courtship rituals. Spawning occurs from August to November when annual spawning runs to the stream mouths are triggered by freshets. Large spawning aggregations are formed at the first riffle before the estuary. This is the only goby that migrates downstream to spawn. Males make and guard nests in crevices of the stream bed where an attracted female will lay her eggs. Females probably produce one clutch a year and also help guard nests. Eggs are one millimeter (0.04 inches) in diameter and tens of thousands make up a nest. Eggs hatch in one day, travel to the ocean over four days and spend five to six months at sea. Post-larvae or hinana are indiscriminately recruited back to streams between December and July. They can be found in schools just after recruitment to estuaries. Adult ‘o‘opu nākea are relatively good climbers and swimmers, and post-larvae use tidal inundation to move upstream. The ‘o‘opu nākea will often burrow under rocks leaving only its eyes showing.

DISTRIBUTION: Historically, ‘o‘opu nākea were found on all the Main Hawaiian Islands. Today, they are found in streams on the island of Hawai‘i, Kaua‘i, Moloka‘i, Maui, and O‘ahu. ‘O‘opu nākea usually are found in the middle to lower reaches of streams, with a larger range in larger streams. Post-larvae are found in oceanic waters, but little is known of its oceanic distribution.

ABUNDANCE: Moderately abundant in undisturbed Hawaiian streams; declines observed in modified or polluted streams. Abundant on Kaua‘i. Populations reduced on O‘ahu.

LOCATION AND CONDITION OF KEY HABITAT: ‘O‘opu nākea are primarily found in the middle and lower reaches of streams. If a river has steep waterfalls, they cannot climb these and thus will only be found in the lower reaches. Areas of slow, deep waters with gravel or fine sediment are key habitat for them. Riffles at stream mouths are critical spawning grounds. The majority of already degraded key habitat is located on O‘ahu, although 58 percent of the 366 perennial streams in the

State have been altered in some way. Specific areas that can also be considered degraded due to water diversions are streams such as Waikolu on Molokaʻi and ʻĪao on Maui. In free flowing streams, such as Pelekunu on Molokaʻi or larger rivers such as Hanalei, Waimea, and Wainiha on Kauaʻi, ʻoʻopu nākea habitat is in a more stable condition. For specific information on stream biota, the Division of Aquatic Resources of the Department of Land and Natural Resources has a database of surveyed streams. Oceanic waters are important to the survival of post-larvae, but little is known of its oceanic distribution or habitat requirements.

THREATS:

- Habitat degradation results from water diversion, stream channelization, dams, pollution, the introduction of exotic species and parasites, and climate change. Water diversions, stream channelization, and dams result in habitat degradation through altered stream flows that lead to: the destruction of key water characteristics such as freshets, riffles and runs; higher water temperatures; and lower dissolved oxygen levels. The reduced water flows from water diversions and dams also can limit larvae from reaching the ocean and recruiting back into streams. Channelization leads to a decrease in riparian vegetation that causes a loss of shelter and erosion control;
- Non-point source water pollution, such as nutrients, sedimentation, and chemicals may threaten the ʻoʻopu nākea. The consequence of these pollutants is relatively unknown and needs to be further studied;
- Exotic species such as tilapia are another important threat to the ʻoʻopu nākea.
- Historical introductions of game fish and more recent unwanted exotic fish from the aquarium trade are both problems. These exotic fishes prey on native fishes, out compete native fishes for food, and spread parasites and diseases;
- Fishing could become a more severe threat in combination with the above threats, because ʻoʻopu nākea are abundant in Kauaʻi rivers and are fished during their spawning migration.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Past actions to restore fish populations have consisted of a ban on gill, drag, draw, and seine netting; stream clean-up efforts, and public outreach. In addition to common statewide and island conservation actions, specific actions include:

- Improve altered or diverted streams;
- Modify or remove gratings or diversions to allow for instream passage of fish;
- Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
- Remove alien species;
- Create pools in frequently dewatered stretches to provide safe usable habitat between flows;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Work to clean streams with significant pollution;
- Use science-based management of recreational fishing;
- Continue developing GIS database and making it web-accessible;

- Increase education and outreach efforts, particularly on issues of fishing-related life history, water pollution, and how to deal with unwanted aquarium pets;
- Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships.

MONITORING:

- Population Surveys: Regular monitoring of population abundance and distributionMonitor number of returning hinana;
- Stream Health: Assess water quality and habitat integrity.
- Juvenile Recruitment: Study the success of juvenile migration and survival rates.
- Threat Evaluation: Monitor the impacts of pollution, invasive species, and habitat alteration. Monitor number of fish taken in recreational fishing each year.

RESEARCH PRIORITIES:

- Determine effects of pollution on populations;
- Life History Studies: Investigate migration, reproduction, and growth cycles Initiate research to study source-sink population structure;
- Habitat Connectivity: Identify barriers and solutions for maintaining stream connectivity. Better understand the role of estuaries in species ecology; Continue researching effects of stream channelization and diversion;
- Invasive Species Impact: Study competitive dynamics with non-native species. Research impacts and methodologies to deal with alien species;
- Climate Resilience: Assess the species' response to changing hydrological conditions;
- Conservation Effectiveness: Evaluate the success of habitat restoration and protection initiatives. Research effect of fishing on total population size and distribution.

CULTURAL INFORMATION:

- Other historical names of the ʻoʻopu nākea also include nōkea and nāwao. The ʻoʻopu kumu iki is the small female nākea variety of ʻoʻopu, while the ʻoʻopu lehe is the large male of the nākea variety of ʻoʻopu, so called because its lehe (lip) is said to show when it hides in the mud.
- This ʻoʻopu was known as being the favorite for eating.
- The ʻāina (land) of Waiheʻe, Maui, was known for its "makani kili ʻoʻopu", or its ʻoʻopu-scented wind.
- An article from a Hawaiian newspaper, *Ka Nūpepa Kūʻokoʻa*, February 18, 1921 that mentions this ʻoʻopu in a mele (song) called *Kaiwiki Hula* says:
- "Ke noho i ka uka lā o Kaiwiki; Residing in the uplands of Kaiwiki,
- He ʻai ulu wale ko kanahele; The fruit of the forest grows wild,
- ʻOʻopu inu wai o Kamaʻili; The water drinking ʻoʻopu of Kamaʻili,
- ʻŌpae kalaʻole noho kuahiwi; The ʻōpae kalaʻole residing in the mountains,
- Nāwao ʻai limu o Honoliʻi" The limu eating nāwao of Honoliʻi

REFERENCES:

Brasher AM. 1997. Habitat use by fish (‘o‘opu), snails (hihiwai), shrimp (‘opae) and prawns in two streams on the island of Moloka`i. Technical Report. Honolulu HI: Cooperative National Park Resources Studies Unit University of Hawaii at Manoa. Report no 116. 92 pp.

Brasher AM. 2003. Impacts of human disturbances on biotic communities in Hawaiian streams. BioScience 53 (11): 1052-1060.

Ching et al. 2023. Understanding amphidromy in Hawai‘i: ‘O‘opu nakea (Awaous stamineus). Journal of Fish Biology. 2023;1–15.

Fitzsimons, J. M., & Nishimoto, R. T. (1990). Behavior and Ecology of Amphidromous Gobies in Hawaiian Streams. *Environmental Biology of Fishes*, 27(1), 1–15.

Ha PY, Kinzie R. 1996. Reproductive biology of *Awaous guamensis*, an amphidromous Hawaiian goby. Environmental Biology of Fishes 45: 383-396.

Hau, S. 1996. Post-larval migration of three native gobies (*Lentipes concolor, Awaous guamensis,* and *Sicyopterus stimpsoni*) in Iao stream on the island of Maui. Proceedings of the October 1994 Hawaii Stream Restoration Symposium; 1994; Hawai‘i. State of Hawai‘i, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Native Stream Fishes of Hawai‘i. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). *Awaous guamensis*. The IUCN Red List of

Keith P. 2003. Review paper: Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal of Fish Biology 63: 831-847.

Kido, M. H. (1996). Ecological Monitoring of Hawaiian Streams. *Bishop Museum Press*.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams.

Kinzie, R. A., & Chong, C. T. (2020). Stream faunas of Hawaii. *Pacific Science*, 74(2), 147-170, A. M. D., & Yamamoto, M. N. (2003). *Impacts of human disturbances on native stream fauna in Hawai‘i*. U.S. Geological Survey.

Lindstrom et al. 2012. Molecular and Morphological Evidence of Distinct Evolutionary Lineages of Awaous guamensis in Hawai’i and Guam. Copeia 2012, No. 2, 293–300.

Murphy, Cheryl A. Personal communication.

Nature Conservancy Hawai‘i Program. (2023). Freshwater Conservation in the Hawaiian Islands. Retrieved from https://www.nature.org

Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Threatened Species. Retrieved from https://www.iucnredlist.org

Yamamoto, M, Tagawa A. 2000. Hawai‘i’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Courtesy Annette Tagawa

Freshwater Fishes
ʻOʻopu naniha
Stenogobius hawaiiensis

SPECIES STATUS:

IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: ʻOʻopu naniha (*Stenogobius hawaiiensis*) is an amphidromous species endemic to Hawaiʻi. It has a slender, elongated body with a mottled appearance, blending well with streambed substrates. This goby primarily occupies lower stream reaches and plays an important role in the native aquatic ecosystem. They are a smaller goby reaching ten to 13 centimeters (four to five inches) in length. As an omnivore, it feeds on algae, worms, crustaceans, and insect larvae that it takes from the bottom sediments using their snouts.

ʻOʻopu naniha display sexual dimorphism and elaborate courtship rituals. Spawning occurs year round. Average-sized ʻoʻopu naniha will lay 6,000-8,000 eggs in crevices guarded by males. Eggs hatch after one day and are carried out to sea. Within five days they will develop enough to be able to begin feeding. They spend approximately 135 days as oceanic plankton. Post-larvae or hinana recruit indiscriminately back to freshwater streams during all hours, utilizing the incoming tide. Recruitment is most prevalent in the spring. ʻOʻopu naniha are poor climbers and swimmers compared to the other native gobies.

DISTRIBUTION: Endemic to the Hawaiian islands**.** Historically, ʻoʻopu naniha were found on all the Main Hawaiian Islands. Today, they also are found on all the Main Hawaiian Islands in the lower reaches of streams and in estuaries that are not blocked by man-made obstructions. Post-larvae are found in oceanic waters, but little is known of its oceanic distribution. Primarily found in lowland areas.

ABUNDANCE: Stable in pristine habitats but declining in degraded or diverted streams. Most common on Oʻahu. Abundance has declined in many areas and is affected by the threats listed below.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for ʻoʻopu naniha is low-elevation stream habitats with moderate flow, rocky substrates, and good water quality and requires unimpeded stream flow to support its amphidromous lifecycle. This is primarily along margins of streams and in low flow areas in the lower reaches of streams and stream mouths. Although they prefer clear, cool streams like the other gobies, they are better adapted than most gobies to live in soft substrates in degraded habitat. For specific information on stream biota, the Division of Aquatic Resources of the Department of Land and Natural Resources has a database of surveyed streams. Oceanic waters are important to the survival of post-larvae, but little is known of its oceanic distribution or habitat requirements.

THREATS:

- Habitat degradation results from water diversion, stream channelization, dams, pollution, the introduction of exotic species and parasites, and climate change. Water diversion, stream channelization, and dams result in habitat degradation through altered stream flows, which also causes a loss of riparian vegetation, shelter and erosion control; higher water temperatures; and lower dissolved oxygen levels. ʻOʻopu naniha are not as threatened by altered streams as other Hawaiian gobies, although reduced water flows still can limit larvae from reaching the ocean and recruiting back into streams;
- Non-point source water pollution, such as nutrients, sedimentation, and chemicals may threaten ʻoʻopu naniha; however, the consequence of these pollutants is relatively unknown and needs to be further studied;
- Introduction of exotic species, diseases and parasites such as tilapia are significant threats to ʻoʻopu naniha. Historical introductions of game fish and more recent unwanted exotic fish from the aquarium trade are both problems. These exotic fish species prey on native fish, outcompete native fish for food, and spread parasites and diseases;
- Fishing for ʻoʻopu naniha occurs and could become a more severe threat in combination with the above threats.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Past actions to restore fish populations have consisted of a ban on gill, drag, draw, and seine netting; stream clean-up efforts, and public outreach. In addition to common state-wide and island conservation actions, specific actions include:

- Improve altered streams;
- Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
- Remove alien species;
- Create pools in frequently dewatered stretches to provide safe usable habitat between flows;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Work to clean streams with significant pollution;
- Continue developing GIS database and making it web-accessible;
- Use science-based management of recreational fishing;
- Increase education and outreach efforts, particularly on issues of fishing-related life history, water pollution, and how to deal with unwanted aquarium pets;
- Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships.

MONITORING:

- Population Dynamics: Conduct regular surveys to assess population trends. Monitor number of returning hinana.
- Water Quality: Monitor pollutants and sediment loads in key habitats.
- Habitat Connectivity: Evaluate stream flow continuity and barrier removal.
- Threat Mitigation: Track progress in reducing invasive species and improving habitat

conditions.

RESEARCH PRIORITIES:

- Research conservation-relevant biology and ecology;
- Life Cycle Studies: Better understand reproductive and migratory behaviors. Initiate research to study source-sink population structure;
- Habitat Use: Examine specific environmental requirements and preferences. Better understand the role of estuaries in species ecology; Continue researching effects of stream channelization and diversion, specifically how this goby is able to have high numbers in altered streams;
- Climate Adaptation: Investigate resilience to changing hydrological conditions;
- Impact of Invasive Species: Study interactions with introduced species. Research impacts and methodologies to deal with alien species;
- Conservation Strategies: Evaluate the effectiveness of current restoration and protection measures. Determine effects of pollution on population; Research effect of fishing on total population size and distribution.

CULTURAL INFORMATION:

- Another historical name of the ʻoʻopu naniha is kāniʻo, also meaning striped, streaked, usually crosswise rather than lengthwise, which is apparent on this ʻoʻopu.
- An ʻōlelo noʻeau, or Hawaiian proverb that pertains to ʻoʻopu says: "He iʻa hāhā i kahawai". The fish groped for in the streams. [The ʻoʻopu, often caught by groping under rocks and hollow places in a stream.]
- Another ʻōlelo noʻeau, or Hawaiian proverb that pertains to ʻoʻopu says: "He ʻoʻopu peke o Hanakāpīʻai". The short ʻoʻopu of Hanakāpīʻai. [The ʻoʻopu at Hanakāpīʻai on Kauaʻi were said to be shorter and plumper than those anywhere else. Mentioned in chants.]

REFERENCES:

Brasher AM. 1997. Habitat use by fish (ʻoʻopu), snails (hihiwai), shrimp (ʻopae) and prawns in two streams on the island of Moloka`i. Technical Report. Honolulu HI: Cooperative National Park Resources Studies Unit University of Hawaii at Manoa. Report no 116. 92 pp.

Fitzsimons, J. M., & Nishimoto, R. T. (1990). Behavior and Ecology of Amphidromous Gobies in Hawaiian Streams. *Environmental Biology of Fishes*, 27(1), 1–15.

Hau S. 1996. Post-larval migration of three native gobies (*Lentipes concolor, Awaous guamensis,* and *Sicyopterus stimpsoni*) in Iao stream on the island of Maui. Proceedings of the October 1994 Hawaii Stream Restoration Symposium; 1994; Hawaiʻi. State of Hawaiʻi, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

Hawaiʻi Division of Aquatic Resources (DAR). (2023). Native Stream Fishes of Hawaiʻi. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). *Stenogobius hawaiiensis*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Keith P. 2003. Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal

of Fish Biology 63: 831-847.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams.

Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Kido, M. H. (1996). Ecological Monitoring of Hawaiian Streams. *Bishop Museum Press*.

Nature Conservancy Hawai‘i Program. (2023). Freshwater Conservation in the Hawaiian Islands. Retrieved from https://www.nature.org

Tate DC. 1997. The role of behavioral interactions of immature Hawaiian stream fishes (Pisces: Gobiodei) in population dispersal and distribution. Micronesica 30 (1): 51-70.

Yamamoto, M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Fishes
‘O‘opu nōpili
Sicyopterus stimpsoni

SPECIES STATUS:

IUCN Red List – Near Threatened
Endemic

SPECIES INFORMATION: ‘O‘opu nōpili (*Sicyopterus stimpsoni*) is an endemic Hawaiian goby known for its remarkable ability to climb waterfalls using its pelvic suction disc. This amphidromous species is integral to the health of Hawaiian freshwater ecosystems and has a streamlined body with mottled brown and green coloration, adapted for fast-flowing streams. Both male and female vary in color based on age and activity and display elaborate courtship rituals. They feed at a lower trophic level than *Lentipes concolor*. Of all the Hawaiian gobies ‘o‘opu nōpili post-larvae often migrate into estuaries in large schools and are most often found in schools at stream mouths. They do not recruit back to the same stream where they were born. Spawning occurs between August and March and eggs are deposited in crevices under rocks and pebbles. Nests are laid in territories defended by males. Eggs hatch within two to three days and larvae are washed out to sea, spending approximately five months as oceanic plankton. Recruitment of post-larvae or hinana occurs year round but is most prevalent in the spring. Post-larvae can be found in schools just after recruitment. After recruitment ‘o‘opu nōpili remain in estuaries for at least 48 hours before they begin migrating upstream. During this time, they undergo a significant metamorphosis. Their snouts enlarge and lengthen and their heads increase in size. Their upper lip also enlarges and their mouths move to a sub-terminal position. This metamorphosis allows the ‘o‘opu nōpili to climb waterfalls using its suction cup and lips. Prior to this metamorphosis, the post-larvae are omnivorous, but after the metamorphosis the sub- terminal mouth is better suited to scraping algae from rocks with a unique feeding behavior.

DISTRIBUTION: Endemic to the Hawaiian islands and found in streams on all the main islands, especially in steep, high-gradient streams. Historically, ‘o‘opu nōpili were found in streams on all of the Main Hawaiian Islands. Today, they also are located on all main islands, primarily in the middle reaches of streams, although they can be found in the lower reaches. On O‘ahu they commonly are found in unaltered streams such as Kaluanui, Kahana, and Waimea. Upstream distribution is limited by instream obstructions. Individual distribution within accessible stream reaches is determined based on displays of aggression during migration and establishment of territories. ‘O‘opu nōpili develop aggressive signaling colors at different rates. Those that develop them early establish territories first. These ‘o‘opu nōpili displace other non-colored ‘o‘opu nōpili further upstream. Post-larvae are found in oceanic waters, but little is known of its oceanic distribution.

ABUNDANCE: Declining in streams impacted by habitat degradation and invasive species. Present on all main islands except for O‘ahu where its numbers are greatly reduced from historical times.

LOCATION AND CONDITION OF KEY HABITAT: ʻOʻopu nōpili do best in the middle reaches of streams utilizing areas with high stream velocities such as riffles and runs. Areas that are undisturbed, with high water quality and high discharge rates, are key to their survival. The majority of already degraded habitat is located on Oʻahu, although 58 percent of the 366 perennial streams in the State have been altered in some way. Additionally, ʻoʻopu nōpili have been used as an "indicator species" to signify high water quality in streams and the possible presence of ʻoʻopu ʻalamoʻo, which is rarer than the ʻoʻopu nōpili. For specific information on stream biota, the Division of Aquatic Resources of the Department of Land and Natural Resources has a database of surveyed streams. Oceanic waters are important to the survival of post-larvae, but little is known of its oceanic distribution or habitat requirements.

THREATS:

- Habitat degradation results from water diversion, stream channelization, dams, pollution, the introduction of exotic species and parasites, and climate change. Water diversions, stream channelization, and dams result in habitat degradation through altered stream flows that lead to: the destruction of key water characteristics such as freshets, riffles and runs; higher water temperatures; and lower dissolved oxygen levels. The reduced water flows from water diversions and dams also can limit larvae from reaching the ocean and recruiting back into streams. Channelization leads to a decrease in riparian vegetation that causes a loss of shelter and erosion control;
- Non-point source water pollution such as nutrients, sedimentation, and chemicals may threaten ʻoʻopu nōpili; however, the consequence of these pollutants is relatively unknown and needs to be further studied;
- Exotic species such as tilapia are another important threat to ʻoʻopu nōpili. Historical introductions of game fish and more recent unwanted exotic fish from the aquarium trade are both problems. These exotic fishes prey on native fish species, out compete native fishes for food, and spread parasites and diseases.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Past actions to restore fish populations have consisted of a ban on gill, drag, draw, and seine netting; stream clean-up efforts, and public outreach. In addition to common statewide and island conservation actions, specific actions include:

- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage of fish;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Remove alien species;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Work to clean streams with significant pollution;

- Continue developing GIS database and making it web-accessible;
- Use science-based management of recreational fishing;
- Increase education and outreach efforts, particularly on issues of water pollution and how to deal with unwanted aquarium pets;
- Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships.

MONITORING:

- Population Surveys: Track abundance and distribution trends. Monitor number of returning hinana.
- Stream Connectivity: Assess and address barriers to migration.
- Water Quality: Monitor levels of pollutants and sediment in key habitats.
- Invasive Species Impact: Evaluate the effects of introduced species on native populations.

RESEARCH PRIORITIES:

- Determine effects of pollution on population;
- Life Cycle Studies: Investigate reproductive and migratory behaviors. Initiate research to study source-sink population structure;
- Habitat Needs: Identify critical habitat requirements and preferences. Better understand the role of estuaries in species ecology; Continue researching effects of stream channelization and diversion;
- Restoration Effectiveness: Measure the success of habitat and streamflow restoration;
- Invasive Species Impact: Study competitive dynamics with non-native species. Research impacts and methodologies to deal with alien species;
- Climate Resilience: Study the species' adaptability to changes in hydrology;
- Cultural Significance: Document traditional ecological knowledge related to the species;

CULTURAL INFORMATION:

- Another historical name of the ʻoʻopu nōpili is nāpili. Called nōpili on Kauaʻi. The word pili means to cling, as this ʻoʻopu has the ability to cling fast to wet stones to be able to climb.
- The ʻoʻopu nōpili was used in housewarming ceremonies so that luck will pili (cling).
- Nāpili were used at the ceremony called māwaewae, a ceremony held a few days after birth, during which the mother was given special foods to ensure good health and milk production for nursing.
- An article from a Hawaiian newspaper *Ka Nūpepa Kūʻokoʻa*, November 10, 1894 that mentions this ʻoʻopu in a moʻolelo (story) called *He Moʻolelo Kaʻao No Nāmakaokapaoʻo* says: "he mahina momona kēia o ka ʻoʻopu, ʻo Nana, ʻo Welo, ʻo Ikiiki", these are the months when the ʻoʻopu fish are fat, in Nana, Welo, and Ikiiki (these are the Hawaiian months that translate from mid-March to the beginning June).

REFERENCES:

Brasher AM. 1997. Habitat use by fish ʻoʻopu), snails (hihiwai), shrimp (ʻopae) and prawns in two streams on the island of Moloka`i. Technical Report. Honolulu HI: Cooperative National Park Resources Studies Unit University of Hawaii at Manoa. Report no 116. 92 pp.

Brasher AM. 2003. Impacts of human disturbances on biotic communities in Hawaiian streams. BioScience 53 (11): 1052-1060.

Fitzsimons, J. M., & Nishimoto, R. T. (1990). Behavior and Ecology of Amphidromous Gobies in Hawaiian Streams. *Environmental Biology of Fishes*, 27(1), 1–15.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Native Stream Fishes of Hawai‘i. Retrieved from https://dlnr.hawaii.gov

Hobson Keith. Canadian Wildlife Service. Personal communication.

International Union for Conservation of Nature (IUCN). (2023). *Sicyopterus stimpsoni*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Keith P. 2003. Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal of Fish Biology 63: 831-847.

Kido, M. H. (1996). Ecological Monitoring of Hawaiian Streams. *Bishop Museum Press*.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams.

Nature Conservancy Hawai‘i Program. (2023). Freshwater Conservation in the Hawaiian Islands. Retrieved from https://www.nature.org

Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Tate DC. 1997. The role of behavioral interactions of immature Hawaiian stream fishes (Pisces: Gobiodei) in population dispersal and distribution. Micronesica 30 (1): 51-70.

Yamamoto M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Invertebrates

Snails

Pīpīwai or *Clithon cariosus*
Pipipi or *Clithon neglectus*
Neritilia hawaiiensis

SPECIES STATUS:
Endemic
IUCN Red List – Not Considered

SPECIES INFORMATION: These are snails that can tolerate high levels of salinity. They likely feed on algae and vegetation growing on submerged rocks. Pīpīwai grow to about two or three centimeters (one inch) in length. Eggs are deposited in capsules that are about one millimeter (0.04 inch) in diameter and contain about 50 to 75 eggs. After hatching, the larvae wash into the ocean where they develop planktonically for a few months before they settle in the estuary or stream mouth, their adult habitat. Little else is known about their life history.
DISTRIBUTION: Historically, they were found on all the main islands. Currently, Pīpīwai can still be found on all the main islands except that they are rare on O‘ahu. Because of their salinity tolerance these species are often found in estuaries. Pīpīwai have been found in some anchialine ponds.

ABUNDANCE: Unknown. There are no formal quantitative surveys for these species.

LOCATION AND CONDITION OF KEY HABITAT: Pīpīwai occur in estuaries and the lower reaches of streams. Pipipi are found in the estuary. *N. hawaiiensis* is more exclusively found in anchialine ponds.
Habitat conditions have been degraded in many streams, estuaries, and anchialine ponds.

THREATS:

- Pīpīwai are used by Hawaiians as a food source where they are still common;
- Decreased water quality from sedimentation, pollution, and stream alterations are likely but need to be confirmed with detailed research.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Work to restore estuaries, streams, and anchialine ponds with significant pollution;
- Continue on-going partnerships focused on environmental education and conservation;

- Restore habitat.

MONITORING:

- Establish a survey schedule to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of the life history, biology, and ecology of these snails.
- Study impacts of pollution, sedimentation, water quality, and reductions in streamflow.

References:

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams. Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Yamamoto M, Tagawa A. 2000. Hawaii's native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Invertebrates

Aquatic Snail

Erinna aulacospira
Lymnaea (Pseudisidora) producta
Lymnaea rubella

SPECIES STATUS:
Endemic
IUCN Red List – Not considered

SPECIES INFORMATION: Little is known specifically about these lymnaed snails. They likely graze on algae and other items growing on hard substrates. Eggs are probably attached to substrate and there are no widely dispersing larval stages. *L. producta* is unusual in that it is coiled sinistrally.

DISTRIBUTION: Stream environments on Kaua‘i, Maui, Moloka‘i and Hawai‘i are the home of these species.

ABUNDANCE: No formal monitoring program or abundance data appear to exist. These three species are more widespread and abundant than the threatened Newcomb’s snail (*E. newcombi*), but they suffer from the same sorts of threats.

LOCATION AND CONDITION OF KEY HABITAT: Unknown.

THREATS:

- Predation by introduced rainbow trout threatens *E. aulacospira*. Other introduced fishes are likely to affect all of these species;
- The large-scale dewatering of streams is likely to be the major threat to these snails, though detailed research is needed;
- Decreased water quality from sedimentation and pollution are likely, but need to be confirmed with detailed research.

CONSVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.

- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental education and conservation and expand partnerships;
- Restore habitat.

MONITORING:

- Establish survey schedules to determine population size and distribution.

RESEARCH PRIORITIES:

- Research impacts and methodologies to deal with alien species;
- Improve understanding of the life history of these snails and the factors that limit their abundance and distribution.
- Study impacts of pollution, sedimentation, water quality, and reductions in streamflow.

References:

Kido MH, Heacock DE, Asquith A. 1999. Alien rainbow trout *(Oncorhynchus mykiss*) (Salmoniformes: Salmonidae) diet in Hawaiian streams. Pacific Science 53 (3):242-251.

Kinzie R, Ford J. 1977. A limnological survey of Lower Palikea and Pipiwai Streams, Kipahulu, Maui. Technical Report #17. Cooperative National Park Resources Studies Unit. 44 pp.

Freshwater Invertebrates

Aquatic Limpet

Ferrissia sharpi

SPECIES STATUS:

Endemic
IUCN Red List – Not considered

SPECIES INFORMATION: Endemic status is a bit questionable as this species may be the same as other Pacific *Ferrissia*. Little else is known about its biology. It is likely an herbivore.

DISTRIBUTION: Streams on Kauaʻi and Oʻahu.

ABUNDANCE: Unknown. No formal monitoring program or abundance data appear to exist.
LOCATION AND CONDITION OF KEY HABITAT: UNKNOWN.

THREATS: None identified, though pollution and stream alterations may have affected them.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads.
- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental education and conservation and expand partnerships with other Pacific Islands agencies;
- Restoration of habitat.

MONITORING:

- Establish survey schedules to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of the life history of this snail and the factors that limit their abundance and distribution.

References:

Hawaiʻi Division of Aquatic Resources. Stream database.

Freshwater Invertebrates

Hīhīwai and Hapawai

Neritina granosa
Neritina vespertine

SPECIES STATUS:
Endemic
IUCN Red List – Not Considered

SPECIES INFORMATION: These fresh and brackish water snails grow to about four centimeters (two inches) in length. Hīhīwai (*N. granosa*) are more active and more visible at night. Both species graze on algae growing on hard substrates. Eggs are deposited in capsules about two millimeters (one-tenth of an inch) long that are attached to rocks or other shells. Each capsule has about 250 eggs. Most egg-laying occurs from June through August. After hatching, the larvae wash into the ocean where they develop planktonically. Hīhīwai larvae develop in the ocean for up to a year before moving back into freshwater or estuaries to live out their lives. The young snails can be seen moving upstream in summer in single file along the rocks when they are about two to three millimeters (one-tenth of an inch) in size. Hapawai (*N. vespertina*) have only a few months developing in the ocean before they recruit to estuaries and ponds, and rarely to streams. Recruitment peaks shortly after rains. Hīhīwai may serve as good indicator species for stream quality. Hīhīwai shells from low elevations differ in shape from those at higher elevations and flows.

DISTRIBUTION: Historically, they were found on all the main islands. Currently, hapawai can still be found on all the main islands in disturbed and undisturbed streams, but hīhīwai are only common in high quality streams and are rare on O‘ahu.

ABUNDANCE: Their abundance is lower than it was historically in all but the most remote streams.

LOCATION AND CONDITION OF KEY HABITAT: Hīhīwai occur more in well-oxygenated lower to middle reaches of streams. They prefer streams with boulders and coarse gravel substrates. Hapawai occur in the lower reaches of streams and extend more into the estuary.

THREATS:

- Both species have been used by Hawaiians as a food source, though hīhīwai are preferred;
- Stream channelization and burial, pollution, and water diversions have affected the distribution and abundance of these snails. In particular, hīhīwai are limited in their upstream migration by low stream flows and in-stream obstructions.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;

- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Continue developing GIS database and making it web-accessible;
- Maintain healthy populations with appropriate fishing regulations and education;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental education and conservation and expand partnerships;
- Restore habitat.

MONITORING:

- Establish survey schedules to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of the life history of these snails and the factors that limit their abundance and distribution.

References:

Hau, Skippy. Hawai‘i Division of Aquatic Resources. Personal communication.

Yamamoto M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Invertebrates

Hawaiian prawn

ʻŌpae ʻoehaʻa

Macrobrachium grandimanus

SPECIES STATUS:

Endemic

IUCN Red List – Not considered

SPECIES INFORMATION: An endemic shrimp that grows to about eight centimeters (three inches) in length. It has asymmetric pincer claws unlike other shrimps in Hawaiʻi. They scavenge plant and animal material from the bottom in slower flow environments.
Reproduction is year-round. Incubation period is about three to four weeks. After hatching, larvae are washed downstream into the ocean where they likely spend one month developing before they return to streams or estuaries to mature. Two introduced *Macrobrachium* species also occur in Hawaiʻi; *M. lar* is widespread and *M. rosenbergii* is known from Kahana estuary, Opaeula and Helemano streams on Oʻahu, and Kuiaha stream on Maui.

DISTRIBUTION: Historic distribution includes all the main islands with perennial streams. Currently they occur in the lower reaches of high water quality streams on Kauaʻi, Oʻahu, Molokaʻi, Maui, and Hawaiʻi as well as estuaries on these islands. They can also be found in anchialine pools and brackish wetlands.

ABUNDANCE: Populations are apparently stable based on Division of Aquatic Resources stream surveys.

LOCATION AND CONDITION OF KEY HABITAT: ʻŌpaeʻoehaʻa (Hawaiian Prawn) are found in the lee of rocks and boulders in lower stream reaches that afford protection from fast stream flows.

THREATS:

- Habitat destruction has reduced available habitat for ʻōpae ʻoehaʻa (Hawaiian prawn),
- Pollution, and stream channelization and diversion have also reduced habitat;
- A number of introduced shrimps and other species may compete with them for food or habitat. They may also compete for food with the native snail *Neritina vespertina*;
- Introduced fishes may be a predatory threat.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce

sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental education and conservation and expand partnerships;
- Restore habitat.

MONITORING:

- Establish survey schedules to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of life history of ʻōpae ʻoehaʻa (Hawaiian prawn);
- Understand the ecological importance of interactions with introduced competitors and predators;
- Research the life history of introduced competitors and predators to develop removal or control strategies.

References:

Chong CT, Larned ST, et al. 2000. Species interactions between estuarine detritivores: inhibition or facilitation? Hydrobiologia 434:11-16.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams. Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Yamamoto M, Tagawa A. 2000. Hawaii's native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Invertebrates

Mountain shrimp

ʻŌpaekalaʻole

Atyoida bisulcate

SPECIES STATUS:

Endemic

IUCN Red List – Not considered

SPECIES INFORMATION: ʻŌpaekalaʻole (mountain shrimp) is a spineless shrimp that grows to about five centimeters (two inches) in length. They filter small food items from the water column in fast flow areas and scavenge material from the bottom in slower flow environments. Reproduction is year-round with females carrying up to 3000 eggs on their swimmeret legs. Incubation period is about two months. After hatching, larvae are washed downstream into the ocean where they spend a few months developing to a size of about five millimeters (one-fifth of an inch) long before they return to stream habitats to mature. Peak recruitment coincides with the rainy season. They are excellent climbers, climbing artificial structures and waterfalls of moderate size.

DISTRIBUTION: Historic distribution includes all the main islands with perennial streams. Currently they occur in high water quality streams on Kauaʻi, Oʻahu, Molokaʻi, Maui, and the island of Hawaiʻi.

ABUNDANCE: Numbers are high in good quality streams but these are much less common than occurred historically. They are also less common than they used to be, even in many high quality streams. Reduced stream flow and in-stream obstructions have restricted their range compared to historical times.

LOCATION AND CONDITION OF KEY HABITAT: ʻŌpaekalaʻole (mountain shrimp) are found in areas of fast flowing water in streams either in the current or in the lee of rocks and boulders. They are great climbers and can accommodate a series of tall waterfalls such as in Kaluanui Stream. They do not require a water flow layer to climb, but can climb completely out of the water. Thus, they are found in the upper reaches of streams down to near stream mouths, but are not common in estuaries. Reduced stream flow and in-stream obstructions have decreased their abundance and range compared to historical times.

THREATS:

- Habitat destruction and pollution from development and agriculture have reduced available habitat for mountain shrimp;
- Stream channelization and diversions have reduced stream flow and in-stream obstructions prevent their movement upstream;
- ʻŌpaekalaʻole (mountain shrimp) are traditionally eaten by Native Hawaiians and remain prized as a food source today;
- A number of introduced shrimps and other species may compete with them for food or

habitat. Introduced fishes may be a predatory threat.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental and fisheries education and conservation and expand partnerships;
- Maintain healthy populations with appropriate fishing regulations and education;
- Restore habitat.

MONITORING:

- Establish survey schedules to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of life history of ʻōpaekalaʻole (mountain shrimp) including lifespan;
- Understand the ecological importance of interactions with introduced competitors and predators;
- Research the life history of introduced competitors and predators to develop removal or control strategies.

References:

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams. Technical Report EL-89-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

McIntosh MD, Benbow M, Burky AJ. 2002. Effects of stream diversion on riffle macroinvertebrate communities in a Maui, Hawaii, stream. River Research and Applications 18(6):569-581.

Yamamoto M, Tagawa A. 2000. Hawaii's native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Freshwater Invertebrates

Aquatic Snail

Erinna aulacospira
Lymnaea (Pseudisidora) producta
Lymnaea rubella

SPECIES STATUS:

IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: Little is known specifically about these lymnaed snails. They likely graze on algae and other items growing on hard substrates. Eggs are probably attached to substrate and there are no widely dispersing larval stages. *L. producta* is unusual in that it is coiled sinistrally.

DISTRIBUTION: Stream environments on Kauaʻi, Maui, Molokaʻi and Hawaiʻi are the home of these species.

ABUNDANCE: No formal monitoring program or abundance data appear to exist. These three species are more widespread and abundant than the threatened Newcomb's snail (*E. newcombi*), but they suffer from the same sorts of threats.

LOCATION AND CONDITION OF KEY HABITAT: Unknown.

THREATS:

- Predation by introduced rainbow trout threatens *E. aulacospira*. Other introduced fishes are likely to affect all of these species;
- The large-scale dewatering of streams is likely to be the major threat to these snails, though detailed research is needed;
- Decreased water quality from sedimentation and pollution are likely, but need to be confirmed with detailed research.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Continue developing GIS database and making it web-accessible;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;

- Continue on-going partnerships focused on environmental education and conservation and expand partnerships;
- Restore habitat.

MONITORING:

- Establish survey schedule to determine population size and distribution.

RESEARCH PRIORITIES:

- Research impacts and methodologies to deal with alien species;
- Improve understanding of the life history of these snails and the factors that limit their abundance and distribution.

References:

Kido MH, Heacock DE, Asquith A. 1999. Alien rainbow trout *(Oncorhynchus mykiss*) (Salmoniformes: Salmonidae) diet in Hawaiian streams. Pacific Science 53 (3):242-251.

Kinzie R, Ford J. 1977. A limnological survey of Lower Palikea and Pipiwai Streams, Kipahulu, Maui. Technical Report #17. Cooperative National Park Resources Studies Unit. 44 pp.

Anchialine Pond Amphipods

Gamarella (=Nuuanu) amikai

Grandidierella koa
Grandidierella palama
Liagoceradocus lonomaka
Parhyale hawaiensis
Paramoera lokowai
Paramoera paakai
Paramoera rua
Rotomelita ana
Rotomelita lokoa
Carnarimelita janstocki

SPECIES STATUS:
IUCN Red List - Not considered
All Endemic except
Parahyale

SPECIES INFORMATION: This group of species lives in anchialine ponds and lava tube caves which have a mix of freshwater and seawater. *Gamarella* and *Parhyale* have been found in the open seas as well. All species are endemic except *P. hawaiensis*. *R. ana, P. lokowai,* and *L. lonomaka* are blind. Little is known about the biology or ecology of these species though *C. janstocki* is unusual in being predatory, apparently in part on the anchialine pond shrimp *Halocaridinia rubra*. It is found in pools with a salinity of around 14 parts per thousand. None of the species have Hawaiian or English common names.

DISTRIBUTION: Currently they are known to occur in a few anchialine ponds on Maui and the island of Hawai‘i, though specific research on these species ecology is rare. *G. amikai* has been found in an artificial pond on Kaho‘olawe. *R. ana, P. rua,* and *G. palama* occur in a single lava tube cave in eastern Maui near Wainapanapa. *C. janstocki* is found in a number of pools in the Kohanaika area of west Hawai‘i. *R. lokoa* and *P. paakai* have the mostwidespread distribution on the island of Hawai‘i.

ABUNDANCE: Abundance of anchialine amphipods appears to have never been recorded.

LOCATION AND CONDITION OF KEY HABITAT: Anchialine ponds are found in geologically young lava fields. The lava in these areas has fissures that connect the ponds to the ocean. Lava tubes can also have anchialine pools. Thus these ponds are always close to the sea and have varying salinity levels and tidal influence. Most ponds are less than 100 square meters (1000 square feet) in size and less than 1.5 m (five feet) in depth. Many ponds have been filledor had non-native species introduced. One pond was created accidentally by a large bomb explosion on Kahoʻolawe and subsequently colonized. It is not clear to what extent these amphipods use hypogeal (underground) habitats so the relative importance of these two habitat types is unknown. All ponds are important but key ones include those in ʻAhihi-Kinaʻu Natural Area Reserve (NAR) and Wainapapa area state lands on Maui; Manuka NAR, Waikoloa Anchialine Pond Preserve, the Ka Lae area near South Point on Department of Hawaiian Home Lands property, and in the Kaloko-Honokohau National Historic Park and Hawaii Volcanoes National Park, all on the island of Hawaiʻi.

THREATS:

- Habitat destruction has reduced available habitat for anchialine pond amphipods. On the island of Hawaiʻi much development has occurred in the major area for anchialine pools between Kawaihae and Kailua-Kona leading to the filling in of many pools;
- Pollution of pools by refuse and human use of the water;
- Introduced fishes (Tilapia, koi, mosquitofish and guppies) and Tahitian prawns may be a major predatory threat and alter the habitat use of remaining amphipods. Over 90 percent of the anchialine ponds on the Kona coast of Hawaiʻi are contaminated with non-native species.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Fencing the pools in ʻAhihi Kinaʻu NAR, and possibly elsewhere;
- Educating people to the value of, threats to and conservation actions to protect the ponds;
- Restoration of habitat by removal of introduced species;
- Creation of man-made pools should be explored.

MONITORING:

- Develop surveys of population and distribution in known and likely habitats;
- Develop quantitative abundance survey methods.

RESEARCH PRIORITIES:

- Improve understanding of life history and biology of anchialine pond amphipods and the role of interstitial underground waters;
- Understand the ecological importance of interactions with introduced competitors and predators;
- Research the life history of introduced competitors and predators to develop removal or control strategies;
- Partner with the Environmental Protection Agency to develop acceptable alternatives to,

or methods to use rotenone in removing introduced fishes.

References:

Barnard JL. 1977. The caverniculous fauna of Hawaiian lava tubes 9. Amphipoda from brackishlava ponds on Hawaii and Maui. Pacific Insects 17:267-299.

Bousefield EL. 1990. A new genus and species of hadzioidean amphipod crustacean from anchialine pools in Hawaii. Beaufortia 41(4):25-30.

Brock RE, Bailey-Brock JH. 1998. An unique anchialine pool in the Hawaiian Islands. International Reviews in Hydrobiology 83:65-75.

Metabetaeus lohena
Courtesy Karl Magnacca

Anchialine Ponds

Anchialine Pond Decapods

Antecaridina lauensis

Calliasmata pholidota

ʻŌpae ʻula or Halocaridina rubra

Metabetaeus lohena

Procaris hawaiana

Palaemonella burnsi

Vetericaris chaceorum

Periclimenes pholeter

Pele ramseyi

SPECIES STATUS:
Vetericaris chaceorum and *Procaris hawaiana* Federally listed as endangered
IUCN Red List - Not considered
All Endemic except *Antecaridina*, *Calliasmata*, *Metabetaeus, Palaemonella and Periclimenes*

SPECIES INFORMATION: This group of species live in underground (hypogeal) environments and in anchialine ponds which have a mix of freshwater and seawater through underground connections to the sea. All of the species except *A. lauensis*, *C. pholidota*, *M. lohena, P. burnsi and P. pholeter* are endemic to Hawaii. *P. hawaiana and V. chaceorum* are currently listed as endangered by the US Fish and Wildlife Service under the Endangered Species Act of 1973. ʻŌpae ʻula reaches 1.5 centimeters (one-half inch) in length and is an herbivore that grazes on algal, bacterial, and diatom films growing on rocks and other hard substrates. They can also filter feed in mid-water and at the surface. The other species are typicallylarger (up to five cm or two inches long) and some are predatory. *M. lohena* is a snapping shrimp and feeds on ʻōpae ʻula. *C. pholidota* feeds on crustaceans and polychaetes, while *P. hawaiana and V. chaceorum* has been seen feeding on shrimp. ʻŌpae ʻula carry about 12 fertilized eggs under their abdomen for a brood period of about 38 days. They reproduce one

to two times per year. The lifespan of ʻōpae ʻula has been confirmed to be 20 years or more in captivity. Less is known about the life history of the other species, but they are relatively long-lived for species in their taxa. *A. lauensis* and *M. lohena* can live six years. *C. pholidota, P. hawaiana* and *V. chaceorum* have rudimentary eyes, characteristic of subterranean or cave-dwelling species. *A. lauensis,* ʻōpae ʻula and *M. lohena* occur in salinities of two to 36 ppt. The rarer species are typically found in pools with higher salinities, usually above 15 ppt. All occur in water temperatures above 20° C. ʻŌpae ʻula also has an unusual amount of intraspecific variability that has been quantified from location to location suggesting the preserving genetic diversity may be an issue. Unpublished genetic analyses indicate *H. palahemo* and ʻōpae ʻula may not be a separate species but part of a genetically diverse cryptic species complex.

DISTRIBUTION: Historic distribution includes 600 to 700 anchialine pools on Oʻahu, Maui, Molokaʻi, and the island of Hawaiʻi and an unknown underground distribution. Currently they occur mostly on Hawaiʻi and Maui, and ʻōpae ʻula has previously occurred in an artificially created anchialine pond on Kahoʻolawe and natural and artificial habitats on Oʻahu and Molokaʻi. ʻŌpae ʻula has also been found in the ocean near a freshwater extrusion. Two species *V. chaceorum* and *P. pholeter* only occur at two locations on the southern portion of Hawaiʻi Island. *P. ramseyi* has only been recorded at ʻAhihi Kī naʻu on Maui. Only ʻōpae ʻula and *M. lohena* have a widespread distribution. The other four species have only been recorded on Maui and Hawaiʻi Island. Six of these eight species can be found in both the ʻĀhihi-Kīnaʻu (Maui) and Manuka (Hawaiʻi) Natural Area Reserves (NARs). ʻŌpae ʻula and *M. lohena have ranges that effectively span across all regions with known anchialine habitats in Hawaiʻi.*.

ABUNDANCE: Abundance of anchialine shrimps in the Waikoloa area has been constant, except for increases in ʻōpae ʻula abundance since 1996. ʻŌpae ʻula is the most abundant anchialine shrimp species, and in good habitat, densities can be hundreds of individuals per square meter. Only a handful of *V. chaceorum* have ever been seen. Because many of the species occur in the interstitial crevices it is difficult to determine the full population size or even spatial extent of populations of these species and no quantitative abundance estimates exist. Overall populations may have declined because many pools have been filled or impacted introduced fishes.

LOCATION AND CONDITION OF KEY HABITAT: Anchialine pond decapods are found in underground (hypogeal) salt waters and in anchialine ponds, which are found in geologically young lava fields near the coast. The porous basalt in these areas commonly have fissures that connect the ponds to the ocean. Thus these ponds are always close to the sea and have varying salinity levels and tidal influence. Most ponds are less than 100 square meters (1000 square feet) in size and less than 1.5 meters (five feet) in depth. Anchialine pond decapods are found in the water column and on the substrate of anchialine ponds as well as in the interstitial spaces that are part of the system linking the pond's water to oceanic influences. Many ponds have been filled or had non-native species introduced. One pond was created accidentally by a large bomb explosion on Kahoʻolawe and subsequently colonized by ʻōpae ʻula through unknown mechanisms as the nearest anchialine ponds are at least ten kilometers (6 miles) away. Possibilities include transport by birds or an already existing underground population. Another

pond was created for use in aquaculture and was colonized by ʻōpae ʻula that turned out to be of a unique genetic make-up, suggesting that the shrimps may have colonized from a previously unknown, but nearby underground source. Thus it is unclear to what extent anchialine ponds are necessary for the survival of ʻōpae ʻula. The ponds may be a source of food for anchialine animals through increased primary productivity as the underground habitat is likely low in productivity without exposure to sunlight.

THREATS:

- Habitat destruction has reduced available habitat for anchialine pond decapods. On the island of Hawaiʻi much development has occurred in the major area for anchialine pools between Kawaihae and Kailua-Kona leading to the filling in of many pools. A monitoring system was set up at Waikoloa to assess the impacts of development there;
- A number of introduced species may compete with native anchialine species for food or may prey on them. Introduced fishes (e.g., tilapia, koi, mosquitofish and guppies) and Tahitian prawns are a major predatory threat and alter the habitat use of native shrimp. It has been estimated that over 90 percent of the anchialine ponds in the Kona coast of Hawaiʻi have been non-native species. The presence of introduced fishes causes the shrimps to retreat into crevices in the substrate. As a result the ponds become overgrown with algae due to decreased grazing byʻōpae ʻula, suggesting that they are a keystone species;
- Pollution of pools by refuse and human use of the water;
- Anchialine pools themselves may thus serve as conduits for pollutants and predatory impacts to the underground areas that may be the primary habitat of these species;
- Collectors taking ʻōpae ʻula to sell for aquarium use or fish feed threaten some ponds.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Fencing the pools in ʻAhihi Kinaʻu NAR, and possibly elsewhere;
- Educating people to the value of, threats to and conservation actions to protect the ponds;
- Restoration of habitat by removal of introduced species;
- Creation of man-made pools should be explored under some circumstances;
- Maintain healthy populations with appropriate regulations and education;
- Closure and rerouting of a portion of the road adjacent to pools in Manuka NAR has been proposed.

MONITORING:

- Continue surveys of population and distribution in known and likely habitats;
- Develop and refine quantitative survey methods.

RESEARCH PRIORITIES:

- Improve understanding of life history of anchialine pond decapods including the importance of ponds vs. underground habitats to the existence and size of decapod populations;
- Understand the ecological importance of interactions between introduced competitors

and predators and native species;
- Investigate the life history of introduced competitors and predators to develop removal or control strategies;
- Partner with the Environmental Protection Agency to develop acceptable alternatives to, or methods to use rotenone in removing introduced fishes.

References:

Bailey-Brock JH, Brock RE. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp, *Halocaridina rubra*. Pacific Science. 47(4):338-345.

Bailey-Brock JH, Brock V, Brock RE. 1999. Intrusion of anchialine species in the marine environment: the appearance of an endemic Hawaiian shrimp, *Halocaridina rubra* on the south shore of Oahu (Hawaiian Islands). Pacific Science 53: 367-369.

Brock RE. 2004. Anchialine resources in two Hawai‘i state NARs: A report prepared for U.S. Fish and Wildlife Service. Honolulu, HI: Environmental Assessment, LLC.

Brock RE, Bailey-Brock JH. 1998. An unique anchialine pool in the Hawaiian Islands. International Reviews in Hydrobiology 83:65-75.

Chai DL, Cuddihy C, Stone C. 1989. An inventory and assessment of anchialine pools in Hawai‘i Volcanoes National Park from Waha‘ula to Ka‘aha, Puna and Ka‘u, Hawai‘i. Technical Report #69. Cooperative National Park Resources Studies Unit. 37 pp. National Park Service Contract No. CA 8015-2-0001.

Maciolek J. 1983. Distribution and biology of Indo-Pacific insular hypogeal shrimps. Bulletin of Marine Science 33:606-618.

Santos, Scott. Auburn University. Personal communication.

Yammamoto M, Tagawa A. 2000. Hawaii’s native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

Marine Mammals

Īlio-holo-i-ka-uaua or Hawaiian monk seal

Neomonachus schauinslandi

SPECIES STATUS:
Federally Listed as Endangered State Listed as Endangered
State Recognized as Indigenous and Endemic
IUCN Red List – Endangered

SPECIES INFORMATION: Īlio-holo-i-ka-uaua, or Hawaiian monk seals, are benthic feeders and feed on reef fishes, octopus, squid, eels, and lobsters over many substrates up to depths of 548 meters (1,800 feet). They are usually solitary, and do not live in groups like other pinnipeds. Monk seals can be seen together on beaches where they haul out to rest, molt, give birth and can becin close proximity to one another and interact. Mating occurs in the spring and early summer. Gestation is approximately one year. Pupping occurs in spring and summer, though can be all year long. Nursing lasts five to six weeks, and pups and mothers stay close to shore until pups are weaned. Most females breed yearly, but after multiple consecutive births, they will skip a year. Sexual maturity occurs at around five to ten years of age, and earliest is at Laysan. Life span is 20 to 25 years of age, with some living up to 30 years. These are the only endangered marine mammals that occur exclusively within the United States, primarily within the Hawaiian Archipelago.

DISTRIBUTION: Hawaiian Monk seals occur in all of the Hawaiian Islands, including a small population (about 400 individuals) in the Main Hawaiian Islands (MHI), although the majority of the population (about 1,200 individuals) and pupping occurs in the Northwestern Hawaiian Islands (NWHI).

ABUNDANCE: The total population is estimated at 1,600 individuals, most of which occur in the NWHI, with a decreasing population trend. About 400 of these seals occur in the MHI, where the population is increasing.

LOCATION AND CONDITION OF KEY HABITAT: Hawaiian monk seals feed primarily in waters around atolls and islands throughout the NWHI and MHI, including within lagoon systems and on reef slopes, submarine ridges and seamounts. Terrestrial habitat is used about one-third of the time and includes haul-out areas for pupping, nursing, molting and resting, primarily on sandy beaches, but virtually all substrates are used. Beach vegetation is used for protection from wind and rain. In 2015, NOAA expanded the critical habitat designation to parts of the MHI, extending protections to 200 meters in depth and 5 meters inland from the shoreline around islands like Kaula, Niʻihau, Kauaʻi, Oʻahu, Maui Nui, and Hawaiʻi Island (NOAA Fisheries, 2015).

THREATS:

- Human disturbance. Capture by humans and disturbance by military activities in the NWHI were once major threats. Harassment of mothers with pups on popular beaches in the MHI is an ongoing threat. Other human-seal interactions that are threatening to the seals on the MHI include intentional feeding, vehicle and boat strikes, and dog attacks.
- Entanglement and fishery interactions. Hooking and entanglement from recreational fisheries and from marine debris are significant sources of mortality. Regulations limiting longline fishing near the NWHI have decreased entanglement. NOAA's stranding response and fishing safety programs have decreased entanglement mortality in the MHI.
- Habitat degradation. Haul-out and pupping beaches in the NWHI are being lost to erosion as a result of sea level rise from climate change and storms.
- Disease. The seals are susceptible or potentially susceptible to disease outbreaks caused by canine distemper, leptospirosis, toxoplasmosis, brucellosis, and West Nile Virus. Toxoplasmosis, a parasite only spread by cats, is a leading cause of seal death in the MHI.
- Predation. Shark predation on seal pups at French Frigate Shoals is a chronic and significant source of mortality.
- Prey availability. Low pup survival rates have been associated with reduced prey resources, potentially due to climate cycles or other oceanographic factors. However, improved survival of young seals in recent years seems to be driving the positive abundance trends.
- Small population size and low genetic diversity exacerbate the other threats.

CONSERVATION ACTIONS: Actions specific to īlio-holo-i-ka-uaua include the continuation of the following:

- Reducing fishery interactions- promoting pono fishing practices and gear modifications such as barbless circle hooks.
- Restoring and conserving habitat to increase prey for Hawaiian monk seals.
- Reducing potential introduction and exposure to infectious diseases.
- Expanding and coordinating education and outreach programs.
- Supporting as-needed capture, rehabilitation and release of sick, injured or emaciated seals.
- Supporting translocation of problem males and pups from low-survival areas to bolster other subpopulations.
- Support and run volunteer programs as well as staff to continue to and monitoring to document and manage the seal population.
- Continuing to remove entanglement hazards & other marine debris from the environment by sustaining DAR's Marine debris rapid response program and the 833-4-Da-Nets removal hotline.

MONITORING: Population monitoring involves ongoing evaluation of population trends and threats, as well as tagging, tracking, and identifying unique markings on adult individuals.

RESEARCH PRIORITIES:

Actions include the continuation of the following:

- Support agencies and local conservation organizations to continue opulation research to enhance survival.
- Partner with agencies and local conservation organizations with foraging and fisheries interaction research to benefit both seals and fishers.
- Partner with agencies and local conservation organizations to understand the mechanisms Toxoplasmosa gondii exposure and infection in monk seals.

References:

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, Mattila DK. 2014. U.S. Pacific

Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

NOAA Fisheries. (2015). Final rule to revise Hawaiian monk seal critical habitat. Retrieved from https://www.fisheries.noaa.gov

NOAA Fisheries. (2023). Hawaiian Monk Seal. National Oceanic and Atmospheric Administration. Retrieved from https://www.fisheries.noaa.gov/species/hawaiian-monk-seal

NOAA Fisheries. (2023). Critical Habitat for Hawaiian Monk Seals. Retrieved from https://www.fisheries.noaa.gov/action/critical-habitat-hawaiian-monk-seals

NOAA Fisheries. (2024). Hawaiian monk seal: Science. Retrieved from https://www.fisheries.noaa.gov/species/hawaiian-monk-seal/science

State of Hawai‘i Division of Aquatic Resources. (2023). Hawaiian monk seal. Retrieved from https://dlnr.hawaii.gov/dar/hawaiian-monk-seal/

Marine Mammals

Humpback whale or Koholā

Megaptera novaeangliae

SPECIES STATUS:
Federally Listed as Endangered (in some populations and delisted in others).
State recognized as Indigenous
IUCN Red List – Least Concern.

SPECIES INFORMATION: Koholā, or humpback whales, migrate to Hawai‘i in the winter to mate, give birth, and nurse their young. Gestation is 11 to 12 months. Females give birth every two to three years. Young are weaned in 8 to 12 months. Females reach maturity at about five to seven years of age. Males sing long-duration and potentially long-distance songs that likely aid in reproduction or other social communication. Little feeding occurs in Hawaiian waters. Life span is 45 years of age or more.

DISTRIBUTION: Kohalā in Hawaiian waters are members of the Central North Pacific stock. Members of this stock winter in Hawaiian waters in December through April, but few individuals can be seen from September through June. In summer they migrate to the nutrient-rich waters off Alaska, Russia, and British Columbia. The greatest concentrations in Hawaiian waters occur off the west side of Maui. The species also occurs in all major oceans from the equator to sub- polar latitudes.

ABUNDANCE: The winter population in Hawaiian waters is estimated at about 11,000 whales, and it is currently unknown if this population is increasing

LOCATION AND CONDITION OF KEY HABITAT: Kohalā prefer warm shallow waters for calving, commonly near offshore reefs, islands, or continental shores. Mothers with calves are first viewed in shallower waters as the calf grows, so does their exploration into deeper waters. Performing males have been found to utilize the Maui Nui region more often as compared to O‘ahu and Kaua‘i, with overall higher sustained seasonal chorusing levels. Feeding grounds are in cold, productive, shallow waters.

THREATS:

- Harassment, and boat strikes, whale-watching boats have harassed and disturbed kohalā. Federal regulations prohibit approaches closer than 100 yards (91 meters) to kohalā, with stiffer fines for violations within the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). In Hawai‘i, vessels collide with kohalā every year, causing injury and mortality, especially to calves.

- Entanglement. Humpbacks are entangled in fishing or mooring gear every years; approximately 30% of it in Hawaiian waters. Entanglement can restrict movement, prevent feeding, cause serious injuries, or drown animals. Underwater noise. essel noise or underwater detonations may interfere with behavior, especially male singing.
- Climate Change: Changes in ocean temperature and prey distribution due to climate change could impact migration, feeding, and breeding patterns

CONSERVATION ACTIONS: Actions specific to conservation of kohalā include the continuation of the following:

- Education and outreach for reducing boat strikes and entanglement. Involves the promotion of vessel speed reduction within sanctuary boundaries through the slogan "Go slow, whales below" a collaborative campaign between HIHWNMS, , DLNR-DAR, DLNR-DOBOR, and Pacific Whale Foundation.
- Reducing marine debris in the marine environment, especially large debris that creates entanglement risks.
- Collaborating with the National Oceanic and Atmospheric Administration (NOAA) on enforcement of the Marine Mammal Protection Act to prevent harassment and disturbance.
- Federal-State partnerships for kohalā conservation, most visibly in the form of management, education, and research with HIHWNMS, including participating in the Large Whale Entanglement Response Program.
- Responding to stranded and deceased humpback whales as part of the Pacific Islands regional stranding partnership.

MONITORING: Actions include partnering with HIHWNMS and other organizations to continue monitoring:

- Abundance and distribution of kohalā.
- Health and injury.

RESEARCH PRIORITIES:

Actions include partnering with HIHWNMS and other organizations to continue researching the following:

- The impact of vessel noise on koholā behavior.
- The impact of vessel operations on koholā.
- Health, especially disease and stress.
- Local feeding patterns.
- The nutrient impact of koholā on the marine food web in Hawai‘i.

References:

Bettridge S, Baker CS, Barlow J, Clapham PJ, Ford M, Gouveia D, Mattila DK, Pace III RM, Rosel PR, Silber GK, and Wade PR. 2015. Status Review of the Humpback Whale (*Megaptera novaeangliae*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC- 540.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, and Mattila DK. 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Carretta JV, et al. 2023. U.S. Pacific Marine Mammal Stock Assessments, 2022. NOAA-TM-NMFS-SWFSC-665.

IUCN Red List of Threatened Species. 2023. www.iucnredlist.org (Accessed November 2024).

Lammers, M.O., Goodwin, B., Kügler, A., Zang, E.J., Harvey, M., Margolina, T., Martinez, J.A., Merkens, K. and Hatch, L.T., 2023. The occurrence of humpback whales across the Hawaiian archipelago revealed by fixed and mobile acoustic monitoring. Frontiers in Marine Science, 10, p.1083583.

National Marine Fisheries Service. 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). Silver Spring, Maryland: Humpback whale recovery team for the National Marine Fisheries Service.

NOAA Fisheries. 2024. Humpback Whale. Available from https://www.fisheries.noaa.gov/species/humpback-whale#:~:text=Lifespan%20&%20Reproduction,to%2016%20feet%20in%20length.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

NatureServe. 2015. NatureServe Explorer: An Online Encyclopedia of Life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available at: http://explorer.natureserve.org. (Accessed May 2015).

Other baleen whales

Balaenoptera acutorostrata (LC) *Balaenoptera borealis* (FE, EN) *Balaenoptera edeni* (LC) *Balaenoptera musculus* (FE, EN) *Balaenoptera physalus* (FE, VU) *Eubalaena japonica* (FE, EN)

SPECIES STATUS:
Federally Listed Endangered (FE)
IUCN Red List - Various (see abbreviations below)
IUCN Endangered (EN) IUCN Least Concern (LC)
IUCN Vulnerable (VU)

SPECIES INFORMATION: Baleen whales are filter feeders and the largest whales found in Hawai‘i. The whales discussed here are the minke whale (*Balaenoptera acutorostrata*), sei whale (*B. borealis*), Bryde’s whale (*B. edeni*), blue whale (*B. musculus*), fin whale (*B. physalus*), and North Pacific right whale (*Eubalaena japonica*). Minke, Bryde’s, blue, and fin whales, known as “gulpers,” feed in separate events, often lunging at large schools of fish. North Pacific right whales are known as “skimmers,” constantly taking in water as they move and filtering out their food. Minke, Bryde’s, blue, and fin whales feed on large schools of fish and krill, whereas North Pacific right whales primarily feed on zooplankton or small shrimps. Sei whales use both skimming and gulping to feed on small fish, krill, squid, and copepods. Baleen whales give birth in winter, with calving intervals of two to three years. Females may mate with more than one male in a season. Gestation periods are 10 to 12 months, and calves wean at six to eight months. Baleen whales usually occur alone or in small groups, although they may congregate in larger groups to feed.

DISTRIBUTION: Bryde’s whale is the only baleen whale in Hawai‘i that is non-migratory and they are most often sighted northwest of the Main Hawaiian Islands (MHI). The others feed at higher latitudes in the summer and migrate to the tropics, including Hawai‘i in the winter to mate or give birth. While here, they tend to be in deeper waters further from shore in small groups or alone.

ABUNDANCE: Abundance estimates in the Hawaiian Islands Exclusive Economic Zone are as follows: sei whale 391, Bryde’s whale 602, fin whale 203, minke whale 438, and blue whale 133. There are no estimates for the North Pacific right whale, and their presence in Hawaiian waters is

rare and/or seasonal.

LOCATION AND CONDITION OF KEY HABITAT: Minke, fin, and North Pacific right whales primarily inhabit coastal and shelf waters, but also can be found in offshore waters. Sei, Bryde's, and blue whales generally occur in coastal, shelf, and oceanic waters

THREATS:

- Whaling. Population declines due to whaling occurred worldwide, although international limits on commercial whaling have greatly reduced this threat.
- Boat strikes and entanglement. Ships colliding with baleen whales and entanglement in fishing gear are significant causes of injury and mortality.
- Marine pollution and debris. Ingestion of marine debris can cause intestinal injury or blockage. Accumulations of tiny, plastic particles containing PCBs and DDEs can cause toxic effects when ingested; this may be particularly dangerous for baleen whales because they take in large quantities of water at a time during feeding.
- Entanglement. Fishing gear poses a major threat to baleen whales, often leading to injury, impaired movement, reduced feeding ability, and sometimes death
- Climate change. Climate change threatens baleen whales by altering their food availability, shifting migration patterns, and increasing exposure to harmful human activities such as ship traffic and fishing gear entanglement.
- Underwater noise. Underwater detonations during military exercises and vessel noise may interfere with feeding and breeding behavior.

CONSERVATION ACTIONS: Actions specific to baleen whales include the continuation of the following:

- Increasing education and outreach to reduce vessel strikes.
- Reducing marine debris and pollutants in the marine environment.
- Collaborating with the National Oceanic and Atmospheric Administration (NOAA) on enforcement of the Marine Mammal Protection Act to prevent marine mammal harassment and disturbance.

MONITORING:

- DLNR will assist agency and local partners with monitoring *Balaenoptera spp*. and Pacific right whales when requested, if staff and resources are available.

RESEARCH PRIORITIES:

- DLNR will assist agency and local partners with researching *Balaenoptera spp*. and Pacific right whales when requested, if staff and resources are available.

References:

Baird, RW. 2016. The lives of Hawa‘i's dolphins and whales: Natural history and conservation. University of Hawai‘i Press, Honolulu, HI.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, and Mattila DK. 2014. U.S. Pacific

Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

IUCN Red List of Threatened Species. 2024. Version 2024.2. www.iucnredlist.org. (Accessed December 2024).

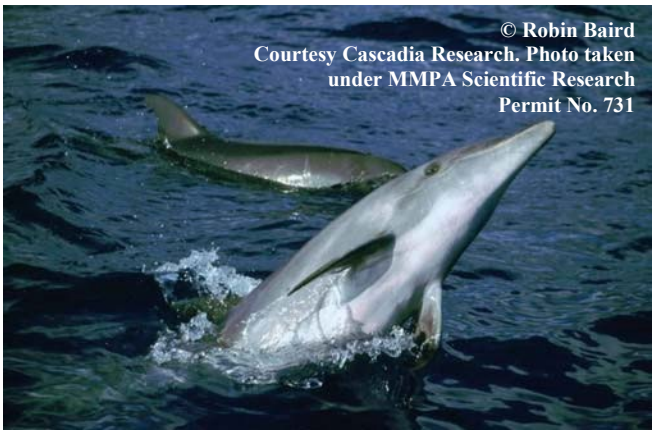
McDermid KJ, McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

NOAA Fisheries. 2024. Find a species. https://www.fisheries.noaa.gov/find-species. (Accessed December 2024).

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

Reeves RR, Smith BD, Crespo EA, Notabartolo di Sciara G. 2003. 2002-2010 Conservation action plan for the world's cetaceans, dolphins, whales and porpoises. Gland, Switzerland: International Union for the Conservation of Nature.

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc.



Marine Mammals

Nai‘a or Bottlenose dolphin

Tursiops truncatus

SPECIES STATUS:
IUCN Red List – Least Concern

SPECIES INFORMATION: Nai‘a, or bottlenose dolphins, feed primarily on benthic fish and invertebrates. They feed cooperatively or alone and obtain prey using methods such as “fish whacking” and steering fish onto mudflats. Like other dolphins, nai‘a give birth year round and gestation lasts approximately a year. Calves are weaned at 18 to 20 months old, but may remain with their mothers for several years after weaning. The minimum calving interval is three years. Nai‘a often associate with other cetaceans, specifically pilot and humpback whales. They will surf waves and ride the bows of vessels, which results in interactions with humans.

DISTRIBUTION: Common throughout the Hawaiian Archipelago. In the Main Hawaiian Islands (MHI), they occur in shallow, inshore waters and in the deeper channels between islands. In the Northwestern Hawaiian Islands (NWHI), they are primarily found in shallower inshore waters. They also occur in temperate and tropical oceans worldwide.

ABUNDANCE: Four independent population stocks occur in Hawaiian waters; abundance estimates are as follows: Kaua‘i/Ni‘ihau 184, O‘ahu 743, Hawai‘i Island 128, 4-Islands (Maui, Lāna‘i, Moloka‘i, Kaho‘olawe) 191, Hawai‘i Pelagic 5,950. Population trends are unknown.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat in Hawai‘i includes nearshore shallow waters, which may be degraded by coastal development and pollution runoff.

THREATS:

- Fisheries interactions. Hooking and entanglement of dolphins in fishing gear are known to cause serious injury and mortality, particularly from longline fisheries. The dolphins are known to take bait and catch from Hawaiian recreational and commercial fisheries, another potential source of injury or mortality.
- Tourist interactions. Close range interaction associated with swim-with-dolphin and dolphin-watching tourism in Hawai‘i may disrupt critical social and resting behavior and decrease energy reserves, which may reduce forage efficiency and ability to care for young.
- Marine pollution and debris. Ingestion of marine debris can cause intestinal injury or blockage. Accumulation of tiny, plastic particles containing PCBs and DDEs can cause toxic effects from ingestion.
- Disease. Toxoplasmosis caused by *Toxoplasma gondii* is a growing concern. This parasite, transmitted via contaminated cat feces that enter the ocean, can

lead to illness and death in dolphins and other marine mammals.
- Habitat degradation. Habitat is degraded as a result of coastal development and runoff into estuaries and bays.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include the continuation of the following:

- Continuing to run DAR's marine debris hotline program and work with partners to reduce marine debris.
- Continue education and outreach campaigns about entanglement and vessel strikes. Continue education and outreach activities on the cetaceans of Hawai‘i.
-
- Continue to collaborate with NMFS on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance.
- Continue to respond to stranded dolphins as part of the Pacific Islands regional stranding partnership.

MONITORING:

Actions include the continuation of the following:

- DLNR will assist agency and local partners with monitoring bottlenose dolphins when requested, if staff and resources are available.

RESEARCH PRIORITIES:

DLNR will assist agency and nonprofit partners with research on bottlenose dolphins when requested and if staff and resources are available.

References:

Baird RW, Gorgone AM, McSweeney DJ, Ligon AD, Deakos MH, Webster DL, Schorr GS, Martien KK, Salden DR, and Mahaffy SD. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25:251-274.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell RL Jr., and Mattila DK. 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Constantine R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (Tursiops truncatusi) due to long-term exposure to swim-with-dolphin tourism. Marine Mammal Science 17 (4): 689-702.

Constantine R, Brunton DH, Dennis T. 2004. Dolphin-watching tour boats change bottlenose dolphin (Tursiops truncatus) behaviour. Biological Conservation 117 (3): 299-307.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

McDermid KJ, and McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc.

Marine Mammals

False killer whale

Ka Palaoa

Pseudorca crassidens

SPECIES STATUS:
Federally Listed as Endangered – Main Hawaiian Insular Distinct Population Segment (DPS)
State Listed as Endangered
Marine Mammal Protection Act - Depleted
IUCN Red List – Near Threatened

SPECIES INFORMATION: False killer whales (*Pseudorca crassidens)* are known to inhabit a broad range of depths in Hawai‘i from shallow waters near the shore to deep offshore waters. In Hawai‘i they feed on mahi mahi, yellowfin tuna, and many other pelagic gamefish, often sharing food. To increase the success of finding prey, they travel in a wide sweeping manner up to several kilometers wide. They have low reproductive rates: females give birth to a single calf every six to seven years and go into menopause in their 40s. Gestation is 14 months and lactation lasts for at least one and half to two years. Females reach sexual maturity around ten years, and males much later at 18 years. Maximum life span has been estimated at 58 years for males and 62 for females. They form strong social bonds, and are usually found in subgroups of 50 to 10 that belong to larger groups of 20 or more individuals. False killer whales around the main Hawaiian Islands are reproductively and genetically isolated from other populations in the Pacific, and this distinct population segment (DPS) is referred to as the Main Hawaiian Islands insular DPS of false killer whales (MHI insular false killer whales)..

DISTRIBUTION: False killer whales are found in tropical and warm temperate waters worldwide. There are three distinct populations of false killer whales around the Hawaiian Islands, with partially overlapping ranges. The Main Hawaiian Islands insular DPS is federally listed as endangered. The Hawai‘i pelagic population is primarily found in offshore waters. The Northwestern Hawaiian Islands population is primarily found in waters around the Northwestern Hawaiian islands (NWHI) and occasionally visits Kaua‘i.

ABUNDANCE: The endangered MHI insular false killer whale population is the smallest of the three populations, with approximately 139 individuals, declining by about 3.5% per year. The non-listed Hawai‘i pelagic population contains an estimated 2,086 individuals. The Northwestern Hawaiian Islands stock is estimated at about 552 whales; the population trend is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Cascadia Research Collective has tagged over 80 MHI insular false killer whales and tracked them via satellite to discover where

they aggregate. Results show that MHI insular false killer whales range across depths of 25 – 2,700 fathoms and concentrate off of the north side of Oʻahu, Molokaʻi, Maui, and Hawaiʻi Island, as well as southwest of Lānaʻi. These findings suggest where the efforts should be focused to monitor and mitigate false killer whale bycatch.

THREATS:

- Fisheries interactions. Injury and mortality can be caused by the accidental hooking and/or entanglement of whales in fishing gear. False killer whales are known to steal fish like ahi and mahi mahi off of trolling lines, which has occasionally resulted in intentional shooting of the whales by fishers. To reduce mortality and injury of pelagic FKW in Hawaiian longline fisheries, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) created a Take Reduction Plan in 2012, as directed by the Marine Mammal Protection Act. The plan describes gear requirements, potential time-area closures, and improved responses to hooked and entangled false killer whales.
- Marine debris. The entanglement in marine debris can lead to injury or mortality. The ingestion of marine debris can cause intestinal injury or blockage.
- Environmental contamination. False killer whales accumulate high levels of toxins from the marine environment, leading to health and reproductive issues. FKW are exposed to chemicals that persist globally and are transported through air and ocean currents, that they obtain from ingesting contaminated prey.
- Climate change. Rising ocean temperatures and ocean acidification from climate change could result in lower ocean productivity and decreased food availability.
- Small population size. The small size of the endangered main Hawaiian Islands insular false killer whale population increases its vulnerability to diseases, environmental changes, and genetic bottlenecks, while also threatening cooperative feeding due to insufficient group size for finding adequate food.

CONSERVATION ACTIONS: Actions specific to false killer whales include the continuation of the following:

- Continue to run DAR's marine debris hotline and work with partnes to reduce marine debris and pollutants in the marine environment.
- Reduce fishery interactions through education and outreach campaigns.
- Collaborate with NMFS on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance.
- Collaborate with agencies, NGO partners, and local organizations working on cetacean conservation and education.
- Collaborate with agency, NGO partners and local organizations on the implementation of the NMFS False Killer Whale Take Reduction Plan to reduce bycatch of pelagic Hawaiian false killer whales in commercial longline fisheries.
- Collaborate with agency, NGO partners, and local organizations on the implementation of the NMFS Final Recovery Plan for the main Hawaiian Islands insular false killer whale
- Respond to stranded false killer whales as part of the Pacific Islands regional stranding partnership.

MONITORING:

Actions include the continuation of the following:

- Monitoring abundance and distribution of false killer whales in Hawaiian waters.

- Monitoring entanglement and fisheries bycatch.
- Monitoring observations of MHI insular FKW.

RESEARCH PRIORITIES:

Actions include the continuation of the following:

- Collaborating with scientists and the on-water community to understand the movements, behavior, and social structure of Hawaiian false killer whales.
- Collaborating with scientists and the on-water community to identify high-use areas of habitat in the main Hawaiian Islands, especially near Fish Aggregating Devices.
- Collaborating with scientists to try to study Hawaiian false killer whale physiology, including stress and the impact of marine pollutants on reproductive success.
- Collaborating with commercial fishers to study MHI insular false killer whales.

References:

Badger JJ, Baird RW, Johnson DS, Bradford AL, Mahaffy SD, Kratofil MA, Cullins T, Currie JJ, Stack SH, Oleson EM. 2025. Accounting for sampling bias reveals a decline in abundance of endangered false killer whales in the main Hawaiian Islands. Endangered Species Research 57:325–340.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, and Mattila DK. 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

Hawaii Division of Aquatic Resources. 2023. Protected species spotlight: False killer whales. https://dlnr.hawaii.gov/dar/10-16-23-hawaiis-false-killer-whales/

IUCN Red List of Threatened Species. 2024.. www.iucnredlist.org. (Accessed November 2024).

McDermid KJ, and McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

National Marine Fisheries Service. 2012. Taking of marine mammals incidental to commercial fishing operations; false killer whale take reduction plan. Final Rule. Federal Register 77:71260-71286.

National Marine Fisheries Service. 2023. False killer whale. Retrieved from https://www.fisheries.noaa.gov/species/false-killer-whale#:~:text=All%20false%20killer%20whales%20are,(ESA)%20and%20the%20MMPA.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

Odell DK, McClune KM. 1999. False killer whale – *Pseudoorca crassidens* (Owen, 1846). pp. 213-244. In: S Ridgeway and Sir R Harrison eds. Handbook of marine mammals. Volume 6. The second book of dolphins and the porpoises. London, UK: Academic Press.

State of Hawaii Division of Aquatic Resources. 2023. Protected Species Spotlight: False Killer Whales. Retrieved from https://dlnr.hawaii.gov/dar/10-16-23-hawaiis-false-killer-whales/

Oleson EM, Boggs CH, Forney KA, Hanson MB, Kobayashi DR, Taylor BL, Wade PR, and Ylitalo GM. 2010. Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered

Species Act. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-22.

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to Marine Mammals of the World. New York, NY: Alfred A. Knopf, Inc.

Marine Mammals

Short-finned pilot whale

Globicephala macrorhynchus

SPECIES STATUS:

IUCN Red List - Least Concern

SPECIES INFORMATION: Short-finned pilot whales (*Globicephala macrorhynchus*) feed primarily on squid, but they also feed on octopus and fish, all from moderately deep water. When they are swimming and looking for food, pilot whales form ranks that can be over a kilometer (one mile) long . They are polygynous and are often found in groups with a ratio of one mature male to about every eight mature females. Females have gestation periods of approximately 15 months and lactate for at least two years. The last calf born to a mother may be nursed for as long as 15 years. The calving interval is five to eight years, but older females do not give birth as often as younger females. These whales form schools of 15 to 50. Additionally, they commonly associate with other cetaceans, such as the bottlenose dolphin.

DISTRIBUTION: Short-finned pilot whales are found throughout Hawai‘i. Possible resident populations are located off the coast of Kona on the island of Hawai‘i and off southwest Lāna‘i.

ABUNDANCE: The 2020 NOAA Stock Assessment Report estimates short-finned pilot whale abundance at 12,607 within the Hawaiian Islands exclusive economic zone, with an unknown population trend.

LOCATION AND CONDITION OF KEY HABITAT: Short-finned pilot whales are found primarily in the deep waters off of the Main Hawaiian Islands. Areas with high density of squid are their primary foraging habitats. Currently their key habitat condition can be considered stable, with no habitat issues of concern.

THREATS:

- Fishery bycatch is a threat to short-finned pilot whales in Hawai‘i. They interact with the longline fishery, the bottomfish fishery, and squid fisheries that use drift and gill nets and seines in the NWHI, but whether these interactions result in death or injury are unknown. This threat needs to be further investigated. They also steal bait and catch from fisherman, which can result in intentional killing of these whales.
- Marine debris, such as tiny plastic particles that accumulate in the Hawaiian Archipelago, is a significant threat to short-finned pilot whales. Not only do these particles contain harmful chemicals such as PCBs and DDEs, but when ingested they also can cause a variety of effects such as internal injury and intestinal blocking. Marine

debris such as derelict fishing gear can entangle whales, often resulting in injury or death.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include the continuation of the following:

- Continue to run DAR's marine debris hotline and work with partners to decrease marine debris.
- Continuing to collaborate with NMFS on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance.
- Continue education and outreach activities on the cetaceans of Hawai‘i.
- Continue to respond to stranded pilot whales as part of the Pacific Islands regional stranding partnership.

MONITORING:
DLNR will assist agency and local partners with monitoring short-finned pilot whales when requested, if staff and resources are available.

RESEARCH PRIORITIES:
DLNR will assist agency and nonprofit partners with research on short-finned pilot whales when requested and if staff and resources are available.

References:

Baird RW, McSweeney DJ, Webster DL, Gorgone AM, Ligon AD. 2003. Studies of odontocete population structure in Hawaiian waters: results of a survey through the Main Hawaiian Islands in May and June 2003. Seattle, WA: National Oceanic and Atmospheric Administration, Western Administrative Support Center.

Barlow J. 2003. Cetacean abundance in Hawaiian waters during summer/fall of 2002. Administrative Report. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. Report nr LJ-03-12. 20 pp.

Bernard HJ, Reilly SB. 1999. Pilot whales *Globicephala* Lesson, 1828. pp. 245-279 In: S Ridgeway and Sir RHarrison editors. Handbook of marine mammals. Volume 6. The second book of dolphins and the porpoises. London, UK: Academic Press.

Carretta JV, Muto MM, Barlow J, Baker J, Forney KA, Lowry M. 2002. U.S. Pacific marine mammal stock assessments. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-346. 290 pp.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

Marine Mammal Science Journal (2021). Impacts of Marine Debris and Noise Pollution on Cetaceans.

McDermid K J McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

NOAA 2022. U.S. Pacific Marine Mammal Stock Assessments. Latest stock and population data available from NOAA's database.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock.

https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

NOAA Fisheries. 2023. Short-finned pilot whale. 2024. https://www.fisheries.noaa.gov/species/short-finned-pilot-whale. (Accessed December 2024).

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc. 527 pp.

Roberts AC, Meadows DW. 2003. Distribution and abundance of short-finned pilot whales (Globicephala macrorhynchus) and other odontocetes in the four-island region of Hawaii. Maui, Hawai‘i: Pacific Whale Foundation. 19 pp.

Marine Mammals

Nai‘a or Spinner dolphin

Stenella longirostris

SPECIES STATUS:
IUCN Red List - Least Concern

SPECIES INFORMATION: Nai‘a or spinner dolphins (*Stenella longirostris*) congregate into large groups and swim offshore to depths of 200 to 300 meters (650 to 1,000 feet) to feed on mesopelagic prey that includes squid, small fish and shrimp. Although in large groups, they also feed in cooperative pairs or groups of pairs offshore. This foraging begins in late afternoon and continues throughout the night as the “deep scattering layer” moves closer to the surface and shore. During the day, they expend less energy by resting or socializing in nearshore, shallow waters such as bays and lagoons surrounded by reefs. They also may stay in their nearshore habitat to avoid predators such as sharks and killer whales. The change in group size from daytime activities to nighttime feeding is unique to Hawaii’s spinner dolphins. Although spinner dolphins are able to give birth at any time during the year, they typically show one or more seasonal peaks. Multiple males may mate with one female in short, consecutive intervals. Gestation lasts approximately 11 months and lactation occurs for one to two years. The calving interval is approximately three years. Additionally, the spinner dolphin is very notable for its ability to leap high out of the water while also spinning multiple times on its longitudinal axis.

DISTRIBUTION: Historically, spinner dolphins were located throughout Hawai‘i. The current distribution of spinner dolphins throughout the entire Hawaiian Archipelago is shown as five distinct stocks; Midway Atoll/Kure, Pearl and Hermes Reef, Ni’ihau/Kauai, Oahu/4-Islands region, and Hawai’i Island. These dolphins travel along the coast of each island or island region. A large “resident” population occurs off the coast of Kona on the island of Hawai‘i and a smaller group off Kahena and Hilo on the east side. On O‘ahu, dolphins are found off of Wai‘anae on the west coast, and along the southern shores. On Lāna‘i, the dolphins are primarily found on the South Shore, specifically spending time in Mānele Bay, and on Maui, groups can be found around Honolua and La Perouse bays.

ABUNDANCE: Abundance estimates vary. The 2018 NOAA Stock Assessment Report estimates the total population abundance in Hawai‘i at approximately 3,200, with an unknown trend

LOCATION AND CONDITION OF KEY HABITAT: Hawai‘i spinner dolphins are found in nearshore habitats such as bays and lagoons during the day and deeper, offshore waters for feeding at night. They feed in water depths of 200 to 300 meters (650 to 1000 feet) and along edges of banks. Conditions of nearshore habitat are location dependent, but generally stable; however, development, pollution runoff, and other habitat altering conditions could negatively affect their daily activities. The condition of their feeding ground habitat is less well known. Studies have shown that dolphins use nearshore habitat opportunistically; thus, they can shift their locations based on disturbance to the area, making them relatively able to survive changes to habitat. However, the long-term implications of such changes on the life history of local populations are presently poorly understood.

THREATS:

- The tourism industry’s swim-with-dolphin and dolphin-watching programs pose a significant threat to spinner dolphins in Hawai‘i due to the close range interaction with the dolphins by humans and boats. These interactions have been shown to disrupt critical resting behaviors. This reduction in rest can result in decreased energy reserves that in turn affect abilities to forage efficiently and provide care for their young. Spinner dolphins may also abandon their habitats as a result of being repetitively disturbed by swim-with-dolphin and other tourism related interactions.
- Fishery bycatch of spinner dolphins in inshore monofilament gillnets (laynets) is another important threat. The extent of this threat is unknown and needs to be further investigated.
- Marine debris, such as tiny plastic particles that accumulate in the Hawaiian Archipelago, is a significant threat to spinner dolphins. Not only do these particles contain harmful chemicals such as PCBs and DDEs, but when ingested they also can cause a variety of effects such as internal injury and intestinal blocking. Marine debris such as derelict fishing gear entangles the dolphins leading to injury or death;
- Man-made noise is a threat that results from high vessel traffic and military vessels that use Hawaiian waters for operations involving sonar. This man-made noise can interfere with acoustic signals critical to dolphins’ reproduction and feeding. Man-made noises also have been shown to cause disturbance responses, hearing loss, and physical harm;
- Vessel collisions are also a threat. High volumes of commercial traffic as well as recreational traffic throughout the Main Hawaiian Islands can lead to increased collisions with marine mammals.
- Habitat degradation from coastal development and run-off is also a threat particular to spinner dolphins as they primarily live in nearshore waters. Diseases such as *Toxoplasma gondii* have been found in stranded spinner dolphins in Hawai‘i, off O‘ahu and Hawai’i island, with a strain found in feral pigs on O‘ahu.

CONSERVATION ACTIONS: The goal of conservation actions to not only protect current populations, reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include the continuation of the following:

- Support education and outreach activities, such as NOAA’s “Ocean Etiquette” program, to promote dolphin-friendly ecotourism.
- Continue to collaborate with NMFSon enforcement of the Marine Mammal Protection Act as it relates to preventing spinner dolphin harassment and disturbance.
- Continue DAR’s marine debris hotline and other programs decrease marine debris.

- Collaborate with partners to decrease pollutants, chemicals, and diseases that affect cetaceans in the marine environment.
- Continue to respond to stranded dolphins as part of the Pacific Islands regional stranding partnership.

MONITORING:

DLNR will assist agency and local partners with monitoring spinner dolphins when requested if staff and resources are available.

RESEARCH PRIORITIES:

DLNR will assist agency and nonprofit partners with research on spinner dolphins when requested and if staff and resources are available.

References:

Andrews, Kimberly R., Leszek Karczmarski, Whitlow W. L. Au, Susan H. Rickards, Cynthia A. Vanderlip, Brian W. Bowen, E. Gordon Grau, and Robert J. Toonen. 2010. Rolling Stones and Stable Homes: Social Structure, Habitat Diversity and Population Genetics of the Hawaiian Spinner Dolphin (Stenella Longirostris): GENETIC STRUCTURE OF HAWAIIAN SPINNER DOLPHIN. Molecular Ecology 19 (4): 732–48. https://doi.org/10.1111/j.1365-294X.2010.04521.x.

Andrews, Kimberly R., Leszek Karczmarski, Whitlow W. L. Au, Susan H. Rickards, Cynthia A. Vanderlip, and Robert J. Toonen. 2006. Patterns of Genetic Diversity of the Hawaiian Spinner Dolphin. Atoll Research Bulletin.

Barlow J. 2003. Cetacean abundance in Hawaiian waters during summer/fall of 2002. Administrative Report. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. Report nr LJ-03-12. 20 pp.

Bazúa-Durán C, Au W. 2004. Geographic variations in the whistles of spinner dolphins (*Stenella longirostris*) of the Main Hawaiian Islands. Journal of Acoustical Society of America 116 (6):3757-3269.

Carretta JV, Muto MM, Barlow J, Baker J, Forney KA, Lowry M. 2002. U.S. Pacific marine mammal stock assessments. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-346. 290 pp.

Constantine R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatusi)* due to long-term exposure to Swim-With-Dolphin tourism. Marine Mammal Science 17 (4): 689-702.

Constantine R, Brunton DH, Dennis T. 2004. Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. Biological Conservation 117 (3): 299-307.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

Lammers, Marc O. 2004. "Occurrence and Behavior of Hawaiian Spinner Dolphins (*Stenella Longirostris*) Along Oahu's Leeward and South Shores. Aquatic Mammals 30 (2): 237–50. https://doi.org/10.1578/AM.30.2.2004.237.

Landrau-Giovannetti N, Waltzek TB, López-Orozco N, Su C, Rotstein D, Levine G, Rodrigues TCS, Silva-Krott I, Humann C, West K. Prevalence and genotype of Toxoplasma gondii in stranded Hawaiian cetaceans. Dis Aquat Organ. 2022 Nov 17;152:27-36. doi: 10.3354/dao03699. PMID: 36394138.

Lammers MO. 2004. Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu's leeward and south shores. Aquatic Mammals 30 (2): 237-250.

McDermid K J, McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

NOAA Fisheries. 2023. Spinner dolphins. https://www.fisheries.noaa.gov/species/spinner-dolphin. (Accessed December 2024).

Ostman-Lind J, Driscoll-Lind AD, Rickards SH. 2004. Delphinid abundance, distribution, and habitat use off the western coast of the island of Hawaii. Seattle, WA: National Oceanic and Atmospheric Administration, Western Administration Support Center. NOAA Contract No. AB133F-02-CN-0123. 29 pp.

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc. 527 pp.

Marine Mammals

Kiko or Spotted dolphin

Stenella attenuata

SPECIES STATUS:
IUCN Red List - Least Concern

SPECIES INFORMATION: Kikoor the spotted dolphin (*Stenella attenuata*) found in Hawaiian waters is considered one of three subspecies of *Stenella attenuata*. The diet of spotted dolphins in Hawai‘i has been studied very little, but it appears that they feed primarily on mesopelagic cephalopods and fish. Studies show that although spotted dolphins may forage during the day, they appear to be more active feeders at night, diving deeper and longer. Spotted dolphins can be associated with yellowfin tuna, however, not as tightly as spotted dolphins in the Eastern Tropical Pacific. Females become reproductively active between age of nine and eleven, meanwhile, males mature by twelve to fifteen years. Spotted dolphins give birth to calves year-round with a few seasonal peaks. They have an 11-month gestation period. Lactation often takes place for two years, but also can last for only one year. At three to six months, however, calves will begin taking solid food. Calving intervals depend on the population, but range from two and a half to four years. During the day, spotted dolphins usually remain in shallower, nearshore waters around Maui ranging from 100 to 300 meters (330 to 1000 feet) deep, but they primarily stay within the top ten meters (33 feet) of the water column. Around the other islands they occur at 1500-2000m (5000 to 6300 feet) deep during daylight (Robin Baird, personal communication). They also are less active during this time. They are usually in small groups averaging approximately 40 individuals and can even be found mixed up in a group of spinner dolphins, rough-toothed dolphins, or bottlenose dolphins

DISTRIBUTION: They are found throughout the Hawaiian Islands, often off leeward coasts. They have small home ranges and may not move between islands. There are three reproductively isolated stocks found along; Oahu, Maui Nui (4-islands), and Hawa’i island. Meanwhile spotted dolphins off Kaua’i and Ni’ihau may be part of a pelagic population.

ABUNDANCE: There are no current NOAA estimates of the O‘ahu, 4-Islands, Hawai‘i Island stocks. The 2017 NOAA Stock Assessment estimates of the Hawai‘i Pelagic stock is 39,798, which includes the population within the Hawai‘i Exclusive Economic Zone. Population tends are unknown

LOCATION AND CONDITION OF KEY HABITAT: Spotted dolphins spend the majority of their day in nearshore, shallower water habitats typically between 90 to 300 meters (300 to 1,000 feet) deep. They can be found in deeper water habitats off of the island of Hawai‘i, Kaua‘i, Lāna‘i, and Ni‘ihau. At night they move further offshore into deeper waters to search for prey and dive to deeper depths than they do during the day. They are often found in locations that

have the highest prey density. The condition of their habitat is currently stable with no known habitat concerns.

THREATS: Spotted dolphins face a variety of threats similar to other cetaceans in Hawai‘i; however, direct and indirect take of spotted dolphins in Hawaiian fisheries appears minimal, but these interactions are rarely reported and could be underestimated. Significant threats include the following:

- Tourism-related interactions with dolphins such as tour boats and swim-with-dolphin programs represent a threat. Feeding, breeding, and social behaviors can be disrupted by the close range, high volume vessel traffic and the large numbers of swimmers, especially since spotted dolphins rest during the daytime. Marine debris, such as tiny plastic particles that accumulate in the Hawaiian Archipelago, is a significant threat to spotted dolphins. Not only do these particles contain harmful chemicals such as PCBs and DDEs, but when ingested they also can cause a variety of effects such as internal injury and intestinal blocking. Marine debris such as derelict fishing gear entangles the dolphins often resulting in injury or death;
- Man-made noise is a threat that results from high vessel traffic and military vessels that use Hawaiian waters for operations involving sonar. This man-made noise can interfere with acoustic signals critical to dolphins' reproduction and feeding. Man- made noises also have been shown to cause disturbance responses, hearing loss and physical harm;
- Habitat degradation from coastal development and run-off is also a threat as spotted dolphins can live in nearshore waters.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include the continuation of the following:

- Continue running DAR's marine debris hotline and working with partners to decrease marine debris;
- Continue to collaborate with NMFS on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance;
- Work with partners to decrease pollutants and chemicals in the marine environment;
- Continue to respond to stranded dolphins as part of the Pacific Islands regional stranding partnership.
- e Continue education and outreach activities on the cetaceans of Hawai‘i.t

MONITORING:
DLNR will assist agency and local partners with monitoring spotted dolphins when requested if staff and resources are available.

RESEARCH PRIORITIES:
DLNR will assist agency and nonprofit partners with research on spotted dolphins when requested and if staff and resources are available

References:

Baird, Robin. Cascadia Research Collective. Personal Communication.

Baird, RW. 2016. The lives of Hawa‘i's dolphins and whales: Natural history and conservation. University of Hawai‘i Press, Honolulu, HI.

Baird RW, Ligon AD, Hooker SK, Gorgone AM. 2001. Subsurface and nighttime behavior of pantropical spotted dolphins in Hawaii. Canadian Journal of Zoology 79: 988-996.

Barlow J. 2003. Cetacean abundance in Hawaiian waters during summer/fall of 2002. Administrative Report. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. Report nr LJ-03-12. 20 pp.

Carretta JV, Muto MM, Barlow J, Baker J, Forney KA, Lowry M. 2002. U.S. Pacific marine mammal stock assessments. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-346. 290 pp.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

McDermid K J McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc. 527 pp.

Marine Mammals

Other Toothed Whales

Feresa attenuata (LC)
Grampus griseus (LC)
Indopacetus pacificus (LC)
Kogia breviceps (LC)
Kogia sima (LC)
Lagenodelphis hosei (LC)
Mesoplodon densirostris **(LC)**
Orcinus orca (DD)
Peponocephala electra **(LC)**
Physeter macrocephalus (FE, SE, VU)
Stenella coeruleoalba **(LC)** ***Steno bredanensis*** **(LC)** ***Ziphius cavirostris*** **(LC)**

SPECIES STATUS:

Sperm whale (*Physeter macrocephalus*) is Federally and State Listed as Endangered (FE, SE)
IUCN Red List - Various (see abbreviations below)
IUCN Least Concern
(LC) IUCN Vulnerable
(VU)

SPECIES INFORMATION: The other toothed whales of Hawai‘i besides the spotted, bottlenose, and spinner dolphins and false killer and short-finned pilot whales, which are considered in separate fact sheets, are: pygmy killer whales (*Feresa attenuata*), Risso’s dolphins (*Grampus griseus*), Longman’s beaked whales (*Indopacetus pacificus*), pygmy sperm whales (*Kogia breviceps*), dwarf sperm whales (*Kogia sima*), Fraser’s dolphins (*Lagenodelphis hosei*), Blainville’s beaked whales (*Mesoplodon densirostris*), killer whales (*Orcinus orca*), melon-headed whales (*Peponocephala electra*), sperm whales (*Physeter macrocephalus*), striped dolphins *(Stenella coeruleoalba),* rough-toothed dolphins (*Steno bredanensis*), and Cuvier’s beaked whales (*Ziphius cavirostris*). Feeding habits vary for these toothed whales. The sperm whale feeds on a variety of prey types including large squid, sharks, demersal rays, and bony fish, while the pygmy and dwarf sperm whales feed on smaller cephalopods and crustaceans. The beaked whales and the majority of the ocean dolphins feed on squid and small fishes. Some also feed on crustaceans. They also differ in their foraging behaviors. The sperm whales, nai‘a, Fraser’s, and Risso’s dolphins and Cuvier’s beaked and melon-headed whales all feed in deep waters. The striped dolphin has a more diverse diet and feeds throughout the water column. Killer whalesh ave the most diverse diet of all the toothed whales, feeding on schooling fish,

squid, sharks, and large baleen whales; they also feed cooperatively. There is little information about reproduction for pygmy killer whales; Longman's, Blainville's, and Cuvier's beaked whales; Risso's and Fraser's dolphins; and rough-toothed whales. Gestation lasts for one year for the pygmy and dwarf sperm whales, striped dolphin, and melon-headed whale. Most species care for a single calf at a time. The killer and sperm whales are sexually mature after 11 years of age. The sperm whale breeds in the tropics and gives birth in the spring. Killer whale calves are nursed for a year. Striped dolphins care for their young in groups of about 30, and calving intervals are four years. Some of these whales, such as the pygmy and dwarf sperm whales, are solitary, while others such as the killer whale, Fraser's dolphin, and melon-headed whale form large social groups. The killer whale, sperm whale, and Longman's beaked whale form strong social bonds.

DISTRIBUTION: Pygmy killer whales have been sighted off Niʻihau, Oʻahu, Maui, and the island of Hawaiʻi. Risso's dolphins are rare and have been sighted off the coast of Kona. Longman's beaked whales and Fraser's dolphins have not been recorded in nearshore Hawaiian waters, but they occur in offshore waters and may be occasional visitors. Pygmy and dwarf sperm whales, Blainville's and Cuvier's beaked whales, and rough-toothed whales are found throughout the Main Hawaiian Islands (MHI). Killer whales are only occasional visitors to Hawaiʻi but have been sighted off Kauaʻi, the Waiʻanae coast of Oʻahu, southwest Lānaʻi, and off Kona, Hawaiʻi. Melon- headed whales are common throughout the MHI, with groups sighted off of the Waiʻanae coast, southwest Lānaʻi, and Kona. The sperm whale is found throughout the MHI and the Northwestern Hawaiian Islands (NWHI). The striped dolphin has been seen off Niʻihau and west of Oʻahu.

ABUNDANCE: Abundance estimates in the Hawaiian Islands Exclusive Economic Zone are as follows: pygmy killer whale 10,328, Risso's dolphin 7,385, Longman's beaked whale 2,550, Fraser's dolphin 40,960, Blainville's beaked whale 1,132, killer whale 146, melon-headed whale 447, sperm whales 5,707, striped dolphin 35,179, rough-toothed whales 76,375, Cuvier's beaked whale 4,431, pygmy sperm whales 42,083, and dwarf sperm whales (unidentified *Kogia)* 53,421. There are no available data on population trends in Hawaiian waters.

LOCATION AND CONDITION OF KEY HABITAT: Most of these species except striped dolphins, dwarf sperm whales, and killer whales live only in deep (e.g., >100 meters depth), oceanic waters but can occur within state waters, especially in areas with steep drop-offs like off much of Hawaiʻi and Southwest Maui County.

THREATS:

- Boat strikes and entanglement. Ships colliding with whales (most notably, sperm whales), and entanglement in fishing gear (both operational and derelict gear) such as drift gillnets, longlines, and purse seines are major threats, causing injury and mortality.
- Underwater noise. Sonar transmissions from military vessels, underwater detonations during military exercises, and vessel noise may interfere with behavior, and result in physical harm or loss of hearing sensitivity. Deep-diving whales like Cuvier's and Blainville's beaked whales appear to be especially sensitive to noise.
- Marine pollution and debris. Ingestion of marine debris can cause intestinal injury or

blockage. Accumulations of tiny, plastic particles containing PCBs and DDEs can cause toxic effects when ingested.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include the continuation of the following:

- Working with partners on outreach and education about educing vessel strikes and entanglement.
- Continuing to run DAR's marine debris hotline and workign with partners to reduce educing marine debris.
- Continue to collaborate with NMFS on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance;
- Continue education and outreach activities on the cetaceans of Hawai‘i.
- Continue to respond to stranded cetaceans as part of the Pacific Islands regional stranding partnership.

MONITORING:

- DLNR will assist agency and local partners with monitoring the toothed whale species, above, when requested, if staff and resources are available.

RESEARCH PRIORITIES:

- DLNR will assist agency and local partners with researching the toothed whales species, above, when requested, if staff and resources are available.

References:

Baird RW. 2005. Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the Main Hawaiian Islands. Pacific Science 59 (3): 461-466.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, Mattila DK. 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: Diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42 (12): 1301-1312.

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

McDermid K J, McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

Migura KA, Meadows DW. 2002. Short-finned pilot whales (*Globicephala macrorhynchus*) interact with melon-headed whales (*Peponocephala electra*) in Hawai‘i. Aquatic Mammals 28(3): 294-297.

NOAA Fisheries. (2024a, October 2). Marine mammal stock assessment reports by species/stock. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-species-stock#cetaceans---large-whales. (Accessed December 2024).

Reeves RR, Smith BD, Crespo EA, Notabartolo di Sciara G. 2003. 2002-2010 Conservation action plan for the world's cetaceans, dolphins, whales and porpoises. Gland, Switzerland: International Union for the Conservation of Nature.

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York, NY: Alfred A. Knopf, Inc.

Roberts AC Meadows DW. 2003. Distribution and abundance of short-finned pilot whales (*Globicephala macrorhynchus*) and other odontocetes in the four-island region of Hawai'i. Maui: Hawaii: Pacific Whale Foundation.

Courtesy NMFS

Marine Reptiles

Honu or Green sea turtle

Chelonia mydas

SPECIES STATUS:
Federally-Listed as Threatened
State Listed as Threatened
State Recognized as Indigenous
IUCN Red List as Endangered, Globally

SPECIES INFORMATION: Mature males are distinguished from females by their longer, thicker tails. Little information exists on the feeding behavior of post-hatchlings and juveniles in pelagic waters, but most likely they are exclusively carnivorous (e.g., soft-bodied invertebrates and fish eggs). Subadult and adult turtles in nearshore benthic environments are almost completely herbivorous; feeding primarily on macroalgae and seagrasses. Research from the Caribbean suggests that green sea turtles are a keystone species that help to maintain healthy seagrass beds. Hawaiian honu exhibits slow growth rates, even compared to other populations, with an average annual growth rate of 1–5 centimeters (0.5 to 2 inches) per year. Turtles reach sexual maturity at about 35 to 40 years of age. Females in the Northwestern Hawaiian Islands (NWHI) breed once every two or more years, while males may breed every year. Honu mate at sea and approximately 25 to 35 days after mating females swim onshore to excavate a nest and lay eggs. Females may lay up to six clutches per season, often returning to the same site for each clutch every 12 to 15 days. Each clutch contains 100 eggs and sex determination is temperature-dependent. Incubation takes about 60 days and hatchlings emerge from their nests at night. Both males and females often haul out between nesting intervals to bask in the sun.

DISTRIBUTION: Occurs around all the Hawaiian Islands. Important foraging areas are along the coasts of Oʻahu, Molokaʻi, Maui, Lānai, Hawaiʻi, Lisianski Island, and Pearl and Hermes Reef. Ninety percent of nesting occurs on French Frigate Shoals of the NWHI, with small numbers of nests on the other islands and atolls of the NWHI and Main Hawaiian Islands (MHI). Hawaiian turtles only migrate throughout the 2,450-kilometer (1,500-mile) expanse of the Hawaiian Archipelago, and so make up a discrete population. Worldwide, green sea turtles occur throughout tropical, subtropical, and to a lesser extent, temperate waters, and they nest in more than 80 countries.

ABUNDANCE: **Hawaii Population**: Approximately 4,000-5,000 nesting females, with a marked increase in numbers since conservation efforts began in the 1970s. The French Frigate Shoals annual nesting population is estimated at 400 breeding females, with an increasing population trend. Worldwide, approximately 100,000 to 150,000 females nest each year.

LOCATION AND CONDITION OF KEY HABITAT: Honu are most often found in shallow, protected, or semi-protected, water around coral reefs and coastal areas. These habitats contain sea grasses and algae for foraging and shelter from predators such as tiger sharks. Key foraging habitats can be found around most of the Hawaiian Islands, but they often return to the same foraging areas after the breeding season. Foraging habitat is degraded on the south coast of Molokaʻi; Kāneʻohe Bay, Oʻahu; Hanalei Bay, Hanamaulu Bay, and Nawiliwili Harbor, Kauaʻi; Maalaea Bay, Kihei, and Lahaina, Maui; and Hilo Bay, Hawaiʻi. Cleaning stations and resting habitats are important habitats for turtles as well. Nesting occurs on minimally disturbed sandy beaches, which is critical to the survival of the honu. The condition of nest beaches in the NWHI is relatively good compared to other areas because the NWHI are designated as a refuge with little development, and predation on eggs and hatchlings is low.

THREATS:

- Disease. Fibropapillomatosis (FP), a tumor-forming disease associated with herpesvirus, occurs on honu in Hawaiʻi. FP tumors are external and can impede critical functions such as swimming, eating, breathing, vision, and reproduction. The prevalence of FP peaked in the mid-1990s and has since declined around most Hawaiian islands, except around watersheds with high nitrogen outputs, where rates are increasing.
- Habitat degradation. Alien seaweeds are displacing important foraging, resting, and cleaning habitats. Other threats include loss or degradation of foraging habitats along coastal areas due to development, sedimentation, soil erosion, or sewage.
- Fisheries bycatch. Accidental capture in fishing gear. Mortality of adult and juvenile turtles results from fisheries bycatch. Due to federally mandated take-reduction measures implemented by Hawaiian longline fisheries, bycatch rates have been reduced by approximately 90 percent since 2004. However, bycatch remains a threat in other regions.
- Predation. Eggs and hatchlings are preyed on by introduced species (e.g., mongoose, rats, dogs, feral pigs, and cats) on the MHI. Predation of hatchlings by seabirds, fish, and sharks in the open ocean is a threat, although the extent of predation is unknown.
- Human disturbance and activities. Snorkeling and other recreational activities may cause disturbance or stress to Honu. Injury or mortality from collisions with boats is also a threat. Illegal harvesting and poaching of eggs and adults.
- Marine debris. Ingestion of plastic and entanglement. Entanglement by, or ingestion of, marine debris is a source of mortality.
- Climate change. Rising sea levels and increased sand temperatures affect nesting sites and hatchling sex ratios. Effects of climate change, such as increased temperatures, sea level rise, ocean acidification, and increased storm frequency leading to erosion, could have a variety of effects on honu, such as decreased reproductive success, loss or degradation of nesting habitat, and changes in juvenile and adult distribution.

CONSERVATION ACTIONS: Actions specific to honu should include the following:

- Protect, restore, and manage nesting, foraging, and resting habitats and cleaning stations.
- Reduce marine debris in the marine environment and on beaches.
- Campaign and address lighting on beaches and partner with lifeguard towers and structures like hotels, condominium buildings, etc that may have light that distracts hatchlings.
- Continue partnerships with local conservation groups to monitor and conserve turtles,

respond to stranding, and conduct research and outreach programs.
- Conduct education and outreach efforts, particularly to address threats such as fishing interactions, marine recreation interactions, and marine debris. Education campaigns to reduce threats like marine debris.

MONITORING:
- Continue to monitor nesting sites.
- Continue to monitor abundance and distribution.
- Continue to monitor the occurrence and effects of FP.
- Continue to monitor turtles harmed or killed by marine debris and from fisheries bycatch.

RESEARCH PRIORITIES:
- Climate Impact Studies: Understanding effects on nesting and sex ratios.
- Fibropapillomatosis: Identifying causes and mitigation measures.
- Habitat Use: Mapping critical habitats and migration pathways.
- Bycatch Solutions: Developing gear modifications to reduce accidental capture.
- Genetics: Studies on population structure and connectivity.
- Lighting: The number of white lights that are used along shorelines where nesting occurs.

References:

Balazs GH. 1980. Synopsis of the biological data on the green turtle in the Hawaiian Archipelago. Prepared for National Marine Fisheries Service, Honolulu, HI. Technical Report NOAA-NMFS- SWFSC-7.

Balazs GH, Forsyth RG, Kan AH. 1987. Preliminary assessment of habitat utilization by Hawaiian green turtles in their resident foraging pastures. Prepared for National Marine Fisheries Service, Honolulu, HI. Technical Report NOAA-NMFS-SWFSC-71.

Balazs, G. H., & Chaloupka, M. (2004). Thirty-year recovery trend in the once depleted Hawaiian green sea turtle stock. *Biological Conservation*, 117(5), 491-498.

Balazs GH, Chaloupka M. 2004. Spatial and temporal variability in somatic growth of green sea turtles (*Chelonia mydas*) resident in the Hawaiian Archipelago. Marine Biology 145 (5):1043-1059.

Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu, HI: Mutual Publishing.

International Union for Conservation of Nature (IUCN). (2023). *Chelonia mydas*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Kaneko JJ, and Bartram PK. 2008. What if you don't speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai'i. 13(2):1-3.

Meadows DW. 2004. Behavior of green sea turtles in the presence and absence of recreational snorkellers. Marine Turtle Newsletter 103: 1-4.

Marine Turtle Specialist Group. (2020). Global conservation priorities for marine turtles. *Science Advances*, 6(31), eabd1170.

National Marine Fisheries Service. 2004. Fisheries off West Coast states and in the western Pacific; western Pacific pelagic fisheries; pelagic longline fishing restrictions, seasonal area closure, limit on swordfish fishing effort, gear restrictions, and other sea turtle take mitigation measures. FR 69:17329-17354.

National Marine Fisheries Service and Fish and Wildlife Service. 1998. Recovery plan for U.S. pacific populations

of the green sea turtle (*Chelonia mydas*). Silver Spring, MD: National Marine Fisheries Service. 95 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Green sea turtle (*Chelonia mydas*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Springs, Maryland, and U.S. Fish and Wildlife Service, Jacksonville, Florida.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2015. Endangered and threatened species; identification and proposed listing of eleven distinct population segments of green sea turtles (*Chelonia mydas*) as endangered or threatened and revision of current listings. FR 80:15272-15337.

National Oceanic and Atmospheric Administration (NOAA). (2023). Green Turtle (Chelonia mydas). Retrieved from https://www.fisheries.noaa.gov

Papahānaumokuākea Marine National Monument. (2023). Habitat protection initiatives. Retrieved from https://www.papahanaumokuakea.gov

Van Houtan KS, Hargrove SK, and Balazs GH. 2010. Land use, macroalgae, and a tumor-forming disease in marine turtles. PLoS ONE 5(9): e12900. doi:10.1371/journal.pone.0012900.

Marine Reptiles

Honu‘ea or ‘Ea
Hawksbill sea turtle

Eretmochelys imbricata

SPECIES STATUS:
Federally-Listed as Endangered
State Listed as Endangered
IUCN Red List – Critically Endangered
State Recognized as Indigenous

SPECIES INFORMATION: Hawksbill sea turtles are medium-sized marine turtles characterized by their narrow, pointed beaks and overlapping scutes on their carapace, giving them a serrated appearance. They primarily feed on sponges, making them unique among sea turtles.

Little information exists on the feeding behavior of post-hatchlings and juveniles in pelagic habitats, but most likely they are exclusively carnivorous (e.g., invertebrates and fish eggs) and feed near the surface. They switch to feeding in benthic reef areas and dive to deeper depths as they grow. They appear to focus on sponges, which are not digestible by many other animals. At Honokowa, Maui, they also feed on algae *Hypnea*. Hawksbill turtles have slow growth rates, with an estimated average annual growth rate of 2 to 5 centimeters per year for juveniles, slowing to negligible growth in adults. Hawksbill turtles in Hawai‘i reach sexual maturity at around 17 to 22 years of age. Females generally breed once every three to four years. Turtles mate at sea. Nesting occurs from late May through November. Females may lay up to six clutches per season, often returning to the same site for each clutch every 14 to 20 days or so. Each clutch contains about 140 eggs. Sex determination is temperature-dependent. Incubation lasts about 60 days. Some individuals have been recaptured over 1,600 kilometers (1,000 miles) from where they were tagged, so long-distance movement is possible, and genetic studies show that foraging areas host individuals from different genetic stocks.

DISTRIBUTION: Occurs in waters around the Main Hawaiian Islands (MHI) and is regularly seen off west Maui, and occasionally around the Northwestern Hawaiian Islands (NWHI). Nesting occurs on the MHI, especially along the east coast of Hawai‘i. Worldwide, the species nests on inland and mainland sandy beaches throughout the tropics and subtropics and occurs in coastal waters of more than 108 countries.

ABUNDANCE: The Hawaiian population is estimated at 10-25 breeding females annually. Population trends are unknown but may be stable on the island of Hawai‘i . This population may constitute one of the smallest hawksbill nesting populations in the world, but is the largest in the Central North Pacific Ocean. Worldwide, the breeding population is estimated at less than 25,000 breeding females.

LOCATION AND CONDITION OF KEY HABITAT: Hawksbill sea turtles are most often seen in shallow waters around reefs, bays, and inlets. Key foraging habitat is located around most of the MHI, especially the north coasts. The turtles occur in small numbers around the NWHI. Nesting habitats are extremely critical to the survival of the species. Nesting occurs within 5 meters (15 feet) of the high water line on beaches, with a preference for areas with woody cover, and sand is not necessary but often used. A black-sand beach in the Halawa River Valley of east Molokaʻi, and Kamehame Beach, Hawaiʻi, are also used consistently. A few beaches on Maui are used occasionally. Two nesting beaches (Halape and Apua Point) are located within Hawaiʻi Volcanoes National Park and receive enhanced protection.

THREATS:

- Habitat degradation. Nesting beaches in Hawaiʻi are degraded by coastal development, vehicles on beaches at Punaluu and Kawa, erosion, artificial lighting, nest predation, and exotic vegetation.
- Fisheries bycatch. Mortality of adult and juvenile turtles results from fisheries bycatch. Due to federally mandated take-reduction measures implemented by Hawaiian longline fisheries, bycatch rates have been reduced by approximately 90 percent since 2004. Bycatch remains a threat in other regions.
- Predation. Eggs and hatchlings are preyed on by introduced species (e.g., mongoose, rats, dogs, feral pigs, and cats) on the MHI. Predation of hatchlings by seabirds, fish, and sharks in the open ocean is a threat, although the extent of predation is unknown.
- Marine debris. Entanglement by, or ingestion of, marine debris are source of mortality.
- Climate change. Rising temperatures alter hatchling sex ratios and inundate nesting beaches. Effects of climate change, such as increased temperatures, sea level rise, ocean acidification, changes to circulation patterns, and increased cyclonic activity, could have a variety of effects, such as changes in reproductive behavior, hatchling dispersal, adult migration, and prey availability, and loss or degradation of nesting habitat.
- Illegal Trade. Harvesting for their distinctive shells (tortoiseshell trade).

CONSERVATION ACTIONS: Actions specific to hawksbill sea turtles should include the following:

- Protect, restore, and manage nesting habitat, especially on MHI beaches.
- Reduce marine debris in the marine environment and on beaches.
- Campaign and address lighting on beaches and partner with lifeguard towers and structures like hotels, condominium buildings, etc that may have light that distracts hatchlings.
- Continue partnerships with local conservation groups to monitor and conserve turtles, respond to stranding, and conduct research and outreach programs.
- Conduct education and outreach efforts, particularly to address threats such as fishing interactions, marine recreation interactions, and marine debris.

MONITORING:

- Nesting Surveys: Monitoring nesting sites and hatching success rates.
- Tagging Programs: Use of satellite and flipper tags to study movements and habitat use.
- Population Assessments: Tracking changes in juvenile and adult populations.
- Health Studies: Evaluating impacts of disease and environmental stressors.

RESEARCH PRIORITIES:

- Spongivory Studies: Understanding their diet and its ecological role on coral reefs.
- Climate Impact Research: Investigating how rising temperatures affect nesting success.
- Genetic Studies: Assessing genetic diversity to inform conservation strategies.
- Habitat Restoration: Developing methods to restore degraded coral reefs and nesting sites.
- Bycatch Mitigation: Creating solutions to reduce accidental capture in fishing gear.
- Lighting: The number of white lights that are used along shorelines where nesting occurs.

References:

International Union for Conservation of Nature (IUCN). (2023). *Eretmochelys imbricata*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Hawaii Department of Land and Natural Resources (DLNR). (2023). Honu‘ea Conservation Efforts. Retrieved from https://dlnr.hawaii.gov

Kaneko JJ, and Bartram PK. 2008. What if you don’t speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai‘i. 13(2):1-3.

King CS, Gilmartin WG, Hau S, Bernard HJ, Canja SM, Nakai G, Grady MJ, Williams S, Hebard AG. 2008.Nesting hawksbill turtles (*Eretmochelys imbricata*) on the Island of Maui, Hawai′i from 1996-2003. *In* Mast RB, Hutchinson BJ, and Hutchinson AH, compilers. Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC- 567.

Mortimer, J. A., & Donnelly, M. (2008). Hawksbill turtles (*Eretmochelys imbricata*). Status and Conservation. *Chelonian Conservation and Biology*, 7(1), 44-56.

National Oceanic and Atmospheric Administration (NOAA). (2023). Hawksbill Turtle (*Eretmochelys imbricata*). Retrieved from https://www.fisheries.noaa.gov

National Marine Fisheries Service. 2004. Fisheries off West Coast states and in the western Pacific; western Pacific pelagic fisheries; pelagic longline fishing restrictions, seasonal area closure, limit on swordfish fishing effort, gear restrictions, and other sea turtle take mitigation measures. FR 69:17329-17354.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery plan for U.S. Pacific Populations of the hawksbill sea turtle (*Eretmochelys imbricata*). Silver Springs, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2013. Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Springs, Maryland, and U.S. Fish and Wildlife Service, Jacksonville, Florida.

Van Houtan KS, Kittinger JN, Lawrence AL, Yoshinaga C, Born VR, and Fox A. 2012. Hawksbill sea turtles in the Northwestern Hawaiian Islands. Chelonian Conservation and Biology 11(1):117-121.

World Wildlife Fund (WWF). (2023). Hawksbill Turtle Conservation. Retrieved from https://www.worldwildlife.org

Marine Reptiles

Leatherback sea turtle

Dermochelys coriacea

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
IUCN Red list – Vulnerable
State Recognized as Indigenous

SPECIES INFORMATION: Leatherback sea turtles are the largest of all sea turtle species and are easily identified by their unique, leathery shell without scales. They primarily feed on jellyfish and are known for their deep-diving ability. Little information exists on the feeding behavior of post-hatchling and juvenile leatherback sea turtles living in pelagic habitats, but most likely they are exclusively carnivorous. Leatherbacks are the only sea turtles in which adults are also pelagic and carnivorous, feeding on jellyfish, siphonophores, and salps, although they also feed on plants. They exhibit rapid growth rates from hatchling to juvenile (approximately 32 centimeters in length per year). Reproduction is seasonal, with two to three years between nesting. Females lay about five to seven clutches per year, and incubation lasts about 60 days. They are known to migrate long distances, up to 11,000 kilometers from their breeding areas. Sex determination is temperature-dependent. Genetic analysis of turtles incidentally caught in the Hawai‘i-based longline fishery reveals that 12 out of 14 turtles came from the west Pacific and the other two originated from the eastern Pacific.

DISTRIBUTION: Transient visitors around the Hawaiian Islands. Rarely sighted in Hawaiian waters but known to traverse the Pacific Ocean for foraging and nesting. The entire Pacific population may be highly interconnected. Worldwide, leatherback sea turtles occur throughout tropical, temperate, and sub-polar regions of the Atlantic, Pacific, and Indian Oceans and the Mediterranean. Nesting occurs on subtropical and tropical beaches of the Atlantic, Pacific, and Indian Oceans.

ABUNDANCE: Rare in Hawai‘i. The Pacific population is critically low, with a few thousand individuals remaining. Globally the annual number of breeding females is estimated at 34,000 to 36,000 nesting females, with significant declines in some populations.

LOCATION AND CONDITION OF KEY HABITAT: Usually found in deep, highly productive waters. They occur in water that is far colder than that inhabited by any other sea turtle species. Nesting does not occur in Hawai‘i but occurs on sandy beaches in the subtropics and tropics.

THREATS:

- Fisheries bycatch: Mortality of adult and juvenile turtles results from fisheries bycatch.

Due to federally mandated sea turtle take-reduction measures implemented by Hawaiian longline fisheries, bycatch rates have been reduced by approximately 90 percent since 2004. Bycatch remains a threat in other regions.
- Habitat loss and degradation: Nesting beaches (all of which occur outside Hawai‘i) are critical to the species' survival and are subject to natural and human-caused threats such as tsunamis, oil spills, sea level rise from climate change, and coastal development.
- Harvest of eggs and adults: Harvest occurs on beaches in many countries, although conservation efforts have reduced this threat.
- Marine debris: Entanglement by, or ingestion of, marine debris is a source of mortality.
- Climate Change: Rising sand temperatures affecting hatchling sex ratios and beach erosion.

CONSERVATION ACTIONS: Actions specific to leatherback sea turtles should include the following:
- International Cooperation: Global agreements to protect migratory routes and nesting sites.
- Fishing Gear Modifications: Use of turtle excluder devices (TEDs) to reduce bycatch.
- Protected Areas: Establishment of marine reserves and protection of nesting beaches.
- Public Awareness: Campaigns to reduce marine debris and illegal trade.

MONITORING:
- Nesting Surveys: Monitoring nesting activity and hatchling success.
- Tagging Programs: Satellite tracking to understand migration and habitat use.
- Population Assessments: Evaluating population trends and threats.
- Health Assessments: Research on disease prevalence and environmental stressors.

RESEARCH PRIORITIES:
- Climate Adaptation Studies: Exploring strategies to mitigate impacts of rising temperatures.
- Migration Patterns: Understanding long-distance movements and critical foraging areas.
- Bycatch Reduction: Testing innovative fishing gear designs.
- Plastic Pollution: Assessing ingestion rates and impacts on health.
- Nesting Site Preservation: Identifying and protecting critical nesting beaches

References:

Conservation International. (2023). Pacific leatherback conservation initiatives. Retrieved from https://www.conservation.org

Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu, HI: Mutual Publishing.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kaneko JJ, and Bartram PK. 2008. What if you don't speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai‘i. 13(2):1-3.

International Union for Conservation of Nature (IUCN). (2023). *Dermochelys coriacea*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

National Oceanic and Atmospheric Administration (NOAA). (2023). Leatherback Turtle (*Dermochelys coriacea*). Retrieved from https://www.fisheries.noaa.gov

National Marine Fisheries Service. 2004. Fisheries off West Coast States and in the Western Pacific; Western Pacific

Pelagic Fisheries; Pelagic Longline Fishing Restrictions, Seasonal Area Closure, Limit on Swordfish Fishing Effort, Gear Restrictions, and Other Sea Turtle Take Mitigation Measures. FR 69:17329-17354.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery plan for U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). Silver Springs, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2013. Leatherback Sea Turtle (*Dermochelys coriacea*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Springs, Maryland, and U.S. Fish and Wildlife Service, Jacksonville, Florida.

Spotila, J. R., Reina, R. D., Steyermark, A. C., Plotkin, P. T., & Paladino, F. V. (2000). Pacific leatherback turtles face extinction. *Nature*, 405(6786), 529-530.

World Wildlife Fund (WWF). (2023). Leatherback Turtle Conservation. Retrieved from https://www.worldwildlife.org

Marine Reptiles

Loggerhead sea turtle

Caretta caretta

SPECIES STATUS:
Federally-Listed as Threatened State Listed as Threatened IUCN Red list – Vulnerable
State Recognized as Non-Native

SPECIES INFORMATION: Loggerhead sea turtles are medium to large-sized turtles characterized by their broad, muscular heads and reddish-brown carapace. They are omnivorous, feeding on a variety of prey such as crustaceans, mollusks, and jellyfish. Mature male loggerhead sea turtles are distinguished by longer and thicker tails. Little information exists on the feeding behavior of post-hatchlings in pelagic waters, but they are most likely exclusively carnivorous (e.g., eating invertebrates and fish eggs). Juveniles and adults feed on benthic invertebrates and occasionally fishes. Loggerheads exhibit slow growth rates; subadults grow approximately 1 centimeter per year. Turtles likely reach sexual maturity at 20 to 30 years of age. Females generally breed once every three or more years. Females lay clutches of about 120 eggs every 14 days during the nesting season. Incubation lasts about 70 days. Sex determination is temperature-dependent.

DISTRIBUTION: Worldwide, loggerhead sea turtles occur throughout temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans, and adults are known to make extensive migrations between foraging areas and nesting beaches. The majority of nesting occurs in the western rims of the Atlantic and Indian Oceans. In the North Pacific, most nesting occurs in Japan. Historically, loggerhead sea turtles may have occurred in the waters around all the Hawaiian Islands. Today, juveniles are very rarely seen in the Hawaiian Islands.

ABUNDANCE: The Pacific Population is small and declining, with nesting primarily in Japan and Australia. Global populations are estimated at 60,000 nesting females globally, with significant regional variations.

LOCATION AND CONDITION OF KEY HABITAT: Loggerhead sea turtles in Hawaiian waters are likely part of the Japanese population. Nesting occurs on sandy beaches but does not occur in Hawai‘i.

THREATS:

- Fisheries bycatch: Mortality of adult and juvenile turtles results from fisheries bycatch. Due to federally mandated take-reduction measures implemented by Hawaiian longline fisheries, bycatch rates have been reduced by approximately 90 percent since 2004.

Bycatch remains a threat in other regions.

- Habitat loss and degradation: Nesting beaches (all of which are outside Hawai‘i) are critical to the species' survival and are subject to natural and human-caused threats such as tsunamis, oil spills, sea level rise from climate change, light pollution, vehicular traffic on beaches, and coastal development.
- Harvest of eggs and adults: Harvest occurs on beaches in many countries, although conservation efforts have reduced this threat.
- Marine debris: Entanglement by, or ingestion of, marine debris is a source of mortality.
- Climate Change: Rising temperatures leading to skewed sex ratios and nesting habitat loss.

CONSERVATION ACTIONS: Actions specific to loggerhead sea turtles should include the following:

- Cooperate with jurisdictions where nesting occurs to restore nesting habitat and reduce the take of eggs and females.
- Reduce marine debris in the marine environment and on beaches.
- Continue partnerships with local conservation groups to monitor and conserve turtles, respond to stranding, and conduct research and outreach programs.
- Conduct education and outreach efforts, particularly to address threats such as fishing interactions, marine recreation interactions, and marine debris.
- Fishing Regulations: Use of turtle excluder devices (TEDs) and bycatch reduction measures.
- Protected Areas: Establishment of marine reserves and nesting beach protections.
- Habitat Restoration: Rebuilding and safeguarding nesting beaches.
- Public Education: Campaigns to reduce plastic waste and promote turtle-safe practices.

MONITORING: Continue to monitor turtles harmed or killed by marine debris and fisheries bycatch.

- Nesting Surveys: Assessing nesting site use and hatchling success rates.
- Tagging Programs: Satellite tracking to study migration patterns.
- Population Studies: Monitoring trends in juvenile and adult populations.
- Threat Analysis: Evaluating impacts of human activities and natural predators
- Climate Impact Studies: Understanding effects of rising temperatures on reproduction and sex ratios.
- Migration Research: Mapping migratory routes and identifying critical habitats.
- Plastic Ingestion Effects: Studying impacts of marine debris on health and survival.
- Bycatch Solutions: Developing innovative fishing gear to minimize accidental capture.
- Restoration Techniques: Advancing methods for restoring and protecting nesting beaches.

RESEARCH PRIORITIES:

- Climate Impact Studies: Understanding effects of rising temperatures on reproduction and sex ratios.
- Migration Research: Mapping migratory routes and identifying critical habitats.
- Plastic Ingestion Effects: Studying impacts of marine debris on health and survival.
- Bycatch Solutions: Developing innovative fishing gear to minimize accidental capture.
- Restoration Techniques: Advancing methods for restoring and protecting nesting beaches.

References:

Bolten, A. B., & Witherington, B. E. (2003). Loggerhead Sea Turtles. *S**mithsonian Institution Press*.

Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu, HI: Mutual Publishing.

International Union for Conservation of Nature (IUCN). (2023). *Caretta caretta*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Kaneko JJ and Bartram PK. 2008. What if you don't speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai'i. 13(2):1-3.

Marine Turtle Specialist Group. (2023). Regional management units for loggerhead turtles. Retrieved from https://mtsg.org

National Oceanic and Atmospheric Administration (NOAA). (2023). Loggerhead Turtle (*Caretta caretta*). Retrieved from https://www.fisheries.noaa.gov

National Marine Fisheries Service. 2004. Fisheries off West Coast states and in the western Pacific; western Pacific pelagic fisheries; pelagic longline fishing restrictions, seasonal area closure, limit on swordfish fishing effort, gear restrictions, and other sea turtle take mitigation measures. FR 69:17329-17354.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery plan for U.S. Pacific populations of the loggerhead turtle (*Caretta caretta*). Silver Springs, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Loggerhead sea turtle (*Caretta caretta*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Springs, Maryland, and U.S. Fish and Wildlife Service, Jacksonville, Florida.

World Wildlife Fund (WWF). (2023). Loggerhead Turtle Conservation. Retrieved from https://www.worldwildlife.org

Marine Reptiles

Olive Ridley Sea Turtle

Lepidochelys olivacea

SPECIES STATUS:
Federally Listed as Threatened, State Listed as Threatened IUCN Red list – Vulnerable
State Recognized as Indigenous

SPECIES INFORMATION: Olive Ridley sea turtles are small to medium-sized turtles known for their heart-shaped carapace and olive-green color. They are omnivorous, feeding on jellyfish, shrimp, snails, algae, and fish. Adult male olive ridley sea turtles are distinguished by longer, thicker tails an elongated carapace, and one enlarged, hooked claw. Olive Ridleys are the smallest and most abundant sea turtle, with adult carapace lengths of 60 to 70 centimeters (about 2 feet). Little information exists on the feeding behavior of post-hatchlings and juveniles in pelagic waters, but they are most likely exclusively carnivorous (e.g., eating invertebrates and fish eggs). Older juveniles and adults feed on a wide variety of benthic organisms. Growth rates are unknown and age at sexual maturity is 10 to 18 years. Females often return to the same site to lay additional clutches every month and do so *en masse*. Incubation lasts 46 to 65 days. Each clutch contains about 100 eggs and sex determination is temperature-dependent. Genetic analysis of olive ridley turtles taken in the Hawai‘i-based longline fishery shows that about two-thirds of the animals came from the eastern Pacific, and the remaining one-third originated in the western Pacific or Indian Ocean. Thus, Hawai‘i represents a point of convergence for these source areas.

DISTRIBUTION: Worldwide, the species occurs in subtropical and tropical waters of the Pacific, Indian, and Atlantic Oceans. Generally only seen in deep oceanic waters around Hawai‘i. Nesting has been recorded only once in Hawai‘i, on Maui in 1985.

ABUNDANCE: Significant nesting aggregations occur in Mexico and Central America. Globally, populations are estimated to be in the hundreds of thousands, with large nesting populations in India, Mexico, and Costa Rica. According to the International Union for Conservation of Nature and Natural Resources Red List, there has been between a 30 to 50 percent reduction in global population size. Although some nesting populations have increased in the past few years or are currently stable, the overall reduction in some populations is greater than the overall increase in others. In the Pacific, large nesting populations occur in Mexico and Costa Rica.

LOCATION AND CONDITION OF KEY HABITAT: Most often found in shallow water around reefs, bays, and inlets. Most nesting occurs on continental beaches. The preferred nesting habitat is mid-level beaches free of debris.

THREATS:

- Fisheries bycatch: Mortality of adult and juvenile turtles results from fisheries bycatch.

Due to federally mandated take-reduction measures implemented by Hawaiian longline fisheries, sea turtle bycatch rates have been reduced by approximately 90 percent since 2004. Bycatch remains a threat in other regions.
- Habitat loss and degradation: Nesting beaches (all of which occur outside Hawai‘i) are extremely critical to the species' survival and are subject to natural and human-caused threats such as tsunamis, oil spills, sea level rise from climate change, light pollution, vehicular traffic on beaches, and coastal development.
- Harvest of eggs and adults: Harvest occurs on beaches in many countries, although conservation efforts have reduced this threat.
- Marine debris: Entanglement by, or ingestion of, marine debris is a source of mortality.
- Illegal Harvesting: Collection of eggs and adult turtles for consumption and trade.
- Climate Change: Rising temperatures affecting sex ratios and loss of nesting habitat.

CONSERVATION ACTIONS: Actions specific to olive ridley sea turtles should include the following:
- Cooperate with jurisdictions where nesting occurs to restore nesting habitat and reduce the take of eggs and females.
- Reduce marine debris in the marine environment and on beaches.
- Continue partnerships with local conservation groups that monitor and conserve turtles, respond to stranding, and conduct research and outreach programs.
- Conduct education and outreach efforts, particularly to address threats such as fishing interactions, marine recreation interactions, and marine debris.
- Fishing Gear Innovations: Implementation of turtle excluder devices (TEDs) and other bycatch reduction strategies.
- Nesting Site Protections: Protection of key nesting beaches and regulation of human activity.
- Marine Protected Areas: Designation of zones to safeguard critical feeding and migration habitats.
- Community Engagement: Education programs to reduce illegal harvesting and promote conservation.

MONITORING:
- Nesting Surveys: Monitoring arribadas and solitary nesting events.
- Tagging Programs: Satellite tracking to identify migratory corridors and critical habitats.
- Population Studies: Assessing trends in global and regional populations.
- Threat Assessments: Evaluating human and environmental impacts on survival rates.

RESEARCH PRIORITIES:
- Climate Resilience: Studying adaptive responses to changing sand temperatures and sea levels.
- Bycatch Reduction: Developing improved fishing gear and sustainable fisheries management practices.
- Migration Studies: Understanding movement patterns to prioritize conservation efforts.
- Plastic Impacts: Assessing ingestion rates and long-term effects of marine debris.
- Restoration of Nesting Sites: Identifying and protecting critical arribada nesting beaches.

References:

Gulko D, Eckert K. 2003. Sea Turtles: An Ecological Guide. Honolulu, HI: Mutual Publishing.

International Union for Conservation of Nature (IUCN). (2023). *Lepidochelys olivacea*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

Kaneko JJ, and Bartram PK. 2008. What if you don't speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai'i. 13(2):1-3.

Marine Turtle Specialist Group. (2023). Olive ridley turtle conservation strategies. Retrieved from https://mtsg.org

National Oceanic and Atmospheric Administration (NOAA). (2023). Olive Ridley Turtle (*Lepidochelys olivacea*). Retrieved from https://www.fisheries.noaa.gov

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). Silver Springs, MD.

National Marine Fisheries Service. 2004. Fisheries off West Coast states and in the western Pacific; western Pacific pelagic fisheries; pelagic longline fishing restrictions, seasonal area closure, limit on swordfish fishing effort, gear restrictions, and other sea turtle mitigation measures. FR 69:17329-17354.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Olive Ridley Turtle (*Lepidochelys olivacea*) 5-year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Springs, Maryland, and U.S. Fish and Wildlife Service, Jacksonville, Florida.

Plotkin, P. T. (2007). Biology and Conservation of Ridley Sea Turtles. *Johns Hopkins University Press*.

World Wildlife Fund (WWF). (2023). Olive Ridley Turtle Conservation. Retrieved from https://www.worldwildlife.org

Marine Reptiles

Yellow-bellied sea snake

Pelamis platurus

SPECIES STATUS:
State recognized as Indigenous
IUCN Red List – Not Considered

SPECIES INFORMATION: The yellow-bellied sea snake is a pelagic sea snake characterized by its distinct yellow underbelly and dark brown or black dorsal coloration. It has a laterally flattened tail adapted for swimming and can grow up to 1 meter in length. It primarily preys on small fish. It breeds year-round with a several-month-long gestation period. They give birth to live young with litter sizes of one to eight. Maturity may take two years. They can occur in large aggregations. They are venomous- but have a small mouth and fangs and are generally un-aggressive unless harassed.

DISTRIBUTION: Occasional sightings in Hawaiian waters occur in tropical and subtropical areas of the Pacific and Indian Oceans, including coastal regions of Africa, Asia, Australia, and the Americas.
ABUNDANCE: Widespread and abundant across its range; exact population estimates are unavailable.
LOCATION AND CONDITION OF KEY HABITAT: Occurs in water from 22 to 30 degrees C, especially in shallow inshore waters. They can dive to depths of 15 meters (50 feet) and are often found around flotsam or debris. Not common in Hawai‘i.

THREATS:

- Marine Pollution: Entanglement in marine debris and exposure to pollutants.
- Climate Change: Changes in ocean currents and temperatures affecting prey distribution.
- Bycatch: Accidental capture in fishing nets and trawling operations.
- Habitat Degradation: Pollution and debris accumulation impacting surface habitats.
- Predation: Natural predators include seabirds, larger fish, and sharks.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations but also to establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Marine Pollution Reduction: Efforts to reduce plastic and chemical pollution in ocean ecosystems.
- Sustainable Fishing Practices: Implementation of measures to reduce bycatch.
- Climate Adaptation Research: Monitoring impacts of changing ocean conditions on distribution.
- Public Awareness: Educational campaigns on the ecological role of sea snakes and reducing human impacts.

MONITORING:

- Distribution Surveys: Tracking occurrence and density in global oceanic waters.
- Population Trends: Assessing abundance and impacts of marine pollution.
- Bycatch Data: Collecting records of incidental capture in fisheries.
- Habitat Assessments: Monitoring the health of surface waters and associated ecosystems.

RESEARCH PRIORITIES:

- Climate Impact Studies: Understanding how ocean warming and current shifts affect sea snake distribution.
- Pollution Effects: Assessing impacts of plastics and pollutants on survival and prey availability.
- Bycatch Solutions: Developing strategies to minimize accidental capture in fisheries.
- Ecological Role: Studying predation and prey relationships within pelagic ecosystems.
- Migration Patterns: Mapping movements to understand habitat connectivity and critical zones.

References:

Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu, HI: Mutual Publishing. 128 pp.

Heatwole, H. (1999). *Sea Snakes*. University of New South Wales Press.

International Union for Conservation of Nature (IUCN). (2023). *Pelamis platurus*. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Lillywhite, H. B. (2014). *How Snakes Work: Structure, Function, and Behavior of the World's Snakes*. Oxford University Press.

Marine Species Database. (2023). Yellow-bellied Sea Snake. Retrieved from https://www.marinespecies.org

NatureServe. [Internet]. 2005. NatureServe Explorer: An online encyclopedia of life. Version 4.3. Arlington, VA: NatureServe. Available from: http://www.natureserve.org/explorer. (Accessed: March, 2005).

NOAA Fisheries. (2023). *Pelamis platurus* Fact Sheet. Retrieved from https://www.noaa.gov

Chaetodon tinkeri
Courtesy Keoki Stender

Geniacanthus personatus
male Courtesy Keoki Stender

Marine Fishes

Active Reef Fishes

Chaetodontidae
Chaetodon fremblii (LC)
Chaetodon tinkeri (LC)
Prognathodes sp. (NC)
Pomacanthidae
Apolemichthys arcuatus (LC)
Centropyge fisheri (LC)
Centropyge loricula (LC)
Genicanthus personatus (LC)
Pomacentridae
Chromis hanui (LC)
Chromis ovalis (LC)
Chromis struhsakeri (NC)
Plectroglyphidodon sindonis (NC)
Priacanthidae
Priacanthus meeki (LC)
Cheilodactylidae
Cheilodactylus vittatus (NC)
Ammodytidae
Ammodytoides pylei (NC)
Lepidammodytes macrophthalamus (NC)
Monacanthidae
Cantherhines verecundus (LC)
Thamnaconus garretti (DD)
Ostraciidae
Ostracion whitleyi (LC)
Tetraodontidae
Torquigener randalli (DD)

SPECIES STATUS:
IUCN Red List – Not Considered (NC), Least Concern (LC), or Data Deficient (DD). All Endemic except *Chaetodon tinkeri*, *Apolemichthys*, *Centropyge loricula,* and *Ostracion whitleyi*

SPECIES INFORMATION: The Hawaiian rock damselfish (*Plectroglyphidodon*) is territorial.

Chaetodon and *Centropyge* feed on invertebrates and algae. *Apolemichthys* prefers sponges. Masked Angelfish (*Genicanthus*) is a protogynous sex changer and primarily feeds on zooplankton and algae. The *Chromis* species and the ammodytids (sand lances) are also planktivores and often feed in groups. Hawaiian rock damselfish (*Plectroglyphidodon*) mostly feeds on algae and occasionally on invertebrates. ʻĀweoweo (*Priacanthus*) is nocturnal and feed on larger zooplankton and may school on occasion. Hawaiian morwong (*Cheilodactylus*) and Randall's pufferfish (*Torquigener*) feed on invertebrates. The monacanthids (filefishes) are omnivorous. The eggs of damselfishes (Pomacentridae) are demersal and guarded by males until hatching. Male Whitley's boxfish are rare in Hawaiʻi. All of these fishes are 30 centimeters (one foot) or less in size except Hawaiian morwong (*Cheilodactylus*) which can reach 40 centimeters (16 inches). The species' common names and Hawaiian names are *Chaetodon fremblii* (bluestriped butterflyfish, kīkākapu), *Chaetodon tinkeri* (Tinker's butterflyfish), *Prognathodes* sp. (orange-margin butterflyfish), *Apolemichthys arcuatus* (bandit angelfish), *Centropyge fisheri* (Fisher's angelfish), *Centropyge loricula* (Hawaiian flame angelfish), *Genicanthus personatus* (masked angelfish), *Chromis hanui* (chocolate-dip chromis), *Chroims ovalis* (oval chromis), *Chromis struhsakeri* (Struhsaker's chromis), *Plectroglyphidodon sindonis* (Hawaiian rock damselfish), *Priacanthus meeki* (Hawaiian bigeye, ʻāweoweo), *Cheilodactylus vittatus* (Hawaiian morwong, kīkākapu), *Ammodytoides pylei* (Pyle's sand lance), *Lepidammodytes macrophthalamus* (no common name), *Cantherhines verecundus* (shy filefish, ʻoʻili), *Thamnaconus garretti* (no common name), *Ostracion whitleyi* (Whitley's boxfish), and *Torquigener randalli* (Randall's pufferfish).

DISTRIBUTION: Tinker's butterflyfish is found from Hawaiʻi Island through Oʻahu. Orange- margin butterflyfish and Hawaiian flame angelfish occur from French Frigate Shoals southeast through the rest of the chain. Hawaiian morwong, (ʻoʻili*),* and Randall's pufferfish occur from Oʻahu through Kure Atoll. Pyle's sand lance occurs from Maui through all of the NWHI and *Lepidammodytes* has been collected from Maui through Maro Reef. All the other species occur throughout the Hawaiian Islands.

ABUNDANCE: The shallow water species are surveyed for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources and data are available online. Masked Angelfish were not found in the main islands WCRP survey. ʻĀweoweo commercial catch has gone from over 2,270 kilograms (5,000 pounds) in the late 1990s to 950 kilograms (2,100 pounds) in 2003.

LOCATION AND CONDITION OF KEY HABITAT: All species except Tinker's butterflyfish, orange-margin butterflyfish and Struhsaker's chromis can be found in shallow water depths. Tinker's butterflyfish is found deeper than 30 meters (100 feet). Orange-margin butterflyfish and Struhsaker's chromis occurs at depths greater than 100 meters (300 feet). Hawaiian flame angelfish prefers finger coral at depths of 60 feet or more. The masked angelfish occurs only at 20 meters (60 feet) depth or greater and prefers drop offs. *Thamnaconus* occurs at least 60 meters (200 feet) deep. Chocolate-dip chromis prefer ledges, walls, or the sides of coral heads. Hawaiian rock damselfish is restricted to shallow surge zones. ʻĀweoweo are often found in caves and under ledges during the day. The sand lances occur over sandy habitats. Randall's pufferfish is found over sandy habitats usually 15 meters (50 feet) or deeper. The rest are found throughout coral reef habitats.

THREATS:

- Overfishing;
- Climate change impacts including coral bleaching and ocean acidification;
- Pollution from land-based sources like sewage and stormwater runoff, coastal development, destructive fishing practices, and sediment accumulation which can smother coral reefs and disrupt

their ecosystem balance

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Commercial collection of reef fishes was prohibited in 2017 due to a Hawai‘i Supreme Court ruling that requires an environmental review before permits can be issued. In addition to common statewide and island conservation actions, specific actions include:

- Habitat Restoration
- Maintaining healthy populations with appropriate fishing regulations and education;
- Establishing Marine Protected Areas (MPAs);
- Monitoring fish populations;
- Conducting community engagement initiatives;
- Managing invasive species

MONITORING:

- Continue to survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size and distribution;
- Support aquaculture research to develop captive breeding for species used in the aquarium trade.

References:

Froese, R. and D. Pauly. Editors. 2024.FishBase. World Wide Web electronic publication. www.fishbase.org

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawai‘i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Voover J. 1993. Hawai‘i’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

Howe JC. 1993. A comparative analysis of the feeding apparatus in pomacanthids, with special emphasis of oesophageal papillae in *Genicanthus personatus.* J. Fish Biology 43(4):593-602.

International Union for the Conservation of Nature and Natural Resources. [Internet] Threatened Red List. Available from: http://www.redlist.org/search/search-expert.php (Accessed May 2005).

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp.

Marine Fishes

Hawaiian surf sardine

Iso hawaiiensis

ʻIao or Hawaiian silverside

Atherinomorus insularum

Nehu or Hawaiian anchovy

Encrasicolina purpurea

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: These are all relatively small, silvery, schooling planktivores. ʻIao and Hawaiian surf sardines are athereinids that attach their eggs by filaments to aquatic plants. Nehu (Hawaiian anchovy) lay oval, floating eggs that hatch in a couple of days. During the day, the ʻIao swim in small schools near the shoreline and disperse over the reef at night to feed on planktonic crustaceans. The Nehu also feed on planktonic crustaceans, swim in schools near the shore, and they swim into bays, estuaries and fishponds to spawn.

DISTRIBUTION: They are found throughout the State.

ABUNDANCE: ʻ Iao are looked for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands by the National Oceanic and Atmospheric Administration. The others are not formally surveyed. There is little quantitative evidence of decline.

LOCATION AND CONDITION OF KEY HABITAT: They all occur in shallow water near the shoreline. Nehu especially can be found in estuaries.
THREATS:

- They are fished commercially and recreationally;
- Introduced baitfish species may compete with the native species for resources;
- Coastal water quality may also be a threat in many areas but needs research.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction.
Regulations set maximum catch at one gallon (four liters) for Nehu and nets over 50 feet (15

meters) are allowed only for commercial fishers. In addition to common statewide and island conservation actions, specific actions include:

- Restoration of habitat;
- Maintain healthy populations with appropriate fishing regulations and education.

MONITORING:
Continue and expand surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:
Improve understanding of factors affecting the species population size.

References:

Froese, R. and D. Pauly. Editors. 2024.FishBase. World Wide Web electronic publication. www.fishbase.org

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai#i Division of Aquatic Resources.

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Image Credit: Keoki Stender

Marine Fishes

Hāpuʻupuʻu or Hawaiian grouper

Hyporthodus quernus

SPECIES STATUS:
IUCN Red List – Least Concern

SPECIES INFORMATION: Hāpuʻupuʻu or the Hawaiian grouper is an endemic species of benthic finfish found throughout the Hawaiian archipelago and Johnston Atoll. Like many groupers, they are sequential protogynous hermaphrodites meaning that they can change from an initial female phase to a terminal male phase throughout their lives. Hāpuʻupuʻu are slow-growing and relatively long-lived, with specimens previously caught up to 50 years old, and an estimated maximum age of up to 76 years.

In Hawaiʻi, hāpuʻupuʻu are a prized foodfish caught almost exclusively by the deep-sea hook and line bottomfish fishery. Hāpuʻupuʻu are a relatively small component of the total main Hawaiian Island (MHI) Deep-7 bottomfish fishery at about 3% in recent years, and are today considered primarily an incidentally-caught species. The were however a primary component of the Northwest Hawaiian Island (NWHI) bottomfish fishery prior to its closure in 2009.

DISTRIBUTION: Hāpuʻupuʻu can be found throughout the Hawaiian archipelago as well as Johnston Atoll.

ABUNDANCE: Unknown. There is no current species-specific stock assessment for hāpuʻupuʻu. The species falls within the MHI Deep-7 bottomfish complex which also includes ʻōpakapaka (Pristipomoides filamentosus; pink snapper), onaga (Etelis coruscans; longtail snapper), ehu (Etelis carbunculus; ruby snapper), kalekale (Pristipomoides seiboldii; Von Siebold's snapper), gindai (Pristipomoides zonatus; oblique-banded snapper), and lehi (Aphareus rutilans; silverjaw snapper). The latest stock assessment published by NOAA Pacific Islands Fishery Science Center (PIFSC) in 2024 found the complex to be neither overfisher, nor experiencing overfishing.

LOCATION AND CONDITION OF KEY HABITAT: Hāpuʻupuʻu depth preference has been noted to vary across its range, with fish found in progressively deeper waters with southern movement down the Hawaiian archipelago. This has previously been attributed to "tropical submergence," or the phenomenon in which species adapted to cooler water are restricted to greater depths in areas where shallow temperatures exceed their tolerances. Though hāpuʻupuʻu as a benthic species are known to be found on coral reef habitat within recreational dive depth limits fish in the NWHI, in the MHI they are most commonly known to utilize rocky habitat and structure beyond the mesophotic zone.

THREATS: Commercial and non-commercial fishing for hāpuʻupuʻu continue today, though rarely targeted directly and making up a relatively small proportion of the total catch of either. Though Deep-7 as a complex have been found to be neither overfished nor experiencing overfishing, health of the MHI population of hāpuʻupuʻu remains unknown. Because the species is relatively long-lived and sequentially hermaphroditic, potential negative impacts of intense fishing may be amplified.

CONSERVATION ACTIONS: The main Hawaiian Island (MHI) Deep-7 bottomfish complex is actively managed through a partnership between the State of Hawaiʻi, National Oceanic and Atmospheric Administration (NOAA), and Western Pacific Regional Fishery Management Council (WesPac). Management of the complex is in accordance with the Magnussen-Stevens Fishery Conservation and Management Act (MSA) which identifies the complex as Management Unit Species (MUS). Regulatory measures in place include in Annual Catch Limit for the combined Deep-7 bottomfish complex, mandatory bottomfish vessel registration, and a non-commercial daily bag limit of five fish per person, per day.

MONITORING: Benchmark stock assessments of the complex occur at five-year intervals, with an update assessment occurring in between. Data collection to inform the stock assessments is primarily fishery-dependent with fishery independent surveys in the past yielding limited information on the species.

RESEARCH PRIORITIES: Research priorities today revolve primarily around improving understanding of the ecology and biology of hāpuʻupuʻu in the MHI to better inform stock assessment and future management strategies. Achieving better understanding of the State's non-commercial bottomfish fishery, which is not required to report catch, is also an area of focus.

References:

Andrews A.H., DeMartini E.E., Brodziak J., Nichols R.S., Humphreys R.L. 2019. Growth and longevity of Hawaiian grouper (Hyporthodus quernus) — input for management and conservation of a large, slow-growing grouper. Canadian Journal of Fisheries and Aquatic Sciences. 76(10):1874–1884. doi:10.1139/cjfas-2018-0170.

DeMartini, E., Everson, A., Nichols, R. 2010. Estimates of body sizes at maturation and at sex change, and the spawning seasonality and sex ratio of the endemic Hawaiian grouper (Hyporthodus quernus, F. Epinephelidae). *Fishery Bulletin* 109(1): 123-134.

Richards BL. 2023. Annual Report: 2021 Bottomfish Fishery-Independent Survey in Hawaiʻi. NOAA Admin Rep. H-23-04, 50 p. doi:10.25923/r2nz-v710

Mundy, Bruce C. (2005). Checklist of the Fishes of the Hawaiian Archipelago. Bishop Museum Bulletins in Zoology. Bishop Museum Press Honolulu. p.704.

Stender, K. & Stender, Y. Epinephelus Quernus. MarinelifePhotography.com. Accessed January 16, 2025.

Syslo J., Oshima M., Ma H., Ducharme-Barth N., Nadon M., Carvalho, F. (2024). Benchmark stock assessment for the main Hawaiian Islands Deep 7 bottomfish complex in 2024 with catch projections through 2029. Department of Commerce. NOAA Stock Assessment Report. NMFSPIFSC-157. doi:10.25923/5ssg-8d54

Marine Fishes

Cryptic Reef Fishes

Apogonidae

Apogon maculiferus

Bleniidae

Cirripectes obscurus

Enchelyurus brunneolus

Entomacrodus marmoratus

Entomacrodus strasburgi

Istiblennius zebra

Plagiotremus ewaensis

Plagiotremus goslinei

Callionymidae

Callionymus caeruleonotatus

Callionymus comptus

Callionymus decorates

Draculo pogognathus

Synchiropus hawaiiensis

Synchiropus kinmeiensis

Gobiidae

Cabillus caudimacula

Eviota rubra

Eviota susanae

Oxyurichthys heisei

Oxyurichthys lonchotus

Pleurosicya larsonae

Psilogobius mainlandi

Hripterygiidae

Enneapterygius atriceps

Antennariidae

Antennarius commerson

Caracanthidae

Caracanthus typicus

Scorpaenidae
Pterois sphex
Scorpaena pele
Scorpaenopsis altirostris
Scorpaenopsis brevifrons
Scorpaenopsis cacopsis
Scorpaenopsis pluralis
Synodontidae
Synodus falcatus
Synodus janus

SPECIES STATUS:
IUCN Red List – Not considered
All Endemic except *Antennarius*

SPECIES INFORMATION: Cryptic reef fishes are small, secretive species that inhabit crevices, sand patches, and reef structures. Their coloration and behavior make them difficult to observe, yet they play vital roles in maintaining reef health by controlling algae and serving as prey for larger species. These are mostly small (less than 18 centimeters or seven inches) site-attached reef fishes. Decorated dragonets (*Callionymus decoratus*) reach 28 centimeters (eleven inches) in length as does Commerson's frogfish (*Antennarius*), and some of the scorpionfishes are also large. ʻUpāpalu (*Apogon*) is a zooplanktivore. The blennies mostly feed on algae except for the *Plagiotremus* species which feed on mucus and skin tissue of other fishes. The callionymids (dragonets) and gobies are carnivorous on small invertebrates. The Hawaiian triplefin (*Enneapterygius*) is omnivorous. Commerson's frogfish (*Antennarius*) is a sit-and-wait predator using a modifield dorsal fin spine as a fishing lure. The scorpionfishes (Scorpaenidae) and lizardfishes (Synodontidae) are ambush predators of fishes and invertebrates. ʻUpāpalu (*Apogon*) males brood young in their mouths until hatching. Male blennies and gobies of most species guard demersal eggs until hatching. Mainland's goby (*Psilogobius*) lives in commensal burrows with an alpheid shrimp and Oxyurichthys lonchotus may do the same. Hawaiian orbicular velvetfish (Caracanthus) may be a protogynous hermaphrodite. The species common names and Hawaiian names are: Apogon maculiferus (spotted cardinalfish, ʻupāpalu), Cirrepecetes obscurus (gargantuan blenny, paoʻo), Enchelyurus brunneolus (no common name), Entomacrodus marmoratus (marbled blenny, paoʻo), Entomacrodus strasburgi (Strasburg's blenny), Istiblennius zebra (zebra blenny, paoʻo), Plagiotremus ewaensis (Ewa blenny), Plagiotremus goslinei (scale-eating blenny), Callionymus caeruleonotatus (bluespotted dragonet), Callionymus comptus (ornamented dragonet), Callionymus decoratus (longtail dragonet), Draculo pogognathus (no common name), Synchiropus hawaiiensis (no common name), Synchiropus kinmeiensis (no common name), Cabillus caudimacula (no common name), Eviota rubra (no common name), Eviota susanae (no common name), Oxyurichthys heisei (ribbon goby), Oxyurichthys lonchotus (no common name), Pleurosicya larsonae (no common name), Psilogobius mainlandi (Mainland's goby), Enneapterygius atriceps (Hawaiian Triplefin), Antennarius commerson (Commerson's frogfish), Caracanthus typicus (Hawaiian orbicular velvetfish), Pterois sphex (Hawaiian

turkeyfish, nohu pinao), Scorpaena pele (no common name), Scorpaenopsis altirostris (no common name), Scorpaenopsis brevifrons (shortnose scorpionfish), Scorpaenopsis cacopsis (titan scorpionfish, nohu), Scorpaenopsis pluralis (no common name), Synodus falcatus (no common name), and Synodus janus (no common name). Synchiropus hawaiiensis and Synchiropus kinmeiensis may be the same species. Bruce Mundy (National Marine Fisheries Service (NMFS)) reports that Jack Randall (Bishop Museum) will publish a manuscript reporting that S. janus is a junior synonym of S. falcatus so these are probably just a single species.

DISTRIBUTION: Distributed throughout the Hawaiian Islands, primarily in shallow reef habitats and tide pools. *Enchelyurus* occurs from Oʻahu to Lisianski. *Entomacrodus strasburgi* occurs from Molokaʻi to Oʻahu. Zebra blennies occur from Hawaiʻi Island to Lisianski. The scale- eating blenny occurs from the island of Hawaiʻi to Pearl and Hermes Atoll. Bluespotted dragonets occur in the main islands only. Ornameneted dragonet, Mainland's goby, and *Scorpaena pele* have been found from Maui to Oʻahu. The longtail dragonet is found from Maui to Pearl and Hermes Atoll. *Draculo* has been found from Molokaʻi to Kauaʻi. *Synchiropus hawaiiensis* has been found from Maui to Molokaʻi. *Synchiropus kinmeiensis* has been collected from Maro Reef through Kure Atoll and the Emperor Seamounts. *Cabillus,* the two *Eviota* species, and *Pleurosicya* have only been found off Oʻahu. The ribbon goby is found off Lānaʻi and Molokaʻi.

Oxyurichthys lonchotus has been collected from Hawaiʻi Island to Oʻahu. Hawaiian orbicular velvetfish have been found from Oʻahu through Midway Atoll. *Scorpaenopsis altirostris* is found from the island of Hawaiʻi to Molokaʻi. *Scorpaenopsis pluralis* is known only from the holotype from near Laysan. *Synodus falcatus* has been found from Molokaʻi through Laysan Island. *Synodus janus* is only known from the holotype collected off the island of Hawaiʻi. All the other species occur throughout the Hawaiian Islands.

ABUNDANCE: Common but underreported in surveys due to their small size and hidden habitats.The shallow water species are surveyed for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands (NMWHI), both by NMFS and the Division of Aquatic Resources and data are available online. Nohu pinao (Hawaiian turkeyfish) and titan scorpionfish may have declined from historic levels and a few hundred pounds of titan scorpionfish are reported in State commercial catch data each year.

LOCATION AND CONDITION OF KEY HABITAT: All species except bluespotted dragonet, the two *Synchiropus* species, ribbon goby, *Synodus falcatus, Scorpaena pele,* and *Scorpaenopsis altirostris* can be found in shallow water depths. *Callionymus coeruleonotatus* is found in depths over 45 meters (150 feet), *Oxyurichthys heisei,* the *Synchiropus species* and *Scorpaenopsis altirostris* and *Scorpaenopsis pluralis* occur over 90 meters (300 feet) deep, *S. falcatus* has only been found in depths greater than 30 meters (100 feet), and *Scorpaena pele* has been found deeper than 150 meters (500 feet). ʻUpāpalu (spotted cardinalfish) occurs in caves during the day and feeds nocturnally over a wider area. The gargantuan blenny lives on rocky shores exposed to wave action. Zebra blennies and the *Entomacrodus* species live in shallow, rocky surge zones and can even leap from pool to pool. *Enchelyurus* occupies dead coral heads. Most callionymids, *Cabillus*, *Oxyurichthys lonchotus*, and the lizardfishes occur in sandy or muddy habitats. The two Eviota species have been found around Kāneʻohe Bay, *E. rubra* from deeper spur and groove and *E.*

susanae from shallow waters inside the bay. The Hawaiian orbicular velvetfish occurs among the branches of live coral. The scorpionfishes are often found hidden or under ledges. The rest are found throughout coral reef habitats.

THREATS:

- Habitat Loss: Coral reef destruction from human activities and climate change.
- Pollution: Sedimentation and nutrient runoff reduce habitat quality.
- Invasive Species: Competition with invasive algae and fish species.
- Climate Change: Ocean warming and acidification impact reef structures and ecosystems.
- Lack of Awareness: Limited recognition of their ecological importance.
- Only a few of these species are prized by aquarists. These are gargantuan blenny, zebra blenny, Commerson's frogfish, Hawaiian orbicular velvetfish, and nohu pinao (Hawaiian turkeyfish);
- Titan scorpionfish are fished commercially and recreationally;
- Many species have restricted ranges within the State (see above).

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Commercial licenses are required for aquarium collectors. In addition to common statewide and island conservation actions, specific actions include:

- Reef Protection: Implement marine protected areas to safeguard reef habitats.
- Habitat Restoration: Promote coral restoration projects and remove invasive species.
- Pollution Control: Mitigate land-based sources of pollution through better watershed management.
- Public Education: Raise awareness about the importance of cryptic reef fishes in ecosystem health.
- Research Support: Fund studies to improve understanding of these species.

MONITORING:

- Population Surveys: Use specialized methods such as cryptic fish surveys and baited remote underwater video systems (BRUVS).
- Habitat Assessment: Monitor reef condition and structural complexity.
- Citizen Science: Engage divers and snorkelers in observing and reporting sightings.

RESEARCH PRIORITIES:

- Species Identification: Catalog cryptic species and their roles in reef ecosystems.
- Ecological Roles: Study their contributions to algae control, nutrient cycling, and food webs.
- Resilience Studies: Assess their adaptability to changing environmental conditions.
- Threat Impact: Investigate specific threats like invasive species and microplastics.
- Conservation Value: Highlight their ecological importance in reef conservation strategies.
- Support aquaculture research to develop captive breeding for species used in the aquarium trad

References:

FishBase. (2023). Species Summary for Cryptic Reef Fishes. Retrieved from https://www.fishbase.org

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawai‘i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Hoover J. 1993. Hawaii’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

Howe JC. 1993. A comparative analysis of the feeding apparatus in pomacanthids, with special emphasis of oesophageal papillae in *Genicanthus personatus*. J. Fish Biology 43(4):593-602.

Hawaii Division of Aquatic Resources (DAR). (2023). Reef Fish Monitoring Programs. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). Cryptic Reef Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Coral Reef Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Waples RS, Randall JE. 1988. A revision of the Hawaiian USA lizardfishes of the genus *Synodus* with descriptions of four new species. Pacific Science 42(3-4): 178-213.

Marine Fishes

Deep Fishes

Ateleopodiformes

Ijimaia plicatellus

Beryciformes

Aulotrachichthys heptalepis

Gadiformes

Caelorinchus doryssus

Caelorinchus gladius

Hymenoceph alusantraeus

Hymenocephalus tenuis

Kumba hebetate

Malacocephalus hawaiiensis

Nezumia ectenes

Nezumia holocentra

Sphagemacrurus gibber

Ventrifossa ctenomelas

Gadella molokaiensis

Physiculus sterops

Bathygadus bowersi

Gonorynchiformes

Gonorynchus moseleyi

Lophiiformes

Halieutaea retifera

Linophryne escaramosa

Lophiodes bruchius

Solocisquama erythrina

Ophidiiformes

Luciobrotula lineata

Pycnocraspedum armatum

Cataetyx hawaiiensis

Grammonus Waikīkī

Microbrotula rubra

Saccogaster hawaii
Osmeriformes
Glossanodon struhsakeri
Perciformes
Champsodon fimbriatus
Epigonus devaneyi
Epigonus glossodontus
Osopsaron incisum
Synagrops argyreus
Squaliformes
Etmopterus villosus
Stomiiformes
Araiophos gracilis
Argyripnus brocki
Eustomias albibulbus
Eustomias bulbiramis
Eustomias magnificus

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Deep-sea fishes exhibit a range of adaptations to life in the dark, high-pressure environments of the ocean's depths. They include predators, scavengers, and planktivores that play crucial roles in deep-sea ecosystems. Deep fishes usually live on soft sediment substrates and feed on fishes and invertebrates in or above those sediments. The grenadiers (gadiformes) are elongate fishes with tails that end in a point. The lophiiformes use a modified dorsal fin spine as a lure to catch prey. Males are permanent parasites of females in *Linophryne*. The bythitids (last four Ophidiiformes) are live-bearers. Struhsaker's deep-sea smelt (*Glossanodon*) is a midwater pelagic planktivore. *Champsodon* is also a vertically migrating and schooling predator. The stomiiformes have bioluminescent organs. The *Eustomias* species are mesopelagic and vertically migrate diurnally. None of the species have Hawaiian names and only some have common names. The species with common names are: *Ijimaia plicatellus* (deep water ateleopid), *Caelorinchus doryssus* (spear-nosed grenadier), *Caelorinchus gladius* (sharp-snouted grenadier), *Hymenocephalus antraeus* (common big-eyed grenadier), *Hymenocephalus tenuis* (slender grenadier), *Kumba hebetate* (dull grenadier), *Malacocephalus hawaiiensis* (Hawaiian softhead grenadier), *Nezumia ectenes* (elongated grenadier), *Nezumia holocentra* (Cramer's grenadier), *Sphagemacrurus gibber* (humped grenadier), *Ventrifossa ctenomelas* (Hawaiian grenadier), *Bathygadus bowersi* (Bower's grenadier), *Gonorynchus moseleyi* (beaked salmon), *Halieutaea retifera* (net bat fish), *Solocisquama* (red bat fish),

Glossanodon (Struhsaker's deep-sea smelt), *Champsodon fimbriatus* (fringed champsodontid), *Etmopterus* (Hawaiian lanternshark), and *Argyripnus brocki* (Brock's bristlemouth).

DISTRIBUTION: Found in the mesophotic and deep-sea zones around the Hawaiian archipelago. *Ijimaia,* common big-eyed grenadier, *Physiculus*, *Pycnocraspedum, Epigoinus glossodontus* and *Argyripnus* have been found from the island of Hawai‘i to O‘ahu.
Aulotrachichthys has been found from Maui to Maro Reef. The spear-nosed grenadier has been found from Maui through the Northwestern Hawaiian Islands (NWHI). The sharp-snouted grenadier and *Ventrifossa* are found in the Main Hawaiian Islands (MHI). The slender grenadier, dull grenadier, elongated grenadier*,* and *Linophryne* are known only from holotypes collected off O‘ahu; and Cramer's grenadier*, Grammonus, Microbrotula, Saccogaster*, and the *Eustomias* species have also only been collected off O‘ahu. The Hawaiian softhead grenadier and the humped grenadier are found from the island of Hawai‘i to French Frigate Shoals. Bower's grenadier is found from Kaua‘i to French Frigate Shoals. Beaked salmon have been collected from Maui to O‘ahu. *Lophiodes* is found from Maui to Necker Island. Red bat fish are found from Maui to Kaua‘i. *Luciobrotula* and *Cataetyx* are known only from the island of Hawai‘i. *Epigonius devaneyi* has been found from Necker Island to Maro Reef. *Osopsaron* occurs from Maui to Laysan Island. *Synagrops* occurs from the island of Hawai‘i to Laysan Island. *Araiophos* is known from the island of Hawai‘i to St. Rogatien Bank. All the other species occur throughout the Hawaiian Islands.
ABUNDANCE: Generally stable but poorly understood due to limited data. Little abundance data appears to exist for these species and trends are unknown. The common big-eyed grenadier is the most common macrourid.

LOCATION AND CONDITION OF KEY HABITAT: All species except *Aulotrachichthys*, *Physiculus*, beaked salmon*,* Net bat fish, *Grammonus*, *Microbrotula, Epigonius devaneyi, Araiophos,* and Brock's bristlemouth can be found in water depths greater than 300 meters (1,000 feet). *Aulotrachichthys* is found from 45 to 275 meters (150 to 900 feet) deep. *Physiculus*, net bat fish and *Epigonius devaneyi* are found from about 100 to 300 meters (300 to 1,000 feet) deep. Beaked salmon are found from 110 to 180 meters (350 to 600 feet) deep. *Grammonus* and *Microbrotula* are known from a few specimens caught in shallow reef habitat. *Araiophos*, *Eustomias albibulbus* and *Eustmoais bulbiramis* have been collected from the surface to 400 meters (1,300 feet) deep. *Eustomias magnificus* has been collected from the surface to 1,800 meters (6,000 feet). Brock's bristlemouth has been collected from 180 to 300 meters (600 to 1,000 feet) deep. *Ijimaia* can be found as shallow as 240 meters (800 feet) as well as deeper than 300 meters (1,000 feet). *Gadella* and Struhsaker's deep-sea smelt can also be found as shallow as 180 meters (600 feet). *Gadella* can be found in rocky crevices. *Synagrops* can be found as shallow as 75 meters (250 feet) deep.

THREATS: Deep offshore aquaculture may become a threat in the future.

- Overfishing: Targeted for commercial and recreational fisheries.
- Habitat Destruction: Bottom trawling and other fishing practices damage seafloor ecosystems.
- Pollution: Marine debris and chemical contaminants affect food webs.
- Climate Change: Ocean warming and acidification alter deep-sea environments.

- Data Deficiency: Lack of information hinders effective management.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Fishing Regulations: Enforce catch limits and gear restrictions to protect populations.
- Marine Protected Areas: Designate areas to conserve deep-sea ecosystems.
- Research and Monitoring: Increase studies on deep-sea species and habitats.
- Pollution Reduction: Address sources of marine debris and chemical contaminants.
- International Collaboration: Work with global partners to protect migratory and shared species.

MONITORING:

- Population Surveys: Use remote-operated vehicles (ROVs) and deep-sea submersibles.
- Habitat Assessment: Map and monitor mesophotic and abyssal ecosystems.
- Fishery Data: Collect catch and bycatch information from deep-water fisheries.

RESEARCH PRIORITIES:

- Species Discovery: Identify and describe new species in Hawaiian deep-sea habitats.
- Life History Studies: Investigate growth, reproduction, and feeding ecology.
- Habitat Connectivity: Study links between mesophotic and deep-sea zones.
- Impact of Fishing: Assess the effects of fishing on deep-sea communities.
- Climate Resilience: Evaluate how deep-sea species respond to environmental changes.

References:

FishBase. (2023). Species Summary for Deep-Sea Fishes. Retrieved from https://www.fishbase.org

Hawaii Division of Aquatic Resources (DAR). (2023). Deep-Water Fisheries in Hawaii. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). Deep-Sea Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Deep-Sea Conservation Initiatives. Retrieved from https://www.nature.org

Nelson, J.S. 1994. Fishes of the World. 3rd edition. John Wiley and Sons, Inc. NY, NY. 600 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Fishes

Eels

Muraenidae

Anarchias sp.
Enchelycore pardalis
Gymnothorax nuttingi
Gymnothorax polyspondylus
Gymnothorax steindachneri

Ophichthidae

Callechelys lutea
Ichthyapus platyrhynchus
Ophichthus fowleri
Ophichthus kunaloa
Scolecenchelys puhioilo

Congridae

Acromycter alcocki
Bathycongrus Aequorea
Gorgasia hawaiiensis

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Eels are elongated, serpentine fish with a wide variety of sizes, colors, and patterns. Freshwater eels migrate between marine and freshwater environments for reproduction, while moray eels are reef-dwelling predators. Both groups are crucial components of aquatic ecosystems. Morays and snake eels (ophicthids) are carnivores of fishes and invertebrates. Morays are often nocturnal. Hawaiian garden eel (*Gorgasia*) is a planktivore. Other conger eels are largely nocturnal carnivores. Many moray eels are hermaphrodites of one form or another. The species common names and Hawaiian names are *Anarchias* sp. (no common name), *Enchelycore pardalis* (dragon eel, puhi-kauila), *Gymnothorax nuttingi* (Nutting's moray), *Gymnothorax polyspondylus* (many-vertebrate moray), *Gymnothorax steindachneri* (Steindachner's moray, puhi), *Callechelys lutea* (yellow-spotted snake eel, puhi), *Ichthyapus platyrhychus* (no common name), *Ophichthus fowleri* (Fowler's snake eel), *Ophichthus kunaloa* (nom common name), *Scolecenchelys phuioilo* (no common name), *Acromycter alcocki* (no common name), *Bathycongrus aequorea* (no common name), and *Gorgasia hawaiiensis* (Hawaiian garden eel, puhi).

D**ISTRIBUTION:** The many-vertebrate moray has been found off O'ahu only. Steindachner's moray has been found from O'ahu through the Northwestern Hawaiian Islands (NWHI).
Fowler's snake eel occurs off Maui, Lāna'i, and O'ahu. *Ophichthus kunaloa* is found from the island of Hawai'i to O'ahu. *Scolecenchelys puhioilo* is known from only two specimens from O'ahu and Maro Reef. *Acromycter alcocki* has been collected from Maui to O'ahu. *Bathycongrus* occurs from the island of Hawai'i to Kaua'i and maybe further northwest. Hawaiian garden eels occur from the island of Hawai'i to

O‘ahu. The other species occur throughout the Hawaiian Islands.

ABUNDANCE: Stable for some species, declining for others due to habitat loss and overfishing. The shallow water species are surveyed for in surveys of coral reef fishes in the Main and NWHI, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources and data are available online.

LOCATION AND CONDITION OF KEY HABITAT: All species except Nutting’s moray, many-vertebrate moray, *Ophichthus kunaloa, Scolecenchelys, Acromycter,* and *Bathycongrus* are found in shallow water. Nutting’s moray is found deeper than 110 meters (350 feet), the many- vertebrate moray was collected deeper than 180 meters (600 feet), and *Ophichthus kunaloa* and *Scolecenchelys puhioilo* are collected only greater than 210 meters (700 feet) deep. *Acromycter* and *Bathycongrus* have been collected only deeper than 300 meters (1,000 feet). Steindachner’s moray is only found deeper than 30 meters (100 feet) in the main islands. Snake eels and Hawaiian garden eels occur in sandy habitat. The rest are found throughout coral reef habitats. Puhi- kauila (dragon eel) is more common in the NWHI.

THREATS:

- Habitat Loss: Stream channelization and reef degradation reduce available habitat. Hawaiian garden eels may be threatened by habitat alteration.
- Pollution: Runoff impacts water quality and prey availability.
- Overfishing: Targeted for food and aquarium trade.
- Climate Change: Rising sea temperatures and ocean acidification affect ecosystems.
- Barriers to Migration: Dams and diversions obstruct migratory pathways for freshwater eels.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction.
Commercial licenses are required for aquarium collectors. In addition to common statewide and island conservation actions, specific actions include:

- Habitat Restoration: Rehabilitate freshwater streams and protect coral reefs.
- Fishing Regulations: Enforce size and catch limits to prevent overharvesting.
- Pollution Mitigation: Reduce agricultural runoff and marine debris.
- Barrier Removal: Address migratory barriers in freshwater systems.
- Community Engagement: Promote the ecological importance of eels in Hawaiian ecosystems.

MONITORING:

- Population Surveys: Use electrofishing and underwater visual census techniques.
- Habitat Assessment: Monitor stream flow, water quality, and coral reef health.
- Fishery Data: Collect catch data to evaluate fishing pressure.

RESEARCH PRIORITIES:

- Life Cycle Studies: Investigate spawning, larval migration, and recruitment.
- Habitat Use: Identify critical habitats and movement patterns.
- Population Genetics: Assess genetic diversity and connectivity between populations.
- Impact of Climate Change: Study resilience to temperature and acidification stressors.
- Traditional Practices: Document Hawaiian cultural knowledge and fishing practices related to eels.
- Support aquaculture research to develop captive breeding for species used in the aquarium trade.

References:

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawai‘i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

FishBase. (2023). Species Summary for *Anguillidae* and *Muraenidae*. Retrieved from https://www.fishbase.org

Hawaii Division of Aquatic Resources (DAR). (2023). Freshwater and Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Stream and Reef Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Fishes
Hawaiian flagtail

Āholehole
Kuhlia xenura

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: Āholehole in Hawai‘i is a silver-bodied fish with a distinctive forked tail and a black margin. Juveniles inhabit brackish estuaries and tidal pools, while adults are found in nearshore waters. The species is known for its schooling behavior and omnivorous diet, feeding on small invertebrates and algae. The Hawaiian flagtail used to be considered a single species in the species *Kuhlia sandvicensis* but have recently been determined to be two species. One of those species is endemic and thus qualifies under the CWCS criteria. This is *K. xenura,* sometimes now called the big eyed mullet. They reach about nine inches in length. They may be found in schools. They are planktivores, primarily nocturnally. They facultatively use streams as well.When in streams they feed on fishes, invertebrates, and insects.

DISTRIBUTION: Found throughout the archipelago in both coastal and inland water systems. They are found throughout the State.

ABUNDANCE: They are looked for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources. Commercial landings for both *Kuhlia* spp. in the Main Hawaiian Islands have averaged about 1,350 kilograms (3,000 pounds) a year in recent years, except there was a decrease to less than 900 kilograms (2,000 pounds) in 2003, the most recent year of data.

LOCATION AND CONDITION OF KEY HABITAT: Young *K. xenura* can be found in shallow water along the coast and in tide pools and estuaries, where this species is denser than *K. sandvicensis*, which prefers higher salinity. Adults are found along the outer edge of the reefs. They can often be found in areas of high surge. At night they spread out to feed on plankton.

THREATS:

- Habitat Degradation: Loss of estuarine and coastal habitats due to development.
- Pollution: Nutrient and sediment runoff impacts water quality.
- Overfishing: Targeted for recreational and subsistence fishing.
- Climate Change: Rising sea levels and temperature changes affect habitat availability.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current

populations, but to also establish further populations to reduce the risk of extinction. Regulations set minimum catch size at five inches. In addition to common statewide and island conservation actions, specific actions include:

- Habitat Protection: Preserve and restore estuarine and coastal ecosystems.
- Fishing Regulations: Establish size and bag limits to ensure sustainable harvesting.
- Pollution Control: Implement measures to reduce agricultural and urban runoff.
- Community Engagement: Educate the public on the ecological importance of the species.

MONITORING:

- Population Surveys: Conduct regular counts in estuaries and nearshore areas.
- Habitat Monitoring: Evaluate water quality and sediment levels.
- Fishery Data: Track catch rates and size distribution to monitor fishing pressure.

RESEARCH PRIORITIES:

- Life Cycle Studies: Investigate larval and juvenile development.
- Habitat Use: Map critical habitats and movement patterns.
- Population Dynamics: Study recruitment, growth rates, and reproduction.
- Impact of Climate Change: Assess resilience to environmental changes.
- Cultural Practices: Explore the relationship between traditional fishing and population sustainability.

References:

Benson, Lori. Personal communication.

Benson LK, Fitzsimons JM. 2002. Life history of the Hawaiian fish *Kuhlia sandvicensis* as inferred from daily growth rings of otoliths. Environmental Biology of Fishes. 65(2):131-137.

FishBase. (2023). Species Summary for *Kuhlia xenura*. Retrieved from https://www.fishbase.org

Hawai‘i Division of Aquatic Resources, State of Hawaii. Commercial marine landings data. 1997 – 2003.

Honolulu, HI: Division of Aquatic Resources.

Hawaii Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Coastal Habitat Conservation. Retrieved from https://www.nature.org

Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press.
Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Aseraggodes borehami Courtesy Keoki Stender

Marine Fishes

Flatfishes

Bothidae

Bothus thompsoni
Engyprosopon hawaiiensis
Engyprosopon xenandrus
Parabothus chlorospilus
Taeniopsetta radula

Pleuronectidae

Poecilopsetta hawaiiensis

Samaridae

Samariscus corallinus

Soleidae

Aseraggodes borehami
Aseraggodes holcomi
Aseraggodes therese

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: Flatfishes are easily recognized by their laterally compressed bodies and both eyes located on one side of their head. They are masters of camouflage, blending seamlessly into sandy and rocky substrates. Their diet primarily consists of small fish and invertebrates. Flatfishes usually live on soft sediment substrates and feed on fishes and invertebrates in those sediments. None of these species has a Hawaiian name. The species common names are: *Bothus thompsoni* (Thompson's flounder), *Engyprosopon hawaiiensis* (no common name), *Engyprosopon xenadrus* (Gilbert's small flounder), *Parabothus chlorospilus* (green-spotted flounder), *Taeniopsetta radula* (round-bodied flounder), *Poecilopsetta hawaiiensis* (no common name), *Samariscus corallinus* (coralline-red flounder), *Aseraggodes borehami* (Boreham's sole), *Aseraggodes holcomi* (no common name), and *Aseraggodes therese* (Therese's sole).

DISTRIBUTION: Found in nearshore coastal waters and sandy flats around the Hawaiian

Islands. Thompson's flounder occurs from Maui to Maro Reef. Gilbert's small flounder and the round-bodied flounder occur from the island of Hawai‘i to Laysan Island. The coralline-red flounder occurs from Moloka‘i to Maro Reef. Boreham's sole has been found from the island of Hawai‘i to O‘ahu. *Aseraggodes holcomi* has only been collected off O‘ahu. All the other species occur throughout the Hawaiian Islands.

ABUNDANCE: Common but patchily distributed in suitable habitats. Little abundance data appears to exist for these species.

LOCATION AND CONDITION OF KEY HABITAT: All species except Thompson's flounder, green-spotted flounder, round-bodied flounder, *Poecilopsetta,* and the coralline-red flounder can be found in shallow water depths. Thompson's flounder, round-bodied flounder, *Poecilopsetta,* and the coralline-red flounder are found in depths over 80 meters (250 feet), and the green- spotted flounder is found in depths over 120 meters (400 feet). These fishes live on soft sediment substrates though the coralline-red flounder has been found on live sponge bottoms and Therese's sole has been found over reef and rubble.

THREATS: None identified.

- Habitat Degradation: Coastal development and sedimentation reduce habitat quality.
- Overfishing: Targeted in local fisheries and as bycatch.
- Pollution: Nutrient runoff and marine debris affect benthic prey availability.
- Climate Change: Altered sediment dynamics and rising sea temperatures impact ecosystems.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Habitat Protection: Safeguard sandy and benthic environments through conservation measures.
- Fishing Regulations: Implement sustainable catch limits and protect juveniles.
- Pollution Control: Reduce nutrient runoff and marine debris through improved waste management.
- Community Education: Raise awareness about flatfish ecology and their role in benthic ecosystems.

MONITORING:

- Population Surveys: Utilize trawl nets and underwater visual censuses.
- Habitat Assessment: Monitor sediment quality and prey availability.
- Fishery Data: Track harvest levels and bycatch rates to inform management decisions.

RESEARCH PRIORITIES:

- Camouflage and Behavior: Study cryptic adaptations and predator-prey interactions.
- Population Dynamics: Investigate recruitment, growth, and reproduction.
- Habitat Use: Map critical habitats and movement patterns.
- Fisheries Impact: Assess vulnerability to overfishing and bycatch.

- Resilience Studies: Explore adaptability to environmental stressors.

References:

FishBase. (2023). Species Summary for Flatfishes. Retrieved from https://www.fishbase.org

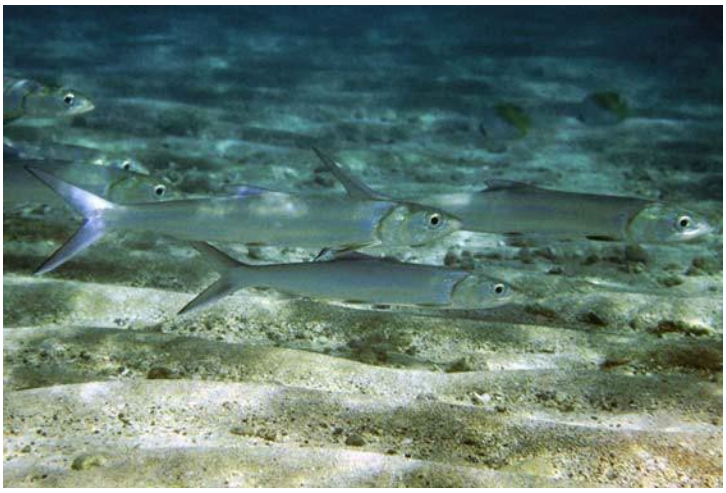
Hawaii Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Coastal Habitat Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.



Marine Fishes

Hawaiian ladyfish or Awa‘aua

Elops hawaiensis

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: The awa‘aua is a sleek, silver-colored fish known for its elongated body and forked tail. Juveniles are often found in estuaries, while adults inhabit coastal waters. They are fast swimmers and opportunistic feeders, consuming small fish and invertebrates. They are one of the most primitive bony fish. They are often confused with mullet. Spawning takes place offshore. The larvae are leptocephalus (eel-like) and as they develop they move into inshore waters and can be found in tidal streams, salt water marshes, and canals. It feeds on fishes and crustaceans. They swim in schools. They are noted for their hard-fighting nature when caught.

DISTRIBUTION: Found in estuaries, lagoons, and nearshore coastal waters throughout the Hawaiian Islands. Found throughout the State and especially common at Hanauma Bay, O‘ahu.

ABUNDANCE: Common in suitable habitats, particularly in protected estuarine environments. Commercial landings in the Main Hawaiian Islands have been about 225 kilograms (500 pounds) a year in recent years. No other abundance data are available.

LOCATION AND CONDITION OF KEY HABITAT: Awa‘aua prefer shallow waters around the shoreline or shallow protected waters over sandy or silty bottoms. They may also be found in brackish water as well as fish ponds. Habitat degraded by coastal development, pollution, and sedimentation.

THREATS:

- Habitat Loss: Coastal development and wetland drainage reduce key nursery areas.
- Pollution: Nutrient and chemical runoff impacts water quality in estuaries.
- Overfishing: Targeted by recreational and small-scale fisheries.
- Climate Change: Rising sea levels and changing water temperatures may alter habitats.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Habitat Protection: Preserve estuarine and coastal habitats through zoning and restoration.
- Fisheries Management: Implement size and bag limits to prevent overharvesting.
- Water Quality Improvement: Reduce runoff and sedimentation through improved

land-use practices.
- Community Engagement: Raise awareness of the species' ecological role and habitat needs.
- Restore Habitat: through reduction in pollution.
- Restore Healthy Population: with appropriate fishing regulations and education.

MONITORING:
- Population Surveys: Conduct regular assessments using nets and visual surveys.
- Habitat Monitoring: Evaluate water quality and sediment levels in estuaries and nearshore areas.
- Fishery Data: Collect data on catches to monitor exploitation levels.

RESEARCH PRIORITIES:
- Life Cycle Studies: Investigate larval and juvenile development stages.
- Habitat Use: Map critical nursery and adult habitats.
- Population Dynamics: Study recruitment, migration, and growth rates.
- Climate Resilience: Assess adaptability to changing environmental conditions.
- Fisheries Impact: Evaluate the sustainability of current fishing practices.

References:

Fishbase. [Internet] online data. http://fishbase.sinica.edu.tw/Summary/SpeciesSummary.cfm?genusname=Elops&speciesname=hawaiensis (accessed May 2005).

FishBase. (2023). Species Summary for *Elops hawaiensis*. Retrieved from https://www.fishbase.org

Hawaii Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Nature Conservancy Hawai‘i Program. (2023). Coastal Habitat Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Western Pacific Fishery Information Network. online data. Available from: http://www.pifsc.noaa.gov/wpacfin/ (accessed May 2005).

Marine Fishes

Whitesaddled goatfish or Kūmū

Paurupeneus porphyreus

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Kūmū Goatfishes are known for their dual chin barbels, used to detect prey in sandy and rocky substrates. They play a crucial role in the reef ecosystem by controlling invertebrate populations and redistributing sediments. They feed on invertebrates in the sediments around reefs. They reach about 38 centimeters (15 inches) in length. They may be found in schools during the day.

DISTRIBUTION: Common on reefs and sandy flats across the Hawaiian Islands. They are found throughout the State.

ABUNDANCE: They are looked for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources. Commercial landings in the Main Hawaiian Islands have dropped from about 1,800 to 2,300 kilograms (4,000 to 5,000 pounds) a year to 1,040 kilograms (2,300 pounds) in 2003, the most recent year of data.

LOCATION AND CONDITION OF KEY HABITAT: Young are common in shallow water in the summer. Adults can be found throughout reef habitats. Threatened by sedimentation, habitat destruction, and overfishing.

THREATS: They are fished commercially and recreationally. In traditional Native Hawaiian culture they were sometimes substituted for pigs when certain offerings were called for. They could only be consumed by men.

- Overfishing: Targeted for food and commercial purposes.
- Habitat Degradation: Coral reef and benthic habitat loss due to sedimentation and coastal development.
- Pollution: Nutrient runoff affecting benthic prey availability.
- Climate Change: Coral bleaching impacts associated reef ecosystems.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Regulations set minimum catch size at ten inches (25 centimeters, Maui only: minimum size - 12”, bag limit - 1). In addition to common statewide and island conservation actions, specific actions include:

- Fishing Regulations: Enforce size and bag limits, particularly for kumu.
- Marine Protected Areas: Establish zones to preserve key habitats.

- Community Engagement: Promote sustainable fishing practices among local communities.
- Habitat Restoration: Rehabilitate degraded benthic environments.

MONITORING: Continue surveys of population and distribution in known and likely habitats.

- Population Surveys: Regular assessments of goatfish abundance and size distribution.
- Habitat Health: Monitor sediment levels and coral cover.
- Fisheries Data: Collect and analyze harvest data for sustainable management.

RESEARCH PRIORITIES:

- Feeding Ecology: Study dietary habits and prey selection.
- Population Trends: Monitor recruitment and growth rates.
- Habitat Use: Investigate habitat preferences and movement patterns.
- Fisheries Impact: Assess the effects of fishing pressure on populations.
- Resilience Studies: Understand adaptability to environmental changes.

References:

Hawaii Coral Reef Initiative. (2023). Reef Fish Conservation in Hawaii. Retrieved from https://www.hcri.org

Hawai‘i Division of Aquatic Resources, State of Hawaii. Commercial marine landings data. 1997 – 2003. Honolulu, HI: Division of Aquatic Resources.

Hawai‘i Division of Aquatic Resources. (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Nature Conservancy Hawai‘i Program. (2023). Coral Reef Conservation. Retrieved from https://www.nature.org

Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press.
Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Calotomus zonarchus male
Courtesy Keoki Stender

Marine Fishes

Spectacled Parrotfish or Uhu

Chlorurus perspicillatus

Yellowbar Parrtofish or Uhu

Calotomus zonarchus

SPECIES STATUS:
IUCN Red List – Not considered
Endemic, except spectacled parrotfish which also occurs at Johnston Atoll

SPECIES INFORMATION: Parrotfishes are brightly colored reef fishes named for their beak-like teeth, used to scrape algae and coral. They play a key role in maintaining coral reef health by preventing algal overgrowth and contributing to sand production. These species are herbivorous and reach over 30 centimeters (one foot) in length. They are protogynous hermaphrodites. Terminal phase males maintain haremic territories. These species have relatively fast growth and maturity. They graze algae from rock and coral surfaces. Young can sometimes be aggregated.

DISTRIBUTION: Found on coral reefs across the Hawaiian Archipelago, including the Northwestern Hawaiian Islands. Spectacled parrotfish occur throughout the State. Yellowbar parrotfish occur from O‘ahu and northwest throughout the Northwestern Hawaiian Islands.

ABUNDANCE: They are surveyed in surveys of coral reef fishes in the Main and NWHI, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources and available online. Spectacled parrotfish numbers have declined in the populated areas of the main islands. Populations vary; uhu are locally important for cultural and subsistence fishing.

LOCATION AND CONDITION OF KEY HABITAT: Both species occur in coral reef areas. Spectacled parrotfish occur from the surface to over 60 meters (200 feet) deep, while yellowbar parrotfish only occur deeper than ten meters (35 feet). Threatened by coral bleaching, overfishing, and sedimentation.

THREATS: They are fished commercially and recreationally. They are sensitive to night-time spearfishing because members of this family rest at night in exposed reef crevices protected by a thin mucus covering they produce across the opening to the crevice.

- Overfishing: Targeted for food and sport.
- Habitat Degradation: Coral reef loss reduces available habitat and food sources.
- Climate Change: Warmer oceans and acidification affect coral health and algae growth.

- Pollution: Sedimentation and nutrient runoff negatively impact reef ecosystems.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Regulations set minimum catch size at 14 inches for *C. perspicillatus* and 10 inches (25 centimeters) for *C. zonarchus* and a bag limit of 2 including all species of parrotfish (commercial bag limit differs, Maui only: no take of male *C. perspicillatus)*. In addition to common statewide and island conservation actions, specific actions include:

- Fishing Regulations: Implement size and bag limits, and establish seasonal closures.
- Marine Protected Areas: Expand no-take zones to include key parrotfish habitats.
- Community Engagement: Educate about the ecological role of parrotfishes.
- Reef Restoration: Rehabilitate damaged reefs to support parrotfish populations.

MONITORING:

- Population Surveys: Use diver observations and underwater cameras to monitor abundance and size distribution.
- Habitat Assessments: Evaluate coral cover and algal levels on reefs.
- Fishing Data: Track harvest trends and compliance with regulations.

RESEARCH PRIORITIES:

- Ecological Roles: Quantify the impact of grazing on reef ecosystems.
- Population Dynamics: Study recruitment, growth rates, and mortality.
- Climate Adaptation: Investigate resilience to changing ocean conditions.
- Reproductive Biology: Understand spawning behaviors and sex ratios.
- Fisheries Management: Develop strategies to balance conservation with sustainable harvests.

References:

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawai‘i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawai‘i Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Hawai‘i Coral Reef Initiative. (2023). Reef Fish Conservation in Hawaii. Retrieved from https://www.hcri.org

Hawai‘i Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawai‘i’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Coral Reef Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawai‘i. Honolulu, HI: University of Hawai‘i Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press.

Marine Fishes

Sex Changing Reef Fishes

Serranidae

Liopropoma aurora
Pseudanthias thompsoni
Pseudogramma polyacanthum hawaiiensis

Labridae

Ammolabrus dicrus
Anampses chrysocephalus
Bodianus sp.
Coris flavovittata Coris
venusta Cymolutes
lecluse Iniistius
umbrilatus

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: Many Hawaiian reef fishes exhibit protogynous hermaphroditism, where individuals begin life as females and later transition to males. These species play critical roles in reef ecosystems, including predation and algae control. These fishes belong to the sea bass and wrasse families. These species are all carnivorous; Hawaiian anthias (*Pseudanthias*) more on zooplankton than the others, which feed in sand or on animals in the reef matrix. Most are less than 30 centimeters (one foot) long. It is likely that all are protogynous hermaphrodites. Many have males with haremic territories. The species common names and Hawaiian names are: sunset basslet (*Liopropoma*), Hawaiian anthias (*Pseudanthias*), palespotted podge (*Pseudogramma*), sand wrasse (*Ammolabrus*), psychedelic wrasse (*Anampses chrysocephalus*), Hawaiian pigfish (*Bodianus*), yellowstripe coris (*Coris flavovittata*, hilu), elegant coris (*Coris venusta*), Hawaiian knifefish (*Cymolutes*), and blackside razorfish (*Iniistius*, lae-nihi).

DISTRIBUTION: Found on reefs throughout the Hawaiian Archipelago. Hawaiian anthias have been reported from Moloka‘i throughout the rest of the chain to the northwest.
Palespotted podge has been found from the island of Hawai‘i to O‘ahu. The sand wrasse has only been found off O‘ahu. Lae-nihi have only been found from the island of Hawai‘i to Necker Island. All the other species occur throughout the Hawaiian Islands.

A**BUNDANCE:** Species like hīnālea are common, while larger groupers like roi have been introduced and may impact native populations. The shallow water species are surveyed for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources and data are

available online.

LOCATION AND CONDITION OF KEY HABITAT: All species except the sunset basslet and the Hawaiian pigfish species can be found in shallow water depths. Sunset basslets occur in deeper water, usually over 60 meters (200 feet) but sometimes to SCUBA diving depths. The undescribed species of Hawaiian Pigfish has only been found in depths greater than 140 meters (450 feet). Psychedelic wrasse terminal phase males are usually only found in depths greater than 15 meters (50 feet). Hawaiian anthias can often be found around reef ledges and drop offs while palespotted podge are more common on coral and rubble substrates. Sand wrasses, Hawaiian knifefish, and blackside razorfish spend most of their time over sandy substrates and the last two can dive into the sand to avoid predators. The rest are found throughout coral reef habitats.

THREATS:

- Overfishing: Targeted for food and aquarium trade. These species are almost all prized by aquarists except for palespotted podge, sand wrasses, and Hawaiian knifefish. Many of these species have different color phases for each sex and also juveniles, and in particular the juvenile color phases are often targeted by collectors.
- Habitat Degradation: Coral reef loss reduces available habitat.
- Climate Change: Warmer oceans and acidification affect coral reef health and prey availability.
- Invasive Species: Introduction of predatory species like roi alters native fish populations.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Commercial licenses are required for aquarium collectors. In addition to common statewide and island conservation actions, specific actions include:

- Fishing Regulations: Establish size and bag limits for reef fish.
- Marine Protected Areas: Designate and enforce no-take zones.
- Community Education: Promote sustainable fishing and reef conservation.
- Restoration Projects: Rehabilitate damaged reef habitats.

MONITORING:

- Population Surveys: Conduct reef fish censuses using diver observations and remote cameras.
- Habitat Monitoring: Assess coral cover and reef health.
- Fisheries Data: Track harvest levels and trends for sex-changing species.
- Behavioral Studies: Observe changes in sex ratios and reproductive behaviors.

RESEARCH PRIORITIES:

- Reproductive Biology: Study the triggers and mechanisms of sex change.
- Ecological Roles: Quantify contributions to reef ecosystem balance.
- Impact of Fishing: Assess the effects of selective harvest on populations.
- Climate Resilience: Investigate species adaptation to changing ocean conditions.
- Invasive Management: Study interactions between native species and introduced predators.
- Support Aquacultural Research: Develop captive breeding for species used in the aquarium trade.

References:

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Hawaii Coral Reef Initiative. (2023). Reef Fish Conservation in Hawaii. Retrieved from https://www.hcri.org

Hawai‘i Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for Conservation of Nature (IUCN). (2023). Marine Species Profiles. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Coral Reef Conservation. Retrieved from https://www.nature.org

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp. Randall, J. E. (2007). *Reef and Shore Fishes of the Hawaiian Islands*. University of Hawaii Press. Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Fishes

Hawaiian sea moth
Eurypegasus papilio

Ball's pipefish or ʻOʻopu huehue
Cosmocampus balli

Redstripe pipefish or ʻOʻopu huehue
Doryrhampus baldwini

Edmondson's pipefish or ʻOʻopu huehue
Halicampus edmondsoni

Fisher's seahorse or Koʻolani
Hippocampus fisheri

Spiny seahorse or Koʻolani
Hippocampus histrix

Yellow seahorse or Koʻolani
Hippocampus kuda

SPECIES STATUS:

IUCN Red List – Not considered except: *Hippocampus fisheri* and *H. histrix*, and *Eurypegasus* listed as Data Deficient *H. kuda* listed as vulnerable All Endemic except *Hippocampus histrix* and *H. kuda*

SPECIES INFORMATION: Seahorses and pipefish are small, elongated fishes with bony armor and unique appearances. Seahorses have prehensile tails for gripping, while pipefish are slender and adapted for camouflage in seagrass and algae. These species all share a body structure made of bony rings. The pipefishes and seahorses have sex-role reversal where the males accept and guard eggs in internal pouches or on their skin until the young hatch. This takes from ten to 50 days. They are predators that feed mostly on small crustaceans. The Hawaiian sea moth is a deeper water species. Redstripe pipefish often occur in small groups of mixed age. They have also been observed cleaning other fishes. Fisher's seahorse is apparently pelagic, attaching to floating algae. All species are less than 30 centimeters (one foot) in length and mostly half of that.

DISTRIBUTION: Hawaiian sea moths and Edmondson's pipefish are found statewide. Ball's pipefish has been found from O'ahu to Kaua'i. The redstripe pipefish has only been found from the island of Hawai'i to O'ahu. Fisher's seahorse is found from Maui to the island of Hawai'i but may be more widespread. The spiny seahorse is only known from a specimen from Maui.
The Yellow seahorse is found in the main islands and up to Necker Island.

ABUNDANCE: Difficult to estimate due to cryptic nature and habitat specificity. These species (except the deep Hawaiian sea moths) are looked for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration and the Division of Aquatic Resources. A recent survey in the main islands found that seahorses and pipefishes were rare.

LOCATION AND CONDITION OF KEY HABITAT: Preferred habitat is shallow, vegetated marine environments such as seagrass beds, coral rubble, and mangroves. Seahorses use plants to anchor themselves by their tails. Pipefishes often use the area under ledges. They all occur in moderately shallow water, except the sea moth which occurs in water over 60 meters (200 feet) deep, often in algal beds. Juvenile Hawaiian sea moths can be found in shallow water.
Edmondson's pipefish can often be found in tidepools. The Yellow seahorse can be found in brackish waters.

THREATS:

- Habitat Loss: Destruction of seagrass beds and coastal habitats.
- Overharvesting: Collection for aquarium trade and traditional medicine. These species are prized by aquarists, and seahorses are used in some Asian cultures for medicinal and other purposes. Aquaculture research collection may also be a threat
- Pollution: Sedimentation and chemical runoff affecting water quality.
- Climate Change: Ocean warming and acidification threatening habitat and prey availability.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Seahorses are listed in CITES Appendix II and pipefishes are being considered for such

protection. Commercial licenses are required for aquarium collectors. In addition to common state-wide and island conservation actions, specific actions include:

- Maintain healthy populations with appropriate fishing regulations and education.
- Habitat Protection: Establish and enforce marine protected areas.
- Trade Regulation: Implement sustainable practices under CITES regulations.
- Community Involvement: Engage local communities in conservation efforts.
- Pollution Control: Reduce coastal runoff and improve water quality management.

MONITORING:

- Population Surveys: Use diver and snorkeler observations to assess population trends.
- Habitat Assessments: Monitor the health of seagrass beds and associated ecosystems.
- Trade Data: Track export/import records for aquarium species.
- Climate Impact Studies: Analyze the effects of changing ocean conditions on species distribution.

RESEARCH PRIORITIES:

- Taxonomy and Distribution: Identify and document Hawaiian species.
- Habitat Use: Study preferences for specific habitats and ecological roles.
- Reproductive Biology: Understand breeding and lifecycle dynamics.
- Climate Resilience: Evaluate adaptive capacity to ocean changes.
- Conservation Techniques: Develop aquaculture and restoration methods for seahorses and pipefish.

References:

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawai‘i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawai‘i Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hoover J. 1993. Hawaii’s fishes. Honolulu, HI: Mutual Publishing. 183 pp.

International Union for the Conservation of Nature and Natural Resources. [Internet] Threatened Red List. Available from: http://www.redlist.org/search/search-expert.php (Accessed May 2005).

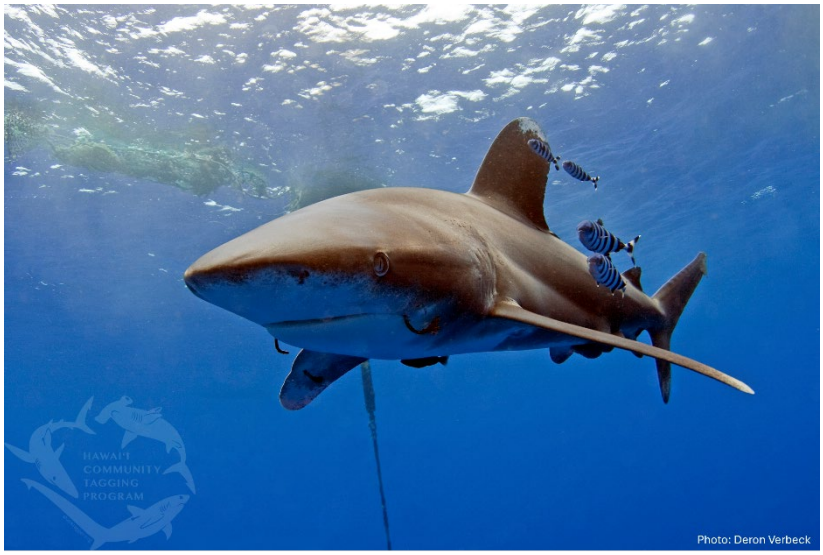
International Union for Conservation of Nature (IUCN). (2023). *Hippocampus* species. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Lourie, S. A., & Vincent, A. C. J. (2004). A marine fish with a unique mode of reproduction: Seahorses. *Fish and Fisheries*.

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Marine Conservation in Hawaii. Retrieved from https://www.nature.org

Project Seahorse. (2023). Conservation and Research. Retrieved from https://www.projectseahorse.org Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.



Marine Fishes

Oceanic Whitetip Shark or Manō

Carcharhinus longimanus

SPECIES STATUS:
Federally Listed as Threatened
IUCN Red List – Critically Endangered

SPECIES INFORMATION: The oceanic whitetip shark is known for their unique white-mottled markings at the tips of their dorsal (top), pectoral (side), and caudal (tail) fins. They get up to 13 ft in length. They are a top predator species, but are opportunistic feeders, meaning they feed on various prey and often eat what's available. Their typical diet consists of bony fish and cephalopods such as squid, cuttlefish, and octopus. They have also been seen foraging on large pelagic game fish, like tuna, and prey on sea birds, sharks and rays, marine mammals. Oceanic whitetips live up to 25 years. They give birth every other year to a litter of pups ranging from one to 14.

DISTRIBUTION: The oceanic whitetip shark (*Carcharhinus longimanus*) is usually found offshore in the open waters of all tropical oceans worldwide. It can be confused with the whitetip reef shark (*Triaenodon obesus*), which is found in shallow waters around reefs.

ABUNDANCE: In 2018, the oceanic whitetip was listed as threatened under the Endangered Species Act (ESA). The International Union for Conservation Nature (IUCN) lists them globally as critically endangered, meaning they face an extremely high risk of extinction. It is known that their populations have dramatically declined due to bycatch in commercial fisheries combined with the rise in demand for shark fins internationally. Globally, there is not much research currently available, however, in Hawai‘i, researchers have been collecting photos of oceanic whitetips to start understanding local population dynamics.

LOCATION AND CONDITION OF KEY HABITAT: The oceanic whitetip shark is found from surface level to at least 200 meters in depth and can be found in pelagic (open ocean) waters. Catch rates suggest that oceanic whitetips are found in shallow waters more commonly than other pelagic sharks. Little is known about the overall migrations and movements of these species, but the Hawai‘i Community Tagging Program is working to tag oceanic whitetips with satellite tags around the main Hawaiian Islands to get a better understanding on their movements in Hawai'i.

THREATS:

- Fisheries interactions. Injury and mortality can be caused by the accidental hooking
- and/or entanglement of oceanic whitetips in fishing gear. Oceanic whitetips are known to steal fish like ahi and mahi mahi off of trolling lines, which has occasionally resulted in intentional shooting of the sharks by fishers.
- Marine pollution and debris. The entanglement in marine debris can lead to injury or mortality. Ingestion of marine debris can cause intestinal injury or blockage.
- Climate change. Rising ocean temperatures and ocean acidification from climate change
- could result in lower ocean productivity and decreased food availability. Environmental

contamination. As top predators, oceanic whitetips at risk for accumulating high levels of toxins from their prey, leading to health and reproductive issues. Many chemicals persist globally and are transported through air and ocean currents.

CONSERVATION ACTIONS: The State proposes the following conservation actions specific to oceanic whitetip sharks:

- Reducing marine debris and pollutants in the marine environment.
- Reducing fishery interactions through education and outreach campaigns.
- Collaborating with local organizations working on OWT conservation and education.
- Collaborating on the implementation of the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) Recovery Plan.

MONITORING: The State proposes the following monitoring actions specific to oceanic whitetip sharks:

- Working with research partners to monitor abundance and distribution of oceanic whitetip sharks in Hawaiian waters.
- Working with partners to monitor entanglement and fisheries bycatch.

RESEARCH PRIORITIES: The State proposes the following research priorities specific to oceanic whitetip sharks:

- Work with research partners to gather information on oceanic whitetip population dynamics and social structure.
- Collaborate with scientists to track the movements and behavior of oceanic whitetip sharks, and identify high-use areas of habitat in the main Hawaiian Islands.

References:

Crow GL, Crites J. 2002. Sharks and rays of Hawaii. Honolulu, HI: Mutual Publishing. 203 pp.

Final Report to the National Marine Fisheries Service, Office of Protected Resources. NOAA Fisheries (2023, August 30). Oceanic Whitetip Shark.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hawai‘i Sharks Task Force. (2023). Protecting Sharks in Hawaiian Waters. Retrieved from https://www.hawaiisharks.org

International Union for the Conservation of Nature and Natural Resources. [Internet] Threatened Red List. Available from: http://www.redlist.org/search/search-expert.php (Accessed May 2005).

International Union for Conservation of Nature (IUCN). (2023). Elasmobranch species. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Marine Conservation in Hawaii. Retrieved from https://www.nature.org

SharkTaggers. (2019). Hawai‘i community tagging program: HCTP. Hawai‘i Community Tagging Program.

Seki T., Taniuchi T., Nakano H. and Shimizu M. (1998) Age, growth and reproduction of the oceanic whitetip Shark from the Pacific Ocean.

Young, C.N., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C.T., Wraith, J. (2017, December). Status review report: oceanic whitetip shark (Carcharhinius longimanus).

Marine Fishes

Oceanic Manta Ray or Hāhālua

Manta birostris

Reef Manta Ray or Hāhālua

Manta alfredi

SPECIES STATUS:
Oceanic Manta: Federally Listed as Threatened IUCN Red List – Endangered
Reef Manta: Not Federally Listed
IUCN Red List – Vulnerable

SPECIES INFORMATION: Oceanic (giant) manta rays (*Mobula birostris*) and reef manta rays (*Manta alfredi*) are two species are often confused, but in 2011 the genetic difference between species confirmed the visual differences that were observed. The oceanic manta is the world's largest ray, with a wingspan ranging from 6 to 22 feet across and weighing up to 5,300 pounds. The reef manta is smaller, ranging from 4 to 12 feet across. Both kinds of manta ray are often solitary most of their lives, but aggregate around food resources, cleaning stations, or in mating trains. Manta rays are planktonic filter feeders. They each have a spot pattern on their ventral (under) side that makes each one unique, allowing them to be monitored over time using photo identification. Manta rays can live over 45 years, based on photo-identification records. Reef manta rays gestation is 12-13 months, very little is known of oceanic manta ray life history. They have among the lowest fecundity of all elasmobranchs, typically giving birth to a single pup every couple years.

DISTRIBUTION: The oceanic manta is a pelagic species, meaning they spend most of their time in deep water, but are occasionally seen coming close to shore. The reef manta ray is more often found in shallower waters.

ABUNDANCE: In 2018, the oceanic manta ray was listed as threatened under the Endangered Species Act. Globally, their populations have declined, primarily due to bycatch in commercial fisheries combined with the international rise in demand for gill rakers. Due to its pelagic nature, the oceanic manta ray can be difficult to study, so there is still much to learn about their ecology and home range. Currently the reef manta ray is not listed under the Endangered Species Act, but they are listed as Vulnerable on the IUCN Red List.

LOCATION AND CONDITION OF KEY HABITAT: Manta rays can be predictably found off parts of the west coast of Hawai‘i Island, and throughout the reef areas on all the main Hawaiian islands. Oceanic manta rays are wide ranging and found further offshore. Not much is currently known about their key habitats in Hawaiian waters. DAR and other partner organizations are currently studying oceanic manta rays to learn more about their key habitats and population dynamics.

THREATS: These species have slow growth rates and low fecundity that limit their recovery from threats.

- Overfishing. Targeted for gill rakers internationally.
- Bycatch. Incidental entanglement in fishing gear, anchor/mooring lines.
- Vessel Strikes. Incidental collisions with mantas surface feeding.
- Habitat Degradation. Loss of coastal habitat, like reefs.
- Climate Change. Altered ocean temperatures and acidification impacting ecosystems.
- Pollution. Bioaccumulation of toxins from plastics and heavy metals.

CONSERVATION ACTIONS: The State proposes the following conservation actions specific to oceanic and reef manta rays:

- Reducing marine debris and pollutants in the marine environment.
- Reducing fishery interactions through education and outreach campaigns, including gear modifications as well as de-hooking techniques.
- Collaborating with local organizations working on manta tracking, identifying, conservation and education.
- Collaborate on the implementation of the NMFS Recovery Plan.

MONITORING: The State proposes the following monitoring actions specific to oceanic and reef manta rays:

- Monitoring abundance and distribution of mantas in Hawaiian waters.
- Monitoring entanglement and fisheries bycatch.

RESEARCH PRIORITIES:
The State proposes the following research priorities specific to oceanic and reef manta rays:

- Performing stock assessments to gather population information.
- Researching the oceanic whitetip social structure.
- Collaborating with scientists to track the movements and behavior of oceanic whitetip sharks.
- Identifying high-use areas of habitat in the main Hawaiian Islands.

References:

Crow GL, Crites J. 2002. Sharks and rays of Hawaii. Honolulu, HI: Mutual Publishing. 203 pp.

Hawai‘i Division of Aquatic Resources (DAR). (2023). Marine Species of Hawaii. Retrieved from https://dlnr.hawaii.gov

Hawaii Sharks Task Force. (2023). Protecting Sharks in Hawaiian Waters. Retrieved from https://www.hawaiisharks.org

International Union for the Conservation of Nature and Natural Resources. [Internet] Threatened Red List. Available from: http://www.redlist.org/search/search-expert.php (Accessed May 2005).

International Union for Conservation of Nature (IUCN). (2023). Elasmobranch species. The IUCN Red List of Threatened Species. Retrieved from https://www.iucnredlist.org

Kashiwagi T, Marshall AD, Bennett MB, Ovenden JR. (2012, July). The genetic signature of recent speciation in manta rays (Manta alfredi and M. birostris).

Kitchen-Wheeler A-M (2013) The behavior and ecology of Alfred mantas (Manta alfredi) in the Maldives (Doctoral dissertation). Newcastle University, School of Biology. April 2013.

Manta Trust. (2023). Research and Conservation of Rays. Retrieved from https://www.mantatrust.org

Marshall, A.D., Compagno, L.J.V. and Bennett, M.B. (2009). Redescription of the genus Manta with resurrection of Manta alfredi (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). Zootaxa.

Miller, M.H. and C. Klimovich. (2017, September 01). Endangered Species Act Status Review Report: Giant Manta Ray (Manta birostris) and Reef Manta Ray (Manta alfredi). Report to National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD.

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, B. P. Bishop Museum Press. 1340 ms. pages.

Nature Conservancy Hawai‘i Program. (2023). Marine Conservation in Hawaii. Retrieved from https://www.nature.org

NOAA Fisheries (2023, September 11). Giant Manta Ray.

Marine Invertebrates

Bivalves

Nahawele li‘i li‘i or Hawaiian mussel

Brachidontes crebristriarus

- Habitat: Forms mats in turbulent shallows among algal turf and sand.
- Size: Attains up to 1 inch.
- Status: Endemic to Hawai‘i.

Pa or Pearl oyster

Pinctada margaritifera

- Habitat: Uncommon, found on black and wire corals at depths greater than 60 feet.
- Size: Attains up to 4 inches.
- Status: Found across the Pacific, but endemic populations exist in Hawai‘i.

Winged pearl oyster

Pteria brunnea

- Habitat: Uncommon, inhabits black and wire corals at depths greater than 60 feet.
- Size: Attains up to 4 inches.
- Status: Endemic to Hawai‘i.

Nahawele or Black purse shell

Isognomon californicum

- Habitat: Commonly found in rocky crevices within the splash zone, often in brackish environments.

- Size: Attains up to 1.5 inches.
- Status: Endemic to Hawai‘i. Despite its species name, it does not occur in California.

Langford’s Scallop (Sunrise Shell)

Bractechlamys langfordi

- Habitat: Uncommon in sand & rubble in deep water. Worn shells washed ashore during winter surf.
- Size: Attains 1 inch.
- Status: Endemic to Hawaii. Formerly reported from Hawaii as *Decatopecten noduliferum*.

SPECIES STATUS:
IUCN Red List: Not evaluated.
Endemism: All species are endemic to Hawai‘i except *Pinctada margaritifera*, which is more widespread.

SPECIES INFORMATION: The Hawaiian mussel (*Brachidontes crebristriarus*), winged pearl oyster (*Pteria brunnea*), and black purse shell (*Isognomon californicum*) are endemic filter-feeding bivalves, while *Pinctada margaritifera* is a widespread species with a notable presence in Hawai‘i. All species exhibit external fertilization and have separate sexes. Their attachment mechenisms are provide below:

- Nahawele li‘i li‘i and *Pinctada* use strong byssal threads to attach to substrates.
- Nahawele can also move using its large foot.

DISTRBUTION

- Historically distributed throughout the Hawaiian Archipelago.
- Presently, Nahawele li‘i li‘i is found primarily on the windward Main Hawaiian Islands.
- Nahawele is most abundant near Maui and Hawai‘i Island.

ABUNDANCE: *Pinctada margaritifera*: Historically overharvested in the Northwestern Hawaiian Islands at Pearl and Hermes Atoll. While recent surveys found populations are no longer rare, they remain insufficient to sustain commercial fisheries. Abundance data for other species is limited or unknown.

LOCATION AND CONDITION OF KEY HABITAT:
Hawaiian Mussel (Nahawele li‘i li‘i):

- Forms patches or beds on limestone shorelines near the low tide mark, particularly where freshwater and saltwater mix.

- Found on basalt shorelines, but in lower densities.

Pearl Oyster (*Pinctada*):

- Resides in shallow waters among coral formations.

Winged Pearl Oyster (*Pteria*):

- Primarily found on black coral, with occasional clustering on wire coral; often hosts bryozoans on its shell.

Black Purse Shell (Nahawele):

- Forms clusters in crevices within the high-tide splash zone, favoring brackish water environments.
- On other islands, found individually in higher salinity waters.

THREATS:

- Harvesting: Historically, Pinctada margaritifera populations declined due to overharvesting for pearls.
- Pollution: As filter feeders, all species are highly susceptible to water pollution, which can impact their health and reproductive success. However, this sensitivity also makes them valuable bioindicators for water quality.

CONSERVATION ACTIONS: The primary conservation goals are to protect existing populations and establish new ones to mitigate extinction risks. Key actions include:

- Collaborating with stakeholders to reduce nearshore pollution.
- Maintaining and restoring healthy habitats.

MONITORING:

- Conduct surveys to assess population size, health, and distribution in known and potential habitats.

RESEARCH PRIORITIES:

- Enhance understanding of factors influencing population dynamics and habitat preferences.

References

Seiber, K. L., et al. 2018. Water Quality of Estuarine Ponds in Hilo, Hawai‘i: Monitoring of Nutrients, Benthic Organisms, and Bacteria. Journal of Young Investigators, University of Hawai‘i at Hilo.

Bisby, F.A., et al. 2005. Species 2000 & ITIS Catalogue of Life: 2005 Annual Checklist. Species 2000: Reading, U.K.

Hoover, J.P. 1998. Hawai‘i’s Sea Creatures: A Guide to Hawai‘i’s Marine Invertebrates. Mutual Publishing.

Kay, A.E. 1979. Hawaiian Marine Shells: Reef and Shore Fauna of Hawai‘i, Section 4: Mollusca. Bishop Museum Press.

Stender, Keoki. Hawaiian Mussel, *Brachidontes Crebristriatus*, Bractechlamys langfordi, Langford’s Scallop. www.marinelifephotography.com

Marine Invertebrates

Black & Wire Corals

ʻEkaha Kū Moana (Black Corals)

Order *Antipatharia* Families
Antipathidae, *Leiopathidae*, *Myriopathidae*, *Schizopathidae*

Grand Black Coral

Antipathes grandis

- Habitat: Found at depths greater than 150 feet along current-swept drop-offs and ledges.
- Size: Flexible branches as thin as 0.3 mm in diameter; colonies may grow large with 12 polyps per cm.
- Status: Endemic to Hawaiʻi. Extensively harvested for the jewelry trade.

Hawaiian Black Coral

Antipathes griggi

- Habitat: Found as shallow as 15 feet, but most commonly at depths of 25–140 feet. Often inhabits rocky areas and ledges.
- Size: Stiff branches with tips thicker than 0.6 mm; about 8 polyps per cm.
- Status: Endemic to Hawaiʻi. Previously identified as *Antipathes dichotoma* or *Antipathes arborea*.

Wire Coral

Cirrhipathes anguina

- Habitat: Common on current-swept vertical faces and rocky outcrops at depths greater than 20 feet. Found throughout Hawai‘i and the Indo-Pacific.
- Size: Stick-like corals that can grow up to 5 feet in length.
- Status: Native to Hawai‘i.

SPECIES STATUS

IUCN Red List: Not evaluated.

Endemism: Both *Antipathes grandis* and *Antipathes griggi* are endemic to Hawai‘i. *Cirrhipathes anguina* is native but not exclusive to Hawai‘i.

SPECIES INFORMATION: Black and wire corals (*Antipatharia*) are tree-like or stick-like cnidarians with dark brown skeletons covered in small spines. Live colonies may appear rusty brown, orange, yellow, green, or white due to the polyps' colors and may fluoresce under certain conditions. These corals play a crucial ecological role by providing food and shelter for various marine life, including fishes, mollusks, crustaceans, and commensal organisms like gobies and shrimps.

- *Antipathes grandis*: Flexible branching structure with high commercial value.
- *Antipathes griggi*: Often associated with rare fishes, such as the longnose hawkfish (*Oxycirrhites typus*) and Tinker’s butterflyfish (*Chaetodon tinkeri*).
- *Cirrhipathes anguina*: Polyps present on all sides of the stick-like coral. Often hosts commensal species like wire coral gobies and shrimps.

Antipatharians have long played a role in Hawaiian cultural traditions and marine ecosystems. These ancient and slow-growing organisms provide essential habitats for symbiotic species and contribute to the biodiversity of Hawai‘i’s deep reefs. Protecting these corals ensures the health of Hawai‘i’s underwater ecosystems for future generations while preserving the natural heritage of these islands.

DISTRIBUTION: Black and wire corals are found along current-swept reefs and drop-offs across the Hawaiian Archipelago. While some species, such as *Antipathes griggi*, are accessible to divers in shallow waters, others, like *Antipathes grandis*, are restricted to depths typically explored by submersibles.

THREATS

- Harvesting: *Antipathes grandis* has been extensively harvested for jewelry, significantly reducing populations.
- Habitat Degradation: Pollution and climate change threaten reef health and the habitats where these corals thrive.
- Regulations: Collecting corals in Hawai‘i is illegal without a special permit.

CONSERVATION ACTIONS

- Policy Enforcement: Strengthen regulations to prevent illegal harvesting and ensure sustainable use.
- Habitat Protection: Protect deep reef ecosystems from damage caused by fishing gear and anchors.
- Research and Monitoring: Conduct surveys to better understand population trends, reproductive success, and habitat health, and study ecological roles and interactions with associated species.

References

Fenner D. 2005. Corals of Hawaii. Honolulu, HI: Mutual Publishing. 144 pp.

Grigg R and D Opresko. 1977. Order Antipatharia. pp. 242-261.In: Reef and Shore Fauna of Hawaii. B. P. Bishop Museum Special Publication 64. Honolulu, HI: Bishop Museum.

Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Wells SM, RM Pyle, and NM Collins. 1983. IUCN Invertebrate Red Data Book. Gland, Switzerland: International Union on the Conservation of Nature and Natural Resources.

Western Pacific Fisheries Management Council. Fishery Management Plan for the precious coral fisheries of the Western Pacific Region. Honolulu, HI: Western Pacific Fisheries Management Council. Available from: http://www.wpcouncil.org/precious.htm

Marine Invertebrates
LOBSTERS

Ula poni or Spiny lobster

Panulirus marginatus

- Habitat: Ula poni are found in dark crevices beyond the surf zone, often in deep caves or ledges. Their habitats range from shallow waters to depths as deep as 600 feet.
- Size: This species can grow up to 16 inches in length.
- Appearance: Ula poni has a purple and white-banded tail and black legs with a single white stripe running down the center.
- Status: Endemic to Hawai'i.

Ula (Tufted or Green Spiny Lobster)

Panulirus penicillatus

- Habitat: Ula are typically found in shallow reefs that are exposed to surge, and they prefer areas with rocky crevices or ledges.
- Size: This species also grows up to 16 inches in length.
- Appearance: They are bluish-green in color with an orange-brown tail. Their legs are striped with blue and white.
- Status: Found in Hawai'i, the Indo-Pacific, and the Tropical Eastern Pacific.

Species Status:
IUCN Red List: Not considered Endemic: Yes

SPECIES INFORMATION: The *Spiny Lobster* family (*Palinuridae*) is characterized by lobsters that lack enlarged claws, which distinguishes them from true lobsters. These species are well-protected by sharp, forward-pointing spines along their exoskeleton. Spiny lobsters, unlike other types of lobsters, do not have large claws and are generally larger-bodied. They are nocturnal feeders, often found in dark crevices or hiding under ledges in coral reefs or rocky habitats. These lobsters are highly valued in commercial and recreational fisheries, but many species, especially large individuals, are becoming increasingly rare due to heavy fishing pressure and disregard for local fishing laws.
There are two key species of spiny lobsters found in Hawai'i: Ula poni (*Panulirus marginatus*) and Ula (*Panulirus penicillatus*). Both species face threats from overfishing, habitat loss, and pollution, but

regulations have been put in place to protect them, including a minimum carapace length of 3.25 inches and seasonal bans on harvesting, particularly to protect breeding females.

Ula poni, or the Hawaiian Spiny Lobster, is nocturnal and carnivorous, feeding on mollusks, crustaceans, fish, and echinoderms. They spawn up to four times a year, with a female capable of producing up to half a million orange eggs each time. The eggs hatch in about four weeks, and the larvae go through several pelagic stages, lasting almost a year before returning to the reef. Juveniles are typically about one inch long. These lobsters are also known for their ability to hide in crevices, caves, or under ledges during the day. They often live near sandy areas next to healthy coral reefs, which provide both shelter and food.

Ula, or the Tufted or Green Spiny Lobster, is a large species that inhabits shallow reefs exposed to surge, often at depths of 20-60 feet. They feed on mollusks, crustaceans, and small fish. They are primarily nocturnal and can be found in rocky crevices or under ledges during the day. This species is highly valued in fisheries, but like Ula poni, it faces pressures from overfishing.

DISTRIBUTION: Ula poni are historically found throughout the Hawaiian Islands, still present across the archipelago today. However, their distribution and abundance have been significantly impacted by overfishing. The larvae typically move with ocean currents, traveling northwest along the archipelago's ridge and then southeast and southwest. The pelagic distribution of larvae is still an area of ongoing research. Found in Hawai'i, the Indo-Pacific, and the Tropical Eastern Pacific, Ula is more common than Ula poni in some areas, including Maui and Midway Atoll. Its distribution spans the Hawaiian Islands, where it is commonly found in healthy coral reef ecosystems.

ABUNDANCE:
Overfishing has caused a significant decline in populations. Commercial catch has been in long-term decline, with recent annual catches falling below 4,500 kilograms. The recreational catch remains unknown, though it is also suspected to be unsustainable.
Although more common than Ula poni, Ula still faces threats from overfishing and habitat destruction. Its populations are more stable, but commercial and recreational harvesting still presents risks to its long-term sustainability.

LOCATION AND CONDITION OF KEY HABITAT: These lobsters are found in a range of depths and areas, from shallow reefs to deeper waters, with their main habitat being in crevices and caves. Healthy coral reefs are vital to their habitat. Ula prefer shallow reefs and rocky areas at depths ranging from 20 to 60 feet. Healthy coral reefs are essential for their habitat, providing both shelter and abundant food sources.

THREATS: Historically, Ula poni was overharvested, especially from the 1970s to the 1990s in the Northwestern Hawaiian Islands. While fishing closures and regulations have been put in place, overfishing, collection for the aquarium trade, and habitat degradation still pose threats. Coral reef destruction, due to pollution and climate change, further impacts their populations.
Like Ula poni, Ula is threatened by overfishing, particularly from the aquarium trade and commercial fisheries. Coral reef degradation and climate change further impact their populations by destroying their habitats and food sources.

CONSERVATION ACTIONS: Conservation efforts include protecting existing populations through fishing regulations, law enforcement, and public education. These efforts aim to ensure that the population remains healthy and sustainable for future generations.
Similar to Ula poni, conservation efforts for Ula focus on enforcing fishing regulations and protecting their habitat from further destruction. Public education and sustainable fisheries management are key to ensuring their future.

MONITORING: Ongoing population monitoring helps assess the effectiveness of current fishing regulations and conservation measures.
Monitoring the populations of Ula is essential for understanding the impacts of fishing practices and the effectiveness of conservation efforts.

RESEARCH PRIORITIES:

- Larval Distribution: Further study of larval movement and distribution is essential to understanding population dynamics.
- Population Dynamics: Research is needed to better understand the factors affecting the population size, such as fishing pressures and habitat changes.

Both species of spiny lobsters are important components of their ecosystems and face significant challenges due to human activities, especially overfishing and habitat destruction. Conservation actions, such as regulated fishing seasons, habitat protection, and public education, are crucial for maintaining healthy populations of these species for future generations.

References:

Gulko, D. (2005). Hawai‘i Endemic Species Status Chart. Hawai‘i Division of Aquatic Resources.

Hoover, J.P. (1998). Hawai'i’s Sea Creatures: A Guide to Hawai'i’s Marine Invertebrates. Honolulu: Mutual Publishing.

Kanciruk, P. (1980). Ecology of juvenile and adult Palinuridae (spiny lobsters). In J.S. Cobb & B.F. Phillips (Eds.), The Biology and Management of Lobsters, Volume II, pp. 59-66.

Polovina, J.J., Kleiber, P., & Kobayashi, D.R. (1999). Application of TOPEX-POSEIDON Satellite Altimetry to Simulate Transport Dynamics of Larvae of Spiny Lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands, 1993-1996. Fisheries Bulletin, 97, 132-143.

Stender, Keoki. Hawaiian Spiny Lobster, *Panulirus marginatus*. Green Spiny Lobster *Panulirus penicillatus*. www.marinelifephotography.com

Marine Invertebrates

Pūpū moʻo or chitons

Green Chiton

Acanthochiton viridis

- Habitat: The Green Chiton is typically found on rocky substrates in the intertidal zone, especially in small depressions on limestone reef flats and under rubble in tidepools. They prefer areas with some protection from the strongest waves, such as crevices and overhangs, where they can hide during the day and emerge at night to feed. This species can also be found in shallow waters along exposed shorelines, where they adhere firmly to the rocks.
- Size: The Green Chiton can grow up to 1 inch (28 millimeters) in length. It has a rounded, slightly elevated shell that extends along the body in a smooth, oblong shape.
- Appearance: The shell of the Green Chiton is predominantly a light green color, but it has a characteristic pale or whitish midline. The valves are smooth at the center, with minutely granulose sides, which provide some texture and protection. The dorsum (top surface) has semi-lunar plates that extend from the sides and terminate with smooth, rounded edges. The posterior terminal valve is distinctly elongated, extending laterally with truncated edges. The anterior valve wraps evenly around the front and sides of the body. These chitons are equipped with a dense, short spicule-covered ligamental border that is dark green and vitreous, which provides additional protection.
- Status: Endemic to Hawai'i. The Green Chiton is a species that is not widely found

outside of the Hawaiian Islands, making it a key species in the region's marine ecosystems.

Flat Chiton

Stenoplax petaloides

- Habitat: The Flat Chiton is commonly found under rocks in shallow water, including tidepools and rocky reef flats. This species prefers areas where the rocks are more mobile and are exposed to surge and wave action. Their preference for hiding under rocks allows them to avoid predation during daylight hours. They are especially common on the lower reaches of the intertidal zone, where they can find stable habitat with constant exposure to the ocean's rhythm.
- Size: The Flat Chiton reaches up to 1/2 inch (approximately 13 millimeters) in length. It has a flattened, glossy body that allows it to fit comfortably into crevices and cracks within its rocky habitat.
- Appearance: The Flat Chiton has an elongated, somewhat glossy shell with a variable coloration that can range from brownish to reddish to greenish, depending on its immediate environment. The pattern on the dorsal surface is often iridescent, and it features a smooth, oval body with eight articulating valves. These valves are covered in minute, dense spicules that help anchor the chiton to the substrate and protect it from predation.
- Status: Endemic to Hawai'i, this species is only found within the Hawaiian Islands and plays an important role in local ecosystems by grazing on algae and detritus.

SPECIES STATUS:
IUCN Red List - Not considered
Endemic

SPECIES INFOMRATION: Chitons, also known as Pūpū moʻo in Hawaiian, are fascinating mollusks that graze on algae and serve a critical role in maintaining the health of marine ecosystems. The Green Chiton (*Acanthochiton viridis*) and Flat Chiton (*Stenoplax petaloides*) are both found in the intertidal and shallow subtidal zones of Hawai'i, thriving in environments with rocky surfaces, tidepools, and reef flats. Unlike some other mollusks, chitons have a tough exterior and are well adapted to cling to hard surfaces, even during harsh wave conditions.

Both the Green Chiton (*Acanthochiton viridis*) and the Flat Chiton (*Stenoplax petaloides*) are nocturnal grazers, primarily feeding on algae that grow on rocks in their habitat. They use their radula (a specialized feeding organ) to scrape algae and detritus off the rocks. The Green Chiton, in particular, is known for its preference for areas that provide both shelter and access to abundant food sources, including small depressions and caves within the reef structure. Chitons play a key role in controlling algal growth, preventing algae from outcompeting other species, and maintaining the balance of the ecosystem. Both species are dioecious (separate sexes), and fertilization occurs externally. During the reproductive season, the chitons release their eggs and sperm into the water column, where fertilization takes place. The embryos develop into free-swimming larvae that eventually settle on rocky surfaces, where they mature into adult chitons.

DISTRIBUTION: The Green Chiton (*Acanthochiton viridis*) is distributed primarily on the Hawaiian Islands, where it inhabits rocky reef flats and tidepools. The Flat Chiton (*Stenoplax petaloides*) also has a similar range, being found throughout Hawai'i, particularly in shallow waters and reef flats. While both species are common within their range, habitat destruction and ocean acidification may pose future risks to their populations.

ABUNDANCE: The abundance of chitons is not well studied, but they are considered locally abundant in suitable habitats, especially in areas where rocky reefs and tidepools are healthy and intact. However, like many marine species, chitons are likely affected by human activities such as coastal development, pollution, and over-harvesting of algae.

LOCATION AND CONDITION OF KEY HABITAT: Key habitats for both species are in rocky and hard substrates found in the intertidal and shallow subtidal zones. These habitats are essential for providing the food sources and shelter necessary for chiton survival. Healthy reef flats and tidepools, along with natural rock outcroppings, are critical for maintaining stable chiton populations.

THREATS: Both species face threats from habitat destruction caused by coastal development, pollution, and the effects of climate change, including ocean acidification and coral reef degradation. While they are not targeted specifically by fisheries, their habitats are vulnerable to human impacts, which could lead to declines in population. Climate change may also alter the composition of algae in their habitats, potentially affecting their food sources.

CONSERVATION ACTIONS: Efforts to conserve chitons primarily focus on maintaining and restoring healthy reef habitats. Protecting the natural intertidal and subtidal zones from development and pollution is essential for the long-term survival of these species. Additionally, conservation strategies can include public education about the importance of protecting marine ecosystems and reducing human impacts on reef habitats.

MONITORING: Ongoing monitoring of chiton populations and the health of their habitats is necessary to assess the effectiveness of conservation efforts. Regular surveys in known habitats will help track population
trends and the impact of environmental stressors, such as pollution and climate change.

RESEARCH PRIORITIES:

- Larval Distribution: Further study is needed to understand the distribution of chiton larvae, including how ocean currents affect their movement and settlement patterns.

- Population Dynamics: More research is needed to understand the factors affecting chiton populations, such as habitat quality, predation pressures, and food availability.
- Impact of Climate Change: Research into the effects of ocean acidification and coral reef degradation on chiton populations is crucial for predicting the long-term viability of these species.

References:

Hoover, J.P. (1998). *Hawai'i's Sea Creatures: A Guide to Hawai'i's Marine Invertebrates*. Honolulu: Mutual Publishing.

Honolulu, HI: Bishop Museum Press.

Kay, A.E. (1979). *Hawaiian Marine Shells Reef and Shore Fauna of Hawaii, Section 4: Mollusca*.

Stender, Keoki. Leaf Chiton, *Stenoplax Petaloides*, www.marinelifephotography.com/marine/mollusks/chitons/stenoplax-petaloides.htm.

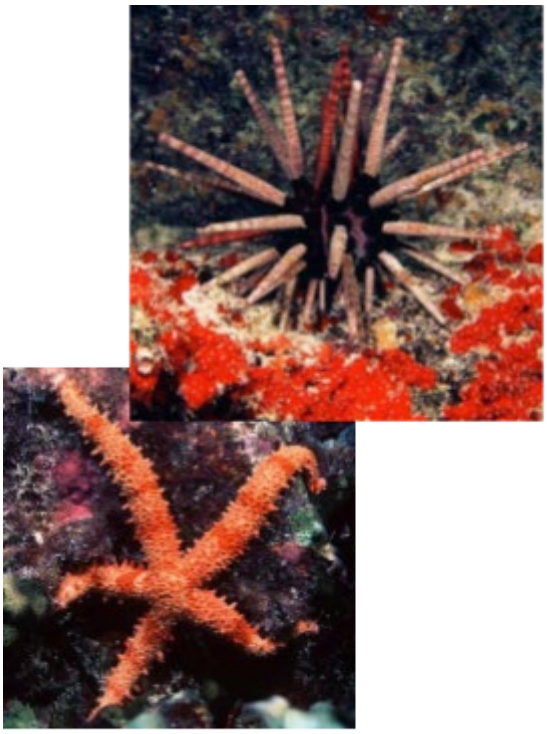


Photo credit: Keoki Stender

Marine Invertebrates

Echinoderms

Echinoids

Acanthocidaris hastigera Actinocidaris thomasi Lissodiadema purpureum Lovenia hawaiiensis Prionocidaris hawaiiensis

Asteroid

Dactylosaster cylindricus pacificus Mithrodia fisheri

Holothuroids

Stichopus sp.1 Stichopus sp. 2 Holothuria cf. dofleinii

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: The spear urchin *(Acanthocidaris hastigera*), Thomas' sea urchin (*Actinocidaris thomasi*), the glass-spined urchin (*Lissodiadema purpureum, Leptodiadema* is a junior synonym), the Hawaiian lovenia (*Lovenia hawaiiensis*), the Hawaiian thorny urchin (*Prionocidaris hawaiiensis*), the Hawaiian cylindrical star (*Dactylosaster cylindricus pacificus*), the fisher's star (*Mithrodia fisheri)* the Hawaiian spiny sea cucumber (*Stichopus sp. 1*), the Hawaiian yellow-tip sea cucumber (*Stichopus sp. 2*), and the chocolate-chip sea cucumber *(Holothuria cf. dofleinii*) are all endemic. Specific feeding habits are known for two species: the fine spined sea urchin grazes on algae and *M. fisheri* feeds on sponges, bryozoans, and other sessile organisms. Little is known on the feeding habits of the two sea cucumbers as they have not been scientifically described; however, sea cucumbers generally eat plant and animal debris from the sea floor. Thomas's urchin may host small molluscs in shallower waters and barnacles in deeper waters. The fine spined sea urchin hosts a commensal shrimp. They all have separate sexes and reproduce by releasing eggs and sperm into the

water. Larvae are part of the planktonic community for a few days to weeks and then they settle to mature.

DISTRIBUTION: All species occur throughout Hawai‘i. The chocolate-chip sea cucumber can be found in the Main Hawaiian Islands (MHI) and the North Western Hawaiian Islands (NWHI).

ABUNDANCE: Unknown

LOCATION AND CONDITION OF KEY HABITAT: The spear urchin and the Hawaiian thorny urchin are found in deeper depth beyond scuba range, whereas the other urchins are found within scuba range depths (up to 130 feet). Thomas's sea urchin primarily is found in deeper waters within scuba range and as shallow as 9 meters (30 feet) and stays under coral slabs and in crevices during the day. The Glass-spined urchins live on rocky substrates from approximately 6 to over 46 meters (20 to over 150 feet). Small fine spined urchins are most often found under stones, while larger ones in caves and crevices. Hawaiian lovenia lives in the sand. Both species of the endemic sea stars are uncommon in scuba depths and live on rocky substrates. *M. fisheri* primary habitat is on cave ceilings and walls. The chocolate chip and the Hawaiian spiny sea cucumbers are found out in the open beside coral reefs in sand and rubble. The Hawaiian spiny sea cucumbers can also be found on steep slopes from approximately 15 to 46 meters (50 to 150 feet). Hawaiian yellow-tip sea cucumbers prefer areas under stones during the day.

THREATS:

- Habitat degradation, pollution, climate change, and invasive species may threaten these species' habitats and populations.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Maintain healthy populations with appropriate fishing regulations, enforcement, and education.

MONITORING:

- Continue to survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size and distribution.

References:

Fabricius, K.E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: Review and synthesis. Marine Pollution Bulletin, 50(2), 125–146.

Gulko, D. 2005. Hawai‘i Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Hoover JP. 1998. Hawaii’s sea creatures, A guide to Hawaii’s marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Hughes, T.P., et al. 2017. Coral reefs in the Anthropocene. Nature, 546(7656), 82–90

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org Keoki Stender's Flora & Fauna ID Site. (2024). https://www.marinelifephotography.com/index.htm Poloczanska, E.S., et al. (2013). Global imprint of climate change on marine life. Nature Climate Change, 3(10), 919–925.

Smith, J.E., Hunter, C.L., & Smith, C.M. 2002. Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. Pacific Science, 56(3), 299–315.

Marine Invertebrates

Hawaiian oyster

Dendostrea sandvicensis

- Habitat: The Hawaiian oyster is commonly found on hard reefs in shallow waters, typically in quiet bays and harbors. These oysters thrive in environments with minimal water movement, where they can attach to rocky substrates and enjoy the protection of their surroundings.
- Size: This species can reach up to 2 inches in size.
- Appearance: Characterized by heavily encrusted coralline algae, the shell often features distorted triangular ribs with sawtooth margins. Its irregular shape adds to its distinctive appearance.
- Status: Endemic to Hawai'i. Formerly known as *Ostrea sandvicensis*.

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION:
The Hawaiian oyster (*Dendostrea sandvicensis*) is a relatively understudied bivalve that is native to Hawai'i. It primarily inhabits shallow marine environments, attaching to hard surfaces such as rocks and reef structures. While much of its life history remains unknown, this oyster plays a significant role in the local marine ecosystem by filtering water and contributing to the overall health of the coral reef system. Its strong attachment to hard surfaces makes it an important species for reef stability and biodiversity.

DISTRIBUTION:
The exact distribution of the Hawaiian oyster is not well-documented, but it is generally found in shallow waters around *the Hawaiian* Islands. Its populations are likely scattered across hard reefs in bays and harbors, though further surveys are needed to better understand its range.

ABUNDANCE:
The abundance of this species is currently unknown. Due to limited research, it is unclear whether populations are stable, declining, or facing pressures from human activity. More studies are needed to establish population trends and determine conservation priorities.

LOCATION AND CONDITION OF KEY HABITAT:
The Hawaiian oyster is found in sheltered areas with stable water conditions, particularly in bays and harbors. These habitats often feature coralline algae-covered rocks, which provide the oysters with attachment points. The condition of these habitats may be influenced by factors such as pollution, sedimentation, and changes in water quality, all of which can impact the health of the oyster populations.

THREATS:
Currently, no specific threats to the Hawaiian oyster have been identified. However, like many marine species, it could be vulnerable to changes in its environment, including pollution, habitat degradation, and the impacts of climate change.

CONSERVATION ACTIONS:
The primary goal of conservation actions for the Hawaiian oyster is to protect existing populations and explore opportunities for establishing new populations to reduce the risk of extinction. Conservation efforts may include:

- Habitat Restoration: Restoring degraded habitat in estuaries and near-shore areas where the oysters live. This could involve efforts to clean up polluted areas and improve water quality.
- Pollution Mitigation: Working to reduce pollution in the marine environment, particularly in areas where oysters are found, to ensure their habitat remains healthy and conducive to growth.

MONITORING:

- Survey Schedule: It is essential to establish a regular survey schedule to monitor the population size, distribution, and health of the Hawaiian oyster. These surveys will help inform conservation decisions and provide data on any changes in population trends.
- Habitat Monitoring: Monitoring the condition of the habitat is crucial to ensure that oysters have suitable environments in which to thrive.

RESEARCH PRIORITIES:

- Life History: A deeper understanding of the life cycle, biology, and ecology of the Hawaiian oyster is critical. This includes researching its reproductive behavior, growth patterns, and role within the broader marine ecosystem.
- Population and Distribution: More detailed studies are needed to determine the current population sizes, distribution patterns, and trends over time.

References:

Haws, M., et al. (2023). "ENAO-Culture of Native Bivalve Species to Expand Mariculture Opportunities and Improve Coastal Environments - HISG." *Exploring New Aquaculture Opportunities*. NOAA.

Marine Invertebrates

ʻOpihi (Limpets)

ʻOpihi makaiauli or Black foot ʻopihi

Cellana exarata

ʻOpihi ʻōmaʻo or Green foot ʻopihi

Cellana melanostoma

ʻOpihi ʻalinalina or Yellow foot ʻopihi

Cellana sandwicensis

ʻOpihi koʻele or Giant ʻopihi

Cellana talcosa

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: The endemic ʻopihi makaiauli or black foot ʻopihi (*C. exarata*), the ʻopihi ʻōmaʻo or green foot ʻopihi (*C. melanostoma*), the ʻopihi ʻalinalina or yellow foot ʻopihi (*C. sandwicensis*), and the ʻopihi koʻele or giant ʻopihi (*C. talcosa*) are all protected by fishing regulations. All ʻopihi feed on algae and most may creep about to graze but return to their "home scar" after feeding. Both ʻopihi ʻalinalina and ʻopihi koʻele are often covered in seaweed.

For reproduction, the ʻopihi shed their gametes into the water for external fertilization. Veligers, the final larval stage, have a short planktonic life between 2-18 days before they settle on nearby available substrate. The ʻopihi grow to maturation size relatively quickly and can produce offspring within a year. Spawning occurs mainly in December and January for ʻopihi makaiauli

and ʻopihi ʻalinalina. Spawning information is sparse for the ʻopihi ʻōmaʻo and ʻopihi koʻele, but it is believed to occur during new moon phases. ʻOpihi makaiauli grow to 40 millimeters (1.6 inches) in diameter, ʻopihi ʻōmaʻo grow to 43 millimeters (1.7 inches), the ʻopihi ʻalinalina grow to 32 millimeters (1.3 inches), and ʻopihi koʻele grow to 90 millimeters (3.5 inches). Once fully grown, ʻopihi makaiauli is characterized by a tall round shell, ʻopihi ʻōmaʻo is characterized by a steep sided shell, ʻopihi ʻalinalina is characterized by a shorter oblong shell, ʻopihi koʻele is characterized by a flat shell that is thin in juveniles and relatively disproportionately massive in large adults. Intertidal thais gastropods, predatory sea snails, are the predominant predator of ʻopihi in Hawaiʻi. The ʻopihi can evade their predators by utilising different methods of fleeing; these methods include stretching the mantle over the shell or "mantle-folding", raising the shell off the rock or "mushrooming", and extending the tentacles on the mantle. When confronted by a predatory gastropod, ʻopihi makaiauli has short mantle tentacles and a long evasion distance, ʻopihi ʻalinalina has long mantle tentacles and a short evasion distance, and ʻopihi koʻele has mantle tentacles of varying lengths. This characteristic is unknown for ʻopihi ʻōmaʻo. In addition to harvesting these ʻopihi for consumption, native Hawaiians also used the ʻopihi shells as scrapers and tools for various activities.

DISTRIBUTION: The primary ranges for the ʻopihi makaiauli, ʻopihi ʻalinalina, and ʻopihi koʻele are along the basalt shorelines of the Main Hawaiian Islands; however, the ʻopihi makaiauli has been found on La Perouse Pinnacle and ʻopihi ʻalinalina on Necker and Nihoa. The ʻopihi ʻōmaʻo is found primarily in the Northwestern Hawaiian Islands, but it has been occasionally collected from Kauaʻi. Historically, it was found on Oʻahu and Maui as well.

ABUNDANCE: The abundance of ʻopihi makaiauli and ʻopihi ʻalinalina have declined in the past decades. ʻOpihi koʻele is rare, especially so on Kauaʻi and Oʻahu. Abundance of ʻopihi ʻōmaʻo is unknown. The amount of ʻopihi caught and reported by commercial fisheries fluctuate from year to to year, however, in 2021 the amount of ʻopihi (Cellana spp.) caught in pounds by commercial fisheries in Hawaiʻi reported a 3.65% increase compared with the short-term average taken from 2011 to 2020 and a 12.4% increase compared with the long-term average taken from 2001 to 2020. The recreational fishery catch is unknown.

LOCATION AND CONDITION OF KEY HABITAT: The primary habitat for ʻopihi is the rocky intertidal zone to ten feet deep waters. ʻOpihi makaiauli thrives in the spray zone or the high-shore zone, although it may be found seaward to the calcareous algal zone. It is well suited for this variable environment due to its ability to ventilate its mantle cavity when it is dry and combat the thermal stress of the environment at low tide. ʻOpihi ʻalinalina are found on and below the zero tide mark where there is a steady splash or the mid-shore zone, and they are often found on coralline algae. They have morphologically adapted to survive in this environment where the hydrodynamic forces are most severe. ʻOpihi koʻele are found in the low-shore zone which is below the tide mark from 0.5 to three meters (one to ten feet) deep, often between boulders. They spend the most time underwater, increasing their risk of encounters with pelagic predators. There is less known of ʻopihi ʻōmaʻo, it is known to be found throughout the intertidal zone, but is believed to mainly inhabit the low-shore zone.

THREATS:

- Localized heavy harvesting pressure is the most significant threat to all ʻopihi species, especially ʻopihi koʻele. Populations in the wild have decreased greatly and

this can impact their reproductive success;
- Habitat disturbance or loss is another significant threat;
- Climate change and other anthropogenic impacts causing the sea temperatures to rise past the threshold of temperature that ʻopihi can tolerate is also of great concern.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common statewide and island conservation actions, specific actions include:

- Maintain healthy populations with appropriate harvesting regulations, enforcement, and education;
- Creating rest zones for ʻopihi, limiting harvest count per day, or limiting ʻopihi harvesting to smaller size ʻopihi.
- Restore habitat and ensure ʻopihi have substrate to grow on with desirable conditions for ʻopihi to thrive;
- Mitigate rising sea temperatures, especially around Oʻahu, by reducing anthropogenic impacts to the ocean.

MONITORING:

- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Research the impact of nearshore habitat disturbance and destruction;
- Improve understanding of factors affecting the species population size and distribution, especially for ʻopihi ʻōmaʻo and ʻopihi koʻele;
- Research what management strategies are effective at maintaining sustainable populations of ʻopihi;
- Research morphological and behavioural characteristics of ʻopihi ʻōmaʻo to fill the data gap on this species

References:

Aruch, S. (2005). Appendix A: Kalaupapa National Historical Park resource overview. In L. HaySmith, F. L. Klasner, S. H. Stephens, & G. H. Dicus (Eds.), *Pacific Island Network Vital Signs Monitoring Plan: Phase III (draft) report*. National Park Service, Pacific Island Network, Hawaii National Park, HI.

Bird, C. (2011). Morphological and behavioral evidence for adaptive diversification of sympatric Hawaiian limpets (Cellana spp.). *Integrative and Comparative Biology, 51*(3), 466–473. https://doi.org/10.1093/icb/icr050

Bird, C. E., et al. (2011). Diversification of sympatric broadcast-spawning limpets (Cellana spp.) within the Hawaiian Archipelago. *Molecular Ecology, 20*(10), 2128–2141. https://doi.org/10.1111/j.1365-294x.2011.05081.x

Gulko, D. (2004). *Hawaiian marine species for ESA candidate listing revised candidate list*. Division of Aquatic Resources, State of Hawaiʻi. Honolulu, HI.

Gulko, D. (2005). *Hawaiʻi endemic species status chart spreadsheet*. Hawaiʻi Division of Aquatic Resources. Honolulu, HI.

Hoover, J. P. (1998). *Hawaii's sea creatures: A guide to Hawaii's marine invertebrates* (366 pp.). Mutual Publishing. Honolulu, HI.

International Union for Conservation of Nature (IUCN). (2024). *The IUCN Red List of Threatened Species* (Version 2024-2). Retrieved from https://www.iucnredlist.org

Iwasaki, K. (1993). Analyses of limpet defense and predator offense in the field. *Marine Biology, 116*, 277–289. https://doi.org/10.1007/BF00350018

Kay, A. E. (1979). *Hawaiian marine shells: Reef and shore fauna of Hawaii, section 4: Mollusca* (653 pp.). Bishop Museum Press. Honolulu, HI.

Kehaunani, T. S. (2011). *An investigation of the cultural use and population characteristics of 'Opihi (Mollusca: Cellana spp.) at Kalaupapa National Historical Park*. University of Hawai'i at Hilo. ProQuest.

Marine Life Photography. (n.d.). *Limpets*. Retrieved December 16, 2024, from https://www.marinelifephotography.com/marine/mollusks/gastropods/limpets/limpets.htm

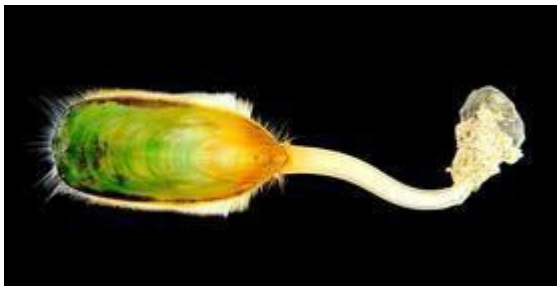
McCoy, M. D. (2008). Hawaiian limpet harvesting in historical perspective: A review of modern and archaeological data on Cellana spp. from the Kalaupapa Peninsula, Moloka'i Island. *Pacific Science, 62*(1), 21–38. https://doi.org/10.2984/1534-6188(2008)62[21:HLHIHP]2.0.CO;2

Rogers, A. J., & Weisler, M. I. (2019). Assessing the efficacy of genus-level data in archaeomalacology: A case study of the Hawaiian limpet (Cellana spp.), Moloka'i, Hawaiian Islands. *The Journal of Island and Coastal Archaeology, 15*(1), 28–56. https://doi.org/10.1080/15564894.2018.1481467

Sea Grant. (2020, September 21). *Indigenous knowledge can save 'Opihi*. University of Hawai'i Sea Grant. Retrieved December 16, 2024, from Indigenous Knowledge Can Save 'Opihi – Hawaii Sea Grant

Western Pacific Regional Fishery Management Council. (2022). *Annual stock assessment and fishery evaluation report for the Hawaii Archipelago Fishery Ecosystem Plan 2021* (T. Remington, M. Sabater, M. Seeley, & A. Ishizaki, Eds.). Honolulu, HI.

Miscellaneous Filter Feeders



Brachiopo

Lingula reevii

Inarticulated brachiopod species assigned to the family *Lingulidae. L. reevii* is rare and is known to occur in shallow, sandy reef flats in Kaneohe Bay, Oahu, Hawaii, as well as in Japan, and Ambon, Indonesia.

Yellow crust bryozoan

Parasmittina sp.

Common on hard surfaces exposed to current or surge at any depth. Many species occur worldwide with a range of colors and forms characterized by crusts with rounded lumps.

Ascidians

Aplidium crateriferum

Aplidium sp.

Aplidium crateriferum Savigny 1816, Crater Sea Squirt. Tropical Indo-Pacific; Red Sea to Western Pacific. Usually grows under rocks (here a colony is doing well under a Sarcophyton in Australia and one in N. Sulawesi). Can be grown in captivity (even reproduced).

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: All of these species are filter-feeders. *Lingula reevii* reproduces asexually and has low dispersal potential. Like other *Lingula,* it resides in burrows in sand or mud. Yellow crust bryozoan (*Parasmittina sp.*), cratered aplidium (*Aplidium crateriferum*), and gold ring aplidium (*Aplidium sp.*) are part of the "fouling community" that grows especially well on boat hulls and other man-made structures. Yellow crust bryozoan is colonial and also reproduces asexually. The ascidians are hermaphrodites and brood their eggs internally. Once the eggs hatch, the next stage is a tadpole-like larvae.

DISTRIBUTION: *Lingula reevii* is found only in Kāneʻohe Bay, Oʻahu. The yellow crust bryozoan is found throughout the Main Hawaiian Islands, but is abundant at Molokini Islet, Maui. Cratered aplidium is found throughout the Main Hawaiian Islands and the Northwestern Hawaiian Islands, but it is most common on the North Shore of Oʻahu. Gold ring aplidium is found at Makena and Molokini Islet, Maui.

ABUNDANCE: *Lingula reevii* is declining based on Division of Aquatic Resources surveys in Kāneʻohe Bay, but abundances are unknown for the other species.

LOCATION AND CONDITION OF KEY HABITAT: *Lingula reevii* primary habitat is the sandy reef flats of Kāneʻohe Bay, Oʻahu, and this habitat is degraded. Yellow crust bryozoan primary habitat includes corals, shells, and stones onto which they encrust. Cratered aplidium prefers crevices and the underside of overhangs on vertical walls that are exposed. Gold ring aplidium occurs at "scuba depths."

THREATS:

- Habitat degradation due to urbanization and sedimentation of Kāneʻohe Bay, Oʻahu threatens *Lingula reevii*;
- Aquarium trade collectors harvest *Lingula reeviii*.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Restore habitat of *Lingula*;
- Maintain healthy populations with appropriate aquarium fishing regulations, enforcement, and education.

MONITORING:

- Continue to survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size and distribution;
- Support aquaculture research to develop captive breeding for *Lingula's* use in the aquarium trade.

References:

Dr Keith Hiscock. "The Marine Life Information Network." MarLIN, www.marlin.ac.uk/species/detail/2322.

Gulko D. 2004. Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Division of Aquatic Resources, State of Hawai`i.

Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Worms - World Register of Marine Species - Lingula Anatina Lamarck, 1801 www.marinespecies.org/aphia.php?p=taxdetails&id=235362.

Dr Keith Hiscock. "The Marine Life Information Network." MarLIN, www.marlin.ac.uk/species/detail/2322.

Meerwasser-Lexikon. Mainpage Reeflex, www.reeflex.net/tiere/13163_Aplidium_crateriferum.htm.

Marine Invertebrates

Nudibranchs

Aldisa pikokai Ardeadoris scottjohnsoni Chromodoris vibrata Glossodoris poliahu Halgerda terramtuentis Hypselodoris andersoni Melibe megaceras Peltodoris fellowsi Sclerodoris paliensis

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION:
The species of nudibranchs listed, including *Aldisa pikokai* (pitted nudibranch), *Ardeadoris scottjohnsoni* (Scott Johnson's nudibranch), *Chromodoris vibrata* (trembling nudibranch), *Glossodoris poliahu* (snow goddess nudibranch), *Halgerda terramtuentis* (gold lace nudibranch), *Hypselodoris andersoni* (Anderson's nudibranch), *Melibe megaceras*, *Peltodoris fellowsi* (Fellow's nudibranch), and *Sclerodoris paliensis* (pali nudibranch), are carnivores that feed on a range of organisms such as sponges, hydroids, corals, and even other nudibranchs. The pitted nudibranch is the only nocturnal feeder among them. All species are hermaphroditic and mate through mutual insemination. They lay their eggs in coiled ribbons, which hatch into trochophore larvae.
These larvae eventually develop into planktonic veligers and lose their shell once they settle. Most nudibranchs have a lifespan of less than a year. Notably, nudibranchs are usually toxic due to the recycling of toxins from their prey, although they do not produce their own toxins.

DISTRIBUTION:
Most of the species are found throughout the Hawaiian archipelago. However, the gold lace nudibranch (*Halgerda terramtuentis*) is restricted to the Main Hawaiian Islands.

ABUNDANCE:
The snow goddess nudibranch (*Glossodoris poliahu*) is uncommon. There is limited quantitative data regarding abundance trends for the other species.

LOCATION AND CONDITION OF KEY HABITAT:
- *Aldisa pikokai* (pitted nudibranch) prefers waters from 2 to 9 meters (6 to 30 feet), though it can be found up to 24 meters (80 feet) deep, favoring areas with stones and crevices.
- *Chromodoris vibrata* (trembling nudibranch) inhabits waters from sea level to 24 meters (80 feet) deep.
- *Halgerda terramtuentis* (gold lace nudibranch) is typically found around caves in waters

ranging from 5 to 30 meters (15 to 100 feet).
- *Hypselodoris andersoni* (Anderson's nudibranch) inhabits caves and under overhangs on exposed rocky shores from 5 to 18 meters (15 to 60 feet), occasionally in shallower waters of harbors and boat channels, where they often live on the yellow sponge *Luffariella metachromia*.
- *Peltodoris fellowsi* (Fellow's nudibranch) is found near cave entrances in waters from 6 to 15 meters (20 to 50 feet) or deeper and typically resides on sponges.
- *Sclerodoris paliensis* (pali nudibranch) is found in waters from 2 to 6 meters (6 to 20 feet) deep. Specific habitat data for the other species has not been provided.

THREATS:
The aquarium trade targets certain species, including the gold lace, Fellow's, and pali nudibranchs.

CONSERVATION ACTIONS:
The primary goals of conservation actions include not only protecting existing populations but also establishing new populations to reduce the risk of extinction. Specific actions include:
- Maintaining healthy populations through appropriate aquarium fishing regulations, enforcement, and education.

MONITORING:
Surveys for populations and distribution in known and potential habitats should continue.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the population sizes and distributions of these species.

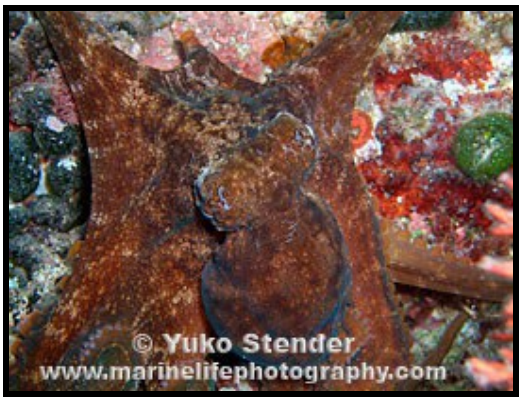
References:

Gulko, D. (2004). Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Division of Aquatic Resources, State of Hawai‘i.

Hoover, J.P. (1998). *Hawai‘i’s Sea Creatures: A Guide to Hawai‘i’s Marine Invertebrates*. Honolulu, HI: Mutual Publishing, 366 pp.

Kay, A.E. (1979). *Hawaiian Marine Shells Reef and Shore Fauna of Hawai‘i, Section 4: Mollusca*. Honolulu, HI: Bishop Museum Press, 653 pp.

Stender, Keoki. Order Nudibranchia, Family Chromodorididae, www.marinelifephotography.com/marine/mollusks/slugs/chromodorididae.htm.



Marine Invertebrates

Cephalopods

He‘e or Hawaiian or crescent octopus

Octopus hawiiensis

Mūhe‘e or Bobtail squid

Euprymna scolopes

Short-Arm Sand Octopus

Amphioctopus arenicola

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: He‘e or Hawaiian or crescent octopus (*Octopus hawaiiensis*), mūhe‘e or bobtail squid (*Euprymna scolopes*), and the Hawaiian short-arm sand octopus (*amphioctopus arenicola)* are all endemic cephalopods to the Hawaiian Islands. The Hawaiian short-arm sand octopus is a relatively newly identified cephalopod species and does not have a documented Hawaiian name. Both He‘e and mūhe‘e are nocturnal predators using venom to capture and killtheir prey. The Hawaiian short-arm sand octopus is known as a crepuscular species, meaning that it hunts for food during twilight hours; their most common prey are crustaceans like hermit crabs and mollusks. He‘e also feed primarily on crabs and other mollusks, and occasionally on fish. Mūhe‘e feed mainly on the shrimp *Palemon debilis*, but also feed on small worms. He‘e, mūhe‘e, and the Hawaiian short-arm sand octopus have complex mating behaviors. The males use a specially modified arm to insert sperm into the female’s mantle cavity. Fertilized eggs are then laid on the bottom of the ocean in clusters. He‘e guard their eggs. Once hatched, the larvae are pelagic. Mūhe‘e lay multiple clutches of eggs throughout the year. After a

20 day embryonic period, hundreds of juveniles can hatch from a singular egg clutch. They grow to a maximum mantle length of 3.5 centimeters and live between three to ten months. Mūheʻe have limited diurnal activity as they bury themselves in the sand during the day. While foraging for shrimp or worms in the water column on moonlit nights, they use counterillumination to camouflage themselves from potential predators on the seafloor. They do this with the help of the luminescent symbiont bacteria, *Vibrio fischeri*, that resides in a light organ within its mantle cavity. Both the heʻe and the Hawaiian short-arm sand octopus have the innate ability to camouflage themselves from predators by changing the color of their skin to match their environment. The Hawaiian short-arm sand octopus is also highly skilled at burrowing into the sand as a way of camouflage. Little is recorded of the habits of heʻe and the Hawaiian short-arm sand octopus.

DISTRIBUTION: All three cephalopod species are found throughout the Hawaiian Islands.

ABUNDANCE: Not known for any of the three species.

LOCATION AND CONDITION OF KEY HABITAT: The primary habitat of heʻe is rocky substrate or shallow reef flats in waters ranging from approximately five to nine meters (15 to 30 feet) deep, however they can be found at any depth. The primary habitat of the Hawaiian short-arm sand octopus are sandy substrates within shallow coastal waters ranging from 1-80 meters in depth. Mūheʻe can be found in shallow waters on either sand or mud flats. This habitat is important to mūheʻe because it uses the substrate during the day to burrow, and its main prey is found in this area. The habitat of mūheʻe is in decline, especially in areas like Kāneʻohe Bay, Oʻahu where the bay is affected by urbanization and sedimentation.

THREATS:

- Habitat degradation is the primary threat to the mūheʻe and a concern for the Hawaiian short-arm sand octopus and heʻe as well. Habitat degradation results from urbanization, runoff, and sedimentation. These threats not only alter its habitat but may negatively affect prey availability;
- Aquarium and research fishing pressure is a concern for mūheʻe;
- Recreational collectors create fishing pressure for heʻe and the Hawaiian short-arm sand octopus.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Restore and maintain habitat, especially for mūheʻe;
- Cooperate with other agencies to minimize pollution in areas such as Kāneʻohe Bay;
- Enforce regulations and education for aquarium trade and recreational collectors.

MONITORING:

- Continue and expand surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Research life history and biological characteristics to better understand management needs.
- Research the *Octopus hawiiensis* and the *amphioctopus arenicola* to fill the data gap on this species.

References:

Gulko, D. (2004). *Hawaiian marine species for ESA Candidate listing revised Candidate list*. Honolulu, HI: Division of Aquatic Resources, State of Hawai‘i.

Hoover, J. P. (1998). *Hawaii’s sea creatures: A guide to Hawaii’s marine invertebrates*. Honolulu, HI: Mutual Publishing.

Huffard, C. L., & Hochberg, F. G. (2005). Description of a new species of the genus *Amphioctopus* (Mollusca: Octopodidae) from the Hawai'ian Islands. *Molluscan Research, 25*(2), 87–95. https://doi.org/10.1071/MR05014

Jones, B. W., & Nishiguchi, M. K. (2004). Counterillumination in the Hawaiian bobtail squid, *Euprymna scolopes* Berry (Mollusca: Cephalopoda). *Marine Biology*. New Mexico State University.

Marine Life Photography. (n.d.). *Cephalopods*. Retrieved December 31, 2024, from https://www.marinelifephotography.com/marine/mollusks/cephalopods/cephalopods.htm

Nyholm, S. V., & McFall-Ngai, M. J. (2021). A lasting symbiosis: How the Hawaiian bobtail squid finds and keeps its bioluminescent bacterial partner. *Nature Reviews Microbiology*.

Rogers, T. F., Yalçın, G., Briseno, J., et al. (2024). Gene modelling and annotation for the Hawaiian bobtail squid, *Euprymna scolopes*. *Scientific Data*. University of Vienna.

Marine Invertebrates

Other Anthozoans

Octocorals

Bicolor Grogorian

Melithaea bicolor

The bicolor gorgonian is rare, typically found under ledges and in caverns exposed to surge. This species forms small colonies, attaining heights of approximately 3 inches (7.5 cm). Colonies are brightly colored, displaying variations of red with yellow tentacles or entirely yellow, white, or light pink. Endemic to Hawai‘i, this species was formerly classified as Acabaria bicolor. The gorgonian's eight-tentacled polyps possess an internal skeleton, which aids its survival in high-surge environments. Feeding primarily on plankton and suspended organic particles, its polyps exhibit limited stinging capabilities compared to other cnidarians.

Blue Soft Coral

Sarcothelia edmondsoni

This octocoral is common on vertical surfaces exposed to surge, particularly along the west coast of Hawai‘i. It exhibits a spectrum of colors from light blue to purplish brown, depending on the density of reflective sclerites embedded in its body wall. The blue soft coral harbors symbiotic zooxanthellae, which provide it with nutrients through photosynthesis. This coral is endemic to Hawai‘i and was previously known as *Anthelia edmondsoni*. Colonies can grow up to 30 cm (12 inches) across, and its polyps reach approximately 1 cm (0.4 inches) in height.

Molokai Leather Coral

Sinularia molokaiensis

The Moloka‘i leather coral is an exceptionally rare soft coral species, with only a few known colonies

globally, all recorded from Moloka‘i. It encrusts limestone or volcanic rocks in fore reef environments at depths of 1–6 meters (3–20 feet). Colonies can attain sizes of 30 cm (12 inches) across. This species relies on plankton as its primary food source and exhibits remarkable resilience in high-energy reef systems.

‘Ōkole or Anemones

Hawaiian Mann’s Anenome

Cladactella manni

Found in dark crevices and pockets within the intertidal zone, Hawaiian Mann’s anemones are uncommon and brightly colored, with vivid red tentacles. These solitary anemones grow up to 10 cm (4 inches) in diameter and are endemic to Hawai‘i. They utilize both zooxanthellae symbiosis and planktonic feeding for nutrition. Reproduction occurs both sexually, with the release of gametes, and asexually through tissue fragmentation, primarily from the foot.

Sand Anenome

Heteractis malu

The sand anemone is rare and occurs in sandy rubble habitats at various depths. Although formerly abundant in Kāne‘ohe Bay and Mā‘alaea Bay, its populations have significantly declined. Specimens are white with intricate fluorescence patterns in orange, green, blue, or violet, often accented with purple-tipped tentacles. These anemones may harbor commensal organisms such as shrimp (Thor amboinensis) or juvenile Hawaiian dascyllus. They can reach up to 12 inches (30 cm) in diameter but are usually much smaller. This species is distributed across Hawai‘i, the East Indian Ocean, and the tropical Pacific.

Zoanthids

White Stripe Zoanthid

Palythoa mutuki

Locally common in shallow waters, this species

attaches to rubble or rock, particularly in bays. Its polyps, measuring up to 3 cm (1.2 inches) tall, are spaced apart and exhibit a striking green disc with bold white radial stripes and white knobs between long tentacles. The body wall incorporates sand, lending rigidity. Contact should be avoided, as it contains potentially deadly palytoxins. Its distribution spans from the Persian Gulf to Hawai‘i.

Sunray Zoanthid

Palythoa heliodiscus

Occasionally observed on shaded vertical surfaces in shallow, wave-exposed areas, the sunray zoanthid has loosely spaced polyps with short, stubby tentacles. Its coloration includes tan polyps with brown discs marked by fine radial lines. Polyps grow to a diameter of 1 inch (2.5 cm). Like other zoanthids, it may produce palytoxins, requiring caution during handling. This species is distributed from Okinawa and Queensland to Hawai‘i.

Rubbery or Pillow Zoanthids

Palythoa tuberculosa

This species commonly forms extensive mats in areas subjected to wave surge. Polyps often remain closed under rough conditions. The texture of the colony resembles hard rubber, and coloration ranges from white to gray or brown. Palytoxins are present, necessitating careful handling. Its range includes Hawai‘i and the Indo-Pacific. Formerly known as *Palythoa caesia*.

Kealakekua Zoanthid

Zoanthus kealakekuaensis

Endemic to Hawai‘i, this zoanthid is locally common along basalt ledges near the waterline. Its tightly packed, fluorescent green polyps form mats. Each polyp measures approximately 5 mm (0.2 inches) in diameter. Like other zoanthids, it may

produce palytoxins.

SPECIES STATUS:
IUCN Red List: Not considered
Most species listed are endemic to Hawai‘i, except for Heteractis malu.

DISTRIBUTION:
- Endemic Species: *Melithaea bicolor*, *Sarcothelia edmondsoni*, *Sinularia molokaiensis*, *Cladactella manni*, and *Zoanthus kealakekuaensis*.
- Wider Distribution: *Heteractis malu* is found in Hawai‘i, the East Indian Ocean, and the tropical Pacific.

LOCATION AND CONDITION OF KEY HABITAT:
- Bicolor Gorgonian: Found in rocky crevices exposed to surge, ranging from 2–430 meters (6–1,400 feet).
- Blue Soft Coral: Occurs on hard and soft surfaces exposed to wave action.
- Moloka‘i Leather Coral: Restricted to Moloka‘i, found on rocky substrates from 1–6 meters (3–20 feet).
- Hawaiian Mann’s Anemone: Intertidal rocky zones constantly washed by waves.
- Zoanthids: Favor shallow, rocky environments.

THREATS:
- Overharvesting for the ornamental and precious coral trades.
- Habitat degradation from sedimentation, nutrient runoff, and shoreline development.
- Competition with introduced alien algae, particularly affecting species like the Hawaiian sand anemone.

CONSERVATION ACTIONS:
- Regulate harvesting in collaboration with Fisheries Management Plans.
- Mitigate land-based pollution and nutrient loading.
- Remove invasive algae and prevent future introductions.

MONITORING & RESEARCH PRIORITIES:
- Monitor invasive species impacts, including alien macroalgae.
- Survey populations and identify suitable habitats.
- Study reproductive and ecological factors influencing population dynamics.

References:

Gulko, D. (2005). *Hawai‘i Endemic Species Status Chart Spreadsheet*. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Gulko, D. (2004). *Hawaiian Marine Species for ESA Candidate Listing*. Honolulu, HI: Division of Aquatic Resources, State of Hawai‘i.

Hoover, J. P. (1998). *Hawai‘i’s Sea Creatures: A Guide to Hawai‘i’s Marine Invertebrates*. Honolulu, HI: Mutual Publishing.

Russo, R. (1994). *Hawaiian Reefs*. California, USA: Wavecrest Publications.

Stender, Keoki. Bicolor Gorgonian, *Melithaea Bicolor*, www.marinelifephotography.com/marine/cnidaria/acabaria-bicolor.htm.

Western Pacific Fisheries Management Council. *Fishery Management Plan for the Precious Coral Fisheries of the Western Pacific Region*. Available at: Western Pacific Fisheries Management Council.

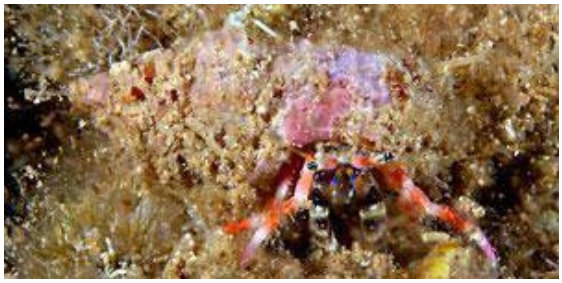
Other Crustaceans

Unauna or Hermit crabs

Hopper's Hermit Crab

Aniculus hopperae

An uncommon medium-sized hermit crab endemic to Hawai'i. Recognized by its hairy body, red arms with brown elbows, and jagged white lines on the claws. Prefers reef habitats around 25 feet deep. Plays a role in cleaning reef environments b scavenging detritus and organic matter.



Painted Hermit Crab

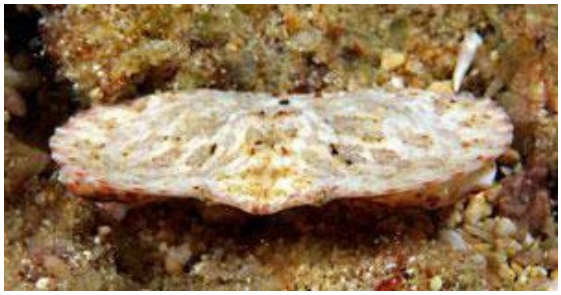
Calcinus pictus

A common hermit crab found in shallow waters exposed to wave action. It attains a size of about 3/4 inch and is more aggressive than other species in the Calcinus genus. Its striking red-and-blue coloration makes it easily recognizable. Endemic to Hawai'i, it was previously misidentified as the Indo-Pacific species *Calcinus elegans*.

Lsurent's Hermit Crab

Calcinus laurentae

This species is common in branching coral deeper than 20 feet. Distinguished by its white claws with black joints, red walking legs with black-and-white tips, and unique black eyes dotted with white. Reaching only 1/4 inch, it is one of the smaller hermit crabs endemic to Hawai'i. Prefers deeper coral reef habitats.



Crabs

Flat Elbow Crab

Aethra edentate

An uncommon crab that hides in rubble or under slabs on sandy or rocky reef bottoms. It has a distinctive flattened carapace that can reach a

width of 2 inches, resembling a "potato chip." Endemic to Hawai'i, it is primarily nocturnal and a predator of small invertebrates.

7-11 or Blood-Spot Crab
Carpilius maculatus

A striking crab with red spots resembling the pattern of dice, hence its nickname "7-11 crab." Its carapace can grow up to 6 inches in width. Found in rocky tidepools and coral reef areas. Although it is widespread throughout the Indo-Pacific, it is also found in Hawai'i. It is a nocturnal omnivore, feeding on algae, small invertebrates, and organic matter.

Sleepy Sponge Crab
Tumidodromia dromia

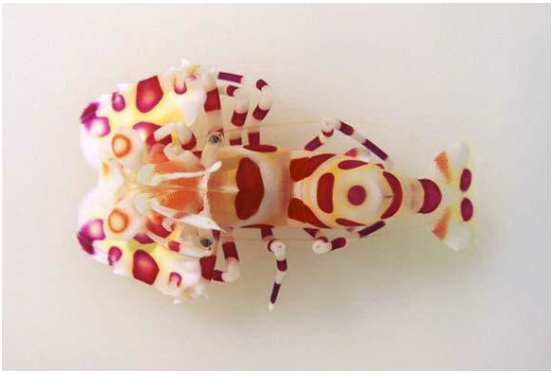
An uncommon species found under ledges and in caverns. This crab uses its hind legs to hold sponges, which serve as camouflage and protection. Its carapace can grow up to 8 inches wide, making it one of the largest crabs in the region. It is believed to be poisonous and is also known as the largest sponge crab in the world. Found in Hawai'i and the Indo-Pacific.

Hawaiian Pom-Pom Crab
Lybia edmondsoni

A fascinating crab known for carrying venomous anemones (*Triactis producta*) in its claws as both a defense mechanism and a tool for capturing prey. Its carapace reaches a width of 1/2 inch. Occasional under rocks in shallow waters, it is endemic to Hawai'i. Related to the Indo-Pacific *Lybia tessellata*.

Button Crab
Pseudopalicus oahuensis

An uncommon crab found on reefs at night, identifiable by its hind legs lined with long hair that aids in camouflage. Carapace width attains1 inch. Distributed across Hawai‘i and the Indo-Pacific. No previous scientific name recorded.



Shrimps

Cinetorhynchus hawaiiensis

A small shrimp endemic to Hawai‘i, commonly seen in finger corals at night. Notable for its dark spot on the side of the abdomen. Reaches up to 1 inch in length and contributes to reef health by foraging for organic matter.

Henderson’s Hinge-Beak Shrimp

Cinetorhynchus hendersoni

Common in coral-rich areas at night, this shrimp exhibits gray coloration with red-orange reticulations, and juveniles may appear blue-green. Reaches up to 3 inches in length and ranges across Hawai‘i and the Indo-Pacific. No previous scientific name recorded.

Harlequin Shrimp

Hymenocera picta

A rare and striking species often found in pairs under ledges at scuba depths. Feeds exclusively on sea stars, playing a unique role in marine food webs. Attains up to 2 inches. Occurs in Hawai‘i, the Indo-Pacific, and the Tropical Eastern Pacific. Formerly known as *Hymenocera elegans*.

Red Pencil Urchin Shrimp

Levicaris mammilata

This small, translucent shrimp is known for its long body and red markings. It has a symbiotic relationship with the red pencil urchin, feeding on detritus and small organisms. It plays an important role in cleaning and maintaining healthy reef ecosystems. Endemic to the Indo-Pacific region.

Knotted Liomera

Liomera supernodosa

A nocturnal species, this shrimp is recognized for the knotted, bulbous bumps on its body. It resides in crevices or under rocks during the day, feeding on plankton and detritus. Found primarily in the Indo-Pacific, it contributes to the ecosystem by recycling organic

material in reef habitats.

Bicolor Sand Shrimp
Metapenaeopsis sp.

This small, burrowing shrimp has a distinctive bicolor pattern with a pale body and darker markings. It plays a crucial role in maintaining the reef ecosystem by feeding on small organisms in the sand and detritus. Found in Indo-Pacific regions, it helps aerate sandy substrates.

Rathbun's Hinge-Beaked Shrimp
Rhynchocinetes rathbunae

A colorful and slender species, Rathbun's shrimp is easily recognized by its distinctive hinge-shaped beak. It is typically found in coral and rock crevices, where it feeds on small organisms. Endemic to Hawai'i and the Indo-Pacific, it plays an important role in the balance of reef ecosystems.

Earl's Coral Shrimp
Stenopus earlei

Known for its vivid red and white coloration, this shrimp has prominent antennae and often occurs in pairs. It feeds on detritus, contributing to the health of coral reef ecosystems. Endemic to Hawai'i, it is a striking and important member of the reef community.

SPECIES STATUS:

IUCN Red List: Not considered.

Endemic Species: All except *Carpilius maculatus*, *Dromia dormia*, and *Hymenocera picta*.

SPECIES INFORMATION:

The Hawaiian crustacean fauna includes a diverse array of hermit crabs, true crabs, and shrimp species, each with unique ecological roles and behaviors:

- Hermit Crabs (Unauna):
  - Habitat: Caves, ledges, and rocky shores.
  - Behavior: Scavengers; rely on empty shells for protection.
- Crabs:
  - Alakuma (7-11 Crab): Predatory, crushing crustaceans and snails.
  - Makua-o-ka-lipoa (Sponge Crab): Largest sponge crab species globally.
  - Kūmimi Pua (Pom Pom Crab): Uses sea anemones on claws for feeding and defense.
  - Button Crab: Algae grazer, found on rocky substrates.
- Shrimps:
  - Harlequin Shrimp: Predator of sea stars, including the crown-of-thorns starfish.

Known for monogamous pair bonding.
    - Red Pencil Urchin Shrimp: Lives commensally with sea urchins (*Heterocentrotus mammillatus*).
    - Hawaiian Cave Shrimp: Restricted to caves.
    - Earl's Coral Shrimp: Found under ledges and in crevices; functions as a cleaner species.

DISTRIBUTION AND ABUNDANCE:

- Earl's Coral Shrimp: Found off Oʻahu and Kauaʻi but considered rare.
- Henderson's Hinge-Beaked Shrimp: Abundant off Kona, Hawaiʻi, but distributed across the islands.
- Other Species: Found throughout the Main and Northwestern Hawaiian Islands, though abundance data remain largely unknown.

HABITAT:

- General: Most species are bottom dwellers found on reefs, rocky shores, caves, and sandy substrates.
- Unique Preferences:
    - Hermit crabs inhabit exposed rocky shores or coral branches.
    - Red Pencil Urchin Shrimp live on urchins.
    - Harlequin Shrimp and Earl's Coral Shrimp prefer crevices and under ledges.
    - Hawaiian Cave Shrimp are cave-restricted.

THREATS:

- Aquarium Trade: Overcollection of species such as alakuma, kūmimi pua, makua-o-ka-lipoa, hinge-beaked shrimp, and harlequin shrimp.

CONSERVATION ACTIONS:

- Population Protection:
    - Develop and enforce sustainable fishing regulations.
    - Educate the public on sustainable harvesting practices.
- Aquaculture Development:
    - Support research on captive breeding to reduce pressures from the aquarium trade.
- Monitoring Efforts:
    - Conduct population surveys in known and potential habitats.
- Research Priorities:
    - Study ecological and environmental factors influencing population dynamics and distribution.

References

Fiedler, G.C. (2002). The influence of social environment on sex determination in harlequin shrimp (*Hymenocera picta*). *Journal of Crustacean Biology,* 22(4): 750-761.

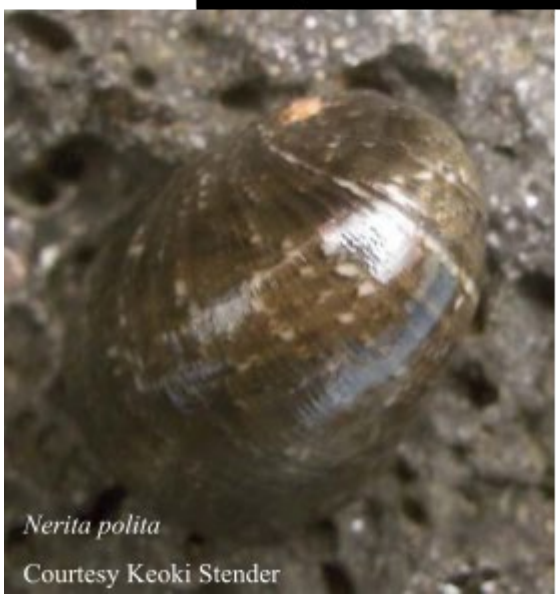
Gulko, D. (2004, 2005). Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Hawaiʻi Division of Aquatic Resources.

Hoover, J.P. (1998). *Hawaiʻi's Sea Creatures: A Guide to Hawaiʻi's Marine Invertebrates.*

Honolulu, HI: Mutual Publishing. 366 pp.

Kay, A.E. (1979). *Hawaiian Marine Shells Reef and Shore Fauna of Hawaii.* Honolulu, HI: Bishop Museum Press. 653 pp

Duplicara gouldi
Courtesy Keoki Stender



Nerita polita
Courtesy Keoki Stender

Snails

Charonia tritonis
Chicoreus insularum
Conus abbreviatus
Cypraea burgessi
Cypraea gaskoini
Cypraea granulata
Cypraea mauiensis
Cypraea ostergaardi
Cypraea rasleighana
Cypraea semiplota
Cypraea sulcidentata
Cypraea tessellata
Cypraea tigris
Duplicara gouldi
Epitonium ulu
Euprotomus hawaiensis
Nerita
picea Nerita plicata
Nerita polita
Smaragdia
bryannae Turbo
sandwicensis

SPECIES STATUS:
IUCN Red List - Not considered
All Endemic except for *Charonia*, *Cypraea tigris*, and *Nerita polita*

SPECIES INFORMATION: The species common names and Hawaiian names are: pu or triton's trumpet (*Charonia tritonis*), burnt murex (*Chicoreus insularum*), pūpū'ala or abbreviated cone (*Conus abbreviatus*), Burgess' cowry (*Cypraea burgessi*), leho or Gaskoin's cowry (*C. gaskoini*), leho or granulated cowry, (*C. granulate*), leho or Maui cowry (*C. mauiensis*), leho or Ostergaard's cowry (*C. ostergaardi*), leho or Rasleigh's cowry (*C. rasleighana*), puleholeho or half- swimmer cowry (*C. semiplota*), leho or groove-toothed cowry (*C. sulcidentata*), leho or checkered cowry (*C. tessellata*), tiger cowry (*C. tigris*), pūpū loloa or Gould's auger (*Duplicara*

gouldi), fungiid wentletrap (*Epitonium ulu*), pipipi or black nerite (*N. picea*), *N. plicata* (none), kūpeʻe or polished nerite (*N. polita*), Hawaiian seagrass snail (*Smaragdia bryannae*), alīlea or Hawaiian stromb (*Euprotomus hawaiensism,* formerly known as *Strombus vomer hawaiiensis*), and pūpū mahina or Hawaiian turban (*Turbo sandwicensis*).

The Pu reaches twenty inches in length (second largest snail in the Pacific) and feeds on sea stars, including crown-of-thorns starfish, urchins, and other mollusks. *Chicoreus* and pūpūʻala are carnivores that prey on bivalves by drilling through the shell and inserting a digestive enzyme and ingesting the tissues through its proboscis. Pupuʻala feeds exclusively on polychaete worms, mollusks, or small fish using a harpoon-like tooth that is connected to a venom gland and paralyzes its prey and swallows it whole.

Leho or cowries are nocturnal and can be herbivores and omnivores, feeding on algae or gastropods, as well as sponges (*C. gaskoini* and Puleholeho). Hawaiian individuals of *C. tigris* are the largest in the world. Pūpū loloa feed solely on the yellow acorn worm (*Ptychodera flava*). The fungiid wentletrap (*Epitonium*) is associated with a solitary coral *Fungia scutaria*, and feeds on the tissue of the coral it's attached to. Nerites (*Nerita* and *Smaragdia*) and alīlea are exclusively herbivores and feed on algae. Kūpeʻe is nocturnal.

Pūpūʻala egg capsules are laid in clusters ranging from 80 to 1000 eggs. Female leho lay eggs in triangular capsules that are attached to the substrate. Eggs develop for one to two weeks. The fungiid wentletrap pelagic stage lasts about 39 days. Nerites lay eggs in capsules that adhere tightly to the surface of rocks and shells. Settlement of nerite veligers peaks in the winter.

DISTRIBUTION: Pu, the burnt murex, *Conus*, lehos, pipipi and kūpeʻe, alīlea, pūpū mahina, and pūpū loloa are found throughout the Archipelago; however, pūpū loloa is rare or possibly absent on the island of Hawaiʻi. The fungiid wentletrap is found only in Kāneʻohe Bay, Oʻahu. *Nerita plicata* is found only on the Northwestern Hawaiian Islands and S*maragdia byrannae* is found specifically at Anini, Kauaʻi; Kāneʻohe Bay, Oʻahu; and near Kaunakakai, Molokaʻi.

ABUNDANCE: Specific abundance for cowries is unknown, but many are rare such as pu, *Cypraea mauiensis*, *C. ostergaardi,* and *C. tigris*. Alīlea is also very rare today.

LOCATION AND CONDITION OF KEY HABITAT: The burnt murex is found at depths of 18 meters (60 feet) or more. Pūpūʻala key habitat is on benches and sandy substrate of reef platforms. Most Lehos including (*C. gaskoni, C. granulata,* Pulholeho, and *C. tessellata*) are found in shallow waters to 60 meters (200 feet). *C. mauiensis* is restricted to shallow waters, while *C. rashleighana* and *C. sulcidentata* are found in more moderately deep waters. *C. ostergaardi* is the only cowry found exclusively in deep waters. *C. mauiensis* has additional key breeding habitat on the leeward side of Maui. Pūpū loloa inhabits the casting of large acorn worms. The fungiid wentletrap lives on a solitary coral *Fungia scutaria* in Kāneʻohe Bay, an area that has been severely degraded. Key habitat for both pipipi and *N.plicata* is intertidal areas, but kūpeʻe is found under sand at the high tide line. *Smaragdia bryannae* is found on fringing and patch reefs only in association with the marine angiosperm *Halophila hawaiiana*. Alīlea lives up to 25 meters (80 feet) deep in sand. Pūpū mahina is common to 18 meters (60 feet) deep.

THREATS:

- Habitat degradation, pollution, climate change, invasive species, overharvesting, and diseases can affect these species' habitats and populations.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include the continuation of the following actions:

- Maintaining healthy populations with appropriate fishing regulations, enforcement, and education.

MONITORING: Includes the continuation of the following actions:

- Surveying for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Research factors affecting these species' population sizes and distributions.

References:

Fabricius, K.E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: Review and synthesis. Marine Pollution Bulletin, 50(2), 125–146.

Gulko D. 2005. Hawai‘i endemic species status chart spreadsheet. Honolulu, HI: Hawai‘i Division of Aquatic Resources.

Gulko D. 2004. Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Division of Aquatic Resources, State of Hawai`i.

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawai`i's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Hughes, T.P., et al. 2017. Coral reefs in the Anthropocene. Nature, 546(7656), 82–90

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawai‘i, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.

Poloczanska, E.S., et al. (2013). Global imprint of climate change on marine life. Nature Climate Change, 3(10), 919–925.

Smith, J.E., Hunter, C.L., & Smith, C.M. 2002. Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. Pacific Science, 56(3), 299–315.

WoRMS Editorial Board. (2023). World Register of Marine Species (WoRMS). Retrieved from https://www.marinespecies.org

Marine Invertebrates

Black reef sponge

Spongia oceania

SPECIES STATUS:
IUCN Red List - Not considered
Endemic

SPECIES INFORMATION: The black reef sponge is a filter feeder, using its collar cells to filter out organic material from the water passing through its cells. The black reef sponge is hermaphroditic. Most often it reproduces asexually through budding or fragmentation; however, sexual reproduction does occur. Gametes are produced at different times within a sponge; therefore, sponges depend on another sponge for fertilization. Sperm is released into the open ocean and other sponges retrieve the sperm to fertilize their eggs internally. These fertilized eggs hatch into free-swimming larvae. Although the black reef sponge has no spicules, it is still too hard to be exploited commercially.

DISTRIBUTION: Once widespread, the black reef sponge is primarily found in Hanauma Bay, O‘ahu and along the Kona Coast on the island of Hawai‘i.

ABUNDANCE: Previously, it was the most common large sponge in the Hawaiian Islands and was very abundant in Hanauma Bay, O‘ahu in the 1940s. Today, numbers have decreased significantly.

LOCATION AND CONDITION OF KEY HABITAT: The black reef sponge primary habitat is in shallow waters on hard substrate that is in open areas with a strong surge or current. Its habitat is threatened by pollution and degradation from trampling of tourists.

THREATS: Although this sponge is not suitable for commercial use, it has severely declined since the 1940s.

- Pollution or degradation from human interactions such as trampling may have caused the decline.
- Climate change, and invasive species may threaten this species’ habitat and population.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition to common state-wide and island conservation actions, specific actions include:

- Restore habitat.

MONITORING:

- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size and distribution.

References:

Fabricius, K.E. 2005. Effects of terrestrial runoff on the ecology of corals and coral reefs: Review and synthesis. Marine Pollution Bulletin, 50(2), 125–146.

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 p.

Hughes, T.P., et al. 2017. Coral reefs in the Anthropocene. Nature, 546(7656), 82–90

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org Poloczanska, E.S., et al. (2013).

Global imprint of climate change on marine life. Nature Climate Change, 3(10), 919–925.

Smith, J.E., Hunter, C.L., & Smith, C.M. 2002. Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. Pacific Science, 56(3), 299–315.

Marine Worms

(No Common Name)

Vermiliopsis torquata

An uncommon species of annelid worm endemic to Hawai'i. Characterized by its segmented body and reddish-brown coloration, it is commonly found in shallow waters and is a carnivore. This species is nocturnal, using its specialized feeding structures to capture small prey. Like other worms in this group, it plays a role in cleaning and maintaining the marine ecosystem.

Flatworms

Hyman's Flatworm

Pericelis hymanae

This species of flatworm is endemic to Hawai'i and is hermaphroditic, capable of both self-fertilization and cross-fertilization. It prefers shallow waters and often hides under stones, where it preys on small invertebrates. Its ability to reproduce both sexually and asexually by fragmentation or budding contributes to its resilience. Hyman's flatworm is nocturnal and plays a role in controlling populations of its prey species.

Hawaiian Spotted Flatworm

Pseudobiceros sp. 2

Endemic to Hawai'i, this species of flatworm is found from the shoreline to depths of up to 15 meters (50 feet). It is hermaphroditic and reproduces both sexually and asexually. The Hawaiian spotted flatworm is nocturnal and carnivorous, feeding on smaller invertebrates. Like other flatworms, it plays a crucial role in maintaining the balance of the marine ecosystem by keeping prey species in check.

Ko‘e kai or Ribbon worm

Baseodiscus cingulatus

Endemic to Hawai'i, the Ko‘e Kai (banded ribbon

worm) is recognized for its long proboscis, which it uses to attack and entrap prey. This species is found in both shallow waters and deeper habitats, as deep as 76 meters (250 feet). It is carnivorous, nocturnal, and has separate sexes, with external fertilization of its eggs. Known for its striking appearance and feeding behavior, the Koʻe Kai plays an important ecological role in its habitat.

SPECIES STATUS:
IUCN Red List: Not considered Endemic to Hawai'i

SPECIES INFORMATION:
Vermiliopsis torquata (no common name), Hyman's flatworm (Pericelis hymanae), Hawaiian spotted flatworm (Pseudobiceros sp. 2), and koʻe kai or banded ribbon worm (Baseodiscus cingulatus) are all endemic species of worms found throughout the Hawaiian Archipelago. All are carnivorous and nocturnal. The koʻe kai (banded ribbon worm) uses its long proboscis to attack and capture prey. Hyman's flatworm and Hawaiian spotted flatworm are hermaphroditic, with internal fertilization and gelatinous egg masses. These eggs develop either into free-swimming larvae or small flatworms. The koʻe kai has separate sexes, with external fertilization of its gelatinous egg masses. Both the flatworms and koʻe kai can reproduce asexually by fragmentation or budding.

DISTRIBUTION: These species are found throughout the Hawaiian Archipelago, inhabiting a variety of shallow marine environments.

ABUNDANCE: The abundance of these species is not well documented. Hyman's flatworm is commonly found at Black Point, Oʻahu.

LOCATION AND CONDITION OF KEY HABITAT:
- Hyman's flatworm prefers shallow waters and is commonly found under stones, sometimes associating with the brown purse shell (Isognomon perna).
- Hawaiian spotted flatworm also prefers shallow waters and is commonly found under stones, extending from the shoreline to depths of about 15 meters (50 feet).
- Koʻe kai (banded ribbon worm) has a large range of primary habitat, found as deep as 76 meters (250 feet), but also in shallow waters and tidepools.

THREATS: No significant threats have been identified for these species.

CONSERVATION ACTIONS:
The goals of conservation actions include maintaining healthy habitats to protect existing populations and establish additional populations to reduce the risk of extinction. Efforts focus on preserving critical habitats across the Hawaiian Archipelago.

MONITORING:
- Ongoing surveys for populations and distribution are planned in known and likely habitats.

RESEARCH PRIORITIES:

- Further research is needed to understand the factors affecting the population sizes and distribution of these species.

References:

Barnes RD. 1980. Invertebrate zoology, 4th edition. Philadelphia, PA: Saunders College Publishing.

Hugues Flodrops. Flatworm with Black Pseudotentacles Orange Laterally Pseudobiceros, seaslugs.free.fr/flatworm/planaire/pseudobiceros_periculosus_a.htm.

Honolulu, HI: Mutual Publishing. 366 pp.

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawaii's marine invertebrates.

Stender, Keoki. Hawaiian Spotted Flatworm, *Pseudobiceros Sp. 2*, www.marinelifephotography.com/marine/worms/pseudobiceros-2.htm.

Stender, Keoki. Banded Ribbon Worm, *Baseodiscus Cingulatus*, www.marinelifephotography.com/marine/worms/baseodiscus-cingulatus.htm.

Photo Credit: Bert Weeks

Marine Invertebrates

All Stony Corals

(All species listed in text)

Acroporidae
Agariciidae
Astrocoeniidae
Balanophyllidae
Caryophyllidae
Dendrophylliidae
Faviidae Fungiidae
Pocilloporidae
Poritidae
Siderastreadae

SPECIES STATUS:
IUCN Red List - Not considered
Some Endemic (see text)

SPECIES INFORMATION:
All stony corals feed on small plankton or dissolved organic matter that is in the waters. Most corals use nematocysts on their tentacles to capture and sting prey, feeding primarily at night. Other species, such as *Pavona duerdeni,* are suspension feeders. Stony corals with endosymbiotic dinoflagellates can get up to 98 percent of their nutrition from the sugars produced by the algae. *Balanophyllia* and *Tubastraea* lack endosymbiotic dinoflagellates,. Stony corals reproduce both sexually and asexually. For sexually reproducing species, a particular combination of day length, tide, and moonlight prompts spawning events. Corals can also reproduce asexually, through planulation, budding, or fragmentation. orals such as the *Pocillopora* sp. and *Porites* sp. brood their eggs and release the larvae or planulae completely formed. Budding is when a coral polyp divides into a genetically identical new polyp while maintaining tissue connections with the colony, while fragmentationis when pieces are broken off and grow into new colonies. Many species of stony corals are important habitat for many reef species such as juvenile fishes, shrimps and other invertebrates. All stony corals are protected under the Convention on International Trade in

Endangered Species (CITES).
Shallow water corals of Hawai‘i:

Acroporidae:	Acropora cytherea, Acropora gemmifera, Acropora humilis, Acropora nasuta, Acropora paniculata, Acropora valida, Anacropora sp., Montipora capitata*, Montipora dilatata*, Montipora flabellata*, Montipora patula*, Montipora studeri, Montipora tuberculosa, Montipora turgescens, Montipora verrilli

Agariciidae:	Gardineroseris planulata, Leptoseris foliosa, Leptoseris hawaiiensis, Leptoseris incrustans, Leptoseris mycetoseroides, Leptoseris papyracea, Leptoseris scabra, Leptoseris tubulifera, Pavona duerdeni*, Pavona maldivensis, Pavona varians
Caryophylliidae:	Tethocyathus minor
Dendrophylliidae:	Cladopsammia eguchii, Eguchipsammia serpentina, Rhizopsammia verrilli, Tubastraea coccinea, Tubastraea diaphana
Fungiidae:	Cycloseris distorta, Cycloseris explanulata, Cycloseris fragilis, Cycloseris sp.*, Cycloseris wellsi, Diaseris fragilis, Diaseris distorta, Pleuractis granulosa, Lobactis scutaria, Sinuorota hexagonalis
Leptastreidae:	Leptastrea bewickensis, Leptastrea transversa, Leptastrea purpurea
Merulinidae:	Cyphastrea agassizi, Cyphastrea ocellina
Pocilloporidae:	Madracis pharensis, Pocillopora damicornis, Pocillopora grandis, Pocillopora ligulata*, Pocillopora meandrina, Pocillopora molokensis*
Poritidae:	Porites cf. annae, Porites bernardi, Porites brighami*, Porites compressa*, Porites duerdeni*, Porites evermanni*, Porites hawaiiensis*, Porites lichen, Porites lobata, Porites monticulosa, Porites pukoensis*, Porites rus, Porites solida, Porites studeri
Psammocoridae:	Psammocora explanulata, Psammocora haimiana, Psammocora nierstraszi, Psammocora profundacella, Psammocora stellata, Psammocora verrilli*

The following are the endemic stony corals of Hawaii and their common and Hawaiian names: serpentine cup coral (*Eguchipsammia serpentina*), Hawaiian plate coral (*Leptoseris hawaiiensis*), rice coral (*Montipora capitata*), irregular rice coral (*Montipora dilatata*), blue rice coral (*Montipora flabellata*), sandpaper rice coral (*Montipora patula*), branching rice coral (*Montipora studeri*, also known as *M. incrassata*), *Montipora verrilli* (no common name), flat lobe coral (*Pavona duerdeni*), Molokaʻi cauliflower coral (*Pocillopora molokensis*), Brigham's coral (*Porites brighami*), pōhaku puna or compressed coral (*Porites compressa*), thick finger coral (*Porites duerdeni*), pōhaku puna or Evermann's coral (*Porites evermanni*, also known as *P. lutea*), *Porites pukoensis* (no common name), and Verrill's lump coral (*Psammocora verrilli*).

The following are the non-endemic stony corals from shallower waters of Hawaii: table coral (*Acropora cytherea*), *Acropora gemmifera* (no common name), finger staghorn coral (*Acropora humilis*), branching staghorn coral (*Acropora nasuta*), fuzzy table coral (*Acropora paniculata*), bushy staghorn coral (*Acropora valida*), *Anacropora* sp. (no common name), oval cup coral (*Balanophyllia* sp., also called *Cladopsammia eguchii*), Wells' coral (Cycloseris *wellsi*), fragile mushroom coral (*Cycloseris fragilis*, also called *Diaseris fragilis*), humpback coral (Sinuorota hexagonalis, formerly *Cycloseris hexagonalis or C. vaughani*), ocellated coral (*Cyphastrea ocellina*), distorted mushroom coral (Cycloseris distorta, formerly *Diaseris distorta*), ākoʻakoʻa

kohe or granulated mushroom coral (Pleuractis granulosa, formerly *Fungia granulosa*), ākoʻakoʻa kohe or mushroom coral (Lobactis scutaria, formerly *Fungia scutaria*), ākoʻakoʻa kohe or *Fungia* sp. (no common name), honeycomb coral (*Gardineroseris planulata*), Bewick's coral (*Leptastrea bewickensis*), *Leptastrea bottae* (no common name, also known as *L. hawaiiensis), Cyphastrea agassizi (no common name*), , crust coral (*Leptastrea purpurea*), transverse coral (*Leptastrea transversa*), foliose coral (*Leptoseris foliosa*), swelling coral (*Leptoseris incrustans*), ridge coral (*Leptoseris myctoseroides*), papyrus coral (*Leptoseris papyracea*), rough plate coral (*Leptoseris scabra*), tube coral (*Leptoseris tubulifera*), hidden orange coral (*Madracis pharensis*), *Montipora tuberculosa* (no common name), lumpy rice coral (*Montipora turgescens*), *Pavona maldivensis* (no common name, formerly known as *P. pollicata*), corrugated coral (*Pavona varians*), Lace coral (*Pocillopora damicornis*), antler coral (*Pocillopora grandis,* formerly known as *Pocillopora eydouxi*), thin cauliflower coral (*Pocillopora ligulata*), cauliflower coral (*Pocillopora meandrina*), nodule coral (*Porites* cf. *annae*), false lichen coral (*Porites bernardi*), plate and knob coral (*Porites monticulosa*), lichen coral (*Porites lichen*), lobe coral (*Porites lobata*), plate and pillar coral (*Porites rus*, also known as *Porites irregularis*), solid coral (*Porites solida*), deep lobe coral (*Porites studeri*), flat coral (Cycloseris explanulata, formerly *Psammocora explanulata*), Haime's lump coral (*Psammocora haimiana*), Nierstrasz's coral (*Psammocora nierstraszi*), stellar coral (*Psammocora stellata*), superficial coral (*Psammocora profundacella*), Verrill's lump coral (*Rhizopsammia verrilli*), tiny cup coral (*Tethocyathus minor*), colonial cup coral (*Tubastraea coccinea*), and black cup coral (*Tubastraea diaphana*).

The following are deep water scleractinian corals from Hawaii (none have common names): *Anisopsammia ampheiliodes, Anthemiphyllia pacifica, Balanophyllia desmophylloides, Balanophyllia diomedeae, Balanophyllia hawaiiensis, Balanophyllia laysanensis, Bathyactis hawaiiensis, Caryophyllia alcocki, Caryophyllia octopalli, Ceratotrochus laxus, Cyathoceras diomedae, Deltocyathus andamanicus, Dendrophyllia oahensis, Desmophyllum cristagallis, Endopachys oahensis, Flabellum deludens, Flabellum pavoninum, Gardineria hawaiensis, Madracis kauaiensis, Madrepora kauaiensis, Paracyathus gardineri, Paracyathus mauiensis, paracyathus molokensis, Paracyathus tenuicalyx, Placotrochus fuscus, Stephanophyllia formosissima*, and *Trochocyathus oahensis*.

DISTRIBUTION:
Acropora cytherea is found in the Northwestern Hawaiian Islands (NWHI) around French Frigate Shoals and a few colonies were identified off Kauaʻi, but are no longer there. Fossils show that historically it was widespread throughout the islands. *A. gemmifera, A. humilis, A. paniculata, A. valida* and *Montipora turgescens* are known only from the NWHI. *Anacropora* has only been found off Maui. An unnamed *Fungia* sp. has been found off of the island of Hawaiʻi. *Gardineroseris planulata* is found only from the island of Hawaiʻi through Oʻahu. *Leptoseris foliosa* is only known from Maui.

Montipora dilatata is found only within Kaneʻōhe Bay. *Porites annae* is known from Maui. *Porites duerdeni* is found only in Kāneʻohe Bay and possibly South Maui. *Porites lichen* is only common near Kure Atoll and Oʻahu. *Porites pukoensis* is found only near Molokaʻi. *Psammocora verrilli* occurs off Oʻahu and Molokaʻi only. No reliable distribution data exists for the deep water corals. Distribution of the other species is statewide.

ABUNDANCE:

The stony corals are extensively monitored by the Division of Aquatic Resources, National Marine Fisheries Service, and the Coral Reef Assessment and Monitoring Program partnership including the University of Hawai‘i. All groups maintain data accessible to managers. Hawaii contains the majority of the coral reefs in the United States and due to the isolation of the islands, a high rate of endemism is found in much of the marine species, including stony corals. The Hawaiian reefs are key to the biodiversity of these unique marine species making it a deciding site for global coral reef conservation.

LOCATION AND CONDITION OF KEY HABITAT:
Readers should refer to the coral guides below for specific information on the location of key habitat for these corals. *Leptoseris papyracea* and *P. studeri* occur in water over 30 meters (100 feet) deep. Other deep water corals that occur over 91 meters (300 feet) deep are listed in a special paragraph above.

THREATS:
Threats vary in character and severity between the Main Hawaiian Islands (MHI) and the NWHI. Primary threats to the coral reefs of the MHI are the following:

- Thermal stress leading to coral bleaching events, as in 2014, 2015, and 2019
- Pollution such as high levels of nutrients, sediments, and freshwater all negatively impact coral reefs in nearshore areas. Water pollution results from urbanization, stream channelization, paving of coastal and upland roads and inadequate land-use practices;
- Tourism activities can lead to coral damage when tourists trample or walk on the coral and when boats anchor on reefs or spill fuel;
- Alien species such as *Kappaphycus spp*., *Eucheuma denticulatum*, and *Gracilaria salicornia* macroalgaes that quickly dominate coral reef habitat and form floating mats or snowflake octocoral (*Carijoa riisei*) that smother live coral colonies;
- Marine debris gets stuck on coral reefs and can break off large pieces of coral colonies. The debris, primarily derelict fishing gear, entangles pieces of coral and it scours the reef as it moves around in the waves;
- Taking or harvesting stony corals is prohibited by law; however, they are still removed; Corals also are important to the aquarium trade;
- Disease is a potential threat in all areas but has not yet caused serious mortality of corals in Hawai‘i.

CONSERVATION ACTIONS:
The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. Stony corals are protected under Appendix II of the Convention on International Trade in Endangered Species (CITES). Many organizations work to protect coral reefs in Hawai‘i through research and conservation such as the Hawaiian Coral Reef Initiative. In addition to common state-wide and island conservation actions, specific actions include:

- Work with partners to minimize nutrient loading and other pollution from land-based sources;
- Increase education and outreach effort, specifically to tourists and tourism programs on the effects of trampling and walking on corals;
- Continue to remove alien species, specifically alien algae using established effective techniques;

- Prevent alien species from entering the ecosystem by preventative measures, education, and rapidly responding to new intruders;
- Enforce existing regulations and educate public on regulations that prohibit the collection and trade of aquarium species;
- Expand on existing MPAs and look for priority areas for new MPAs;
- Restore habitat where feasible;
- Establish rapid response team to deal with shipwrecks, oil spills, disease, hurricanes, and other acute impacts;
- Develop and implement day-use mooring buoys that prevent anchor damage to coral reefs
- Continue working to remove marine debris.

MONITORING:

- Monitor alien macroalgae and removal operations to determine impacts on coral;
- Implement comprehensive disease monitoring statewide;
- Collaborate with partners to monitor bleaching events;
- Establish long-term monitoring at coral reef restoration sites to evaluate the efficacy of interventions;
- Continue monitoring coral populations and expand to unsurveyed areas such as is being done with the new MHI RAMP cruises in partnership of DAR and NMFS.

RESEARCH PRIORITIES:

- Research the compounded effects of threats such as water pollution, harvesting of coral, and alien species on coral health;
- Continue researching the most effective means for removing invasive macroalgae.
- Develop new responsible restoration strategies

References:

Brainard R, Friedlander A, Gulko D, Hunter C, Kelty R, Maragos J. 2002. Status of coral reefs in the Hawaiian Archipelago. pp. 237-248. In: Status of coral reefs of the world 2002. Australia: Australian Institute of Marine Science.

Fenner D. 2005. Corals of Hawaii. Honolulu, HI: Mutual Publishing. 144 pp.

Gulko D. 1998 . Hawaiian coral reef ecology. Honolulu, HI: Mutual Publishing. 244 pp.

Hawaii Coral Reef Initiative. 2002. The First Four Years: Hawai`i Coral Reef Initiative Research Program 1998-2002. Available from: www.hawaii.edu/ssri/hcri/rp/publications.htm

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Maragos J. 1977. Order Scleratinia. pp. 158-241. In: Reef and shore fauna of Hawaii. Honolulu, HI: B. P. Bishop Museum Special Publication 64

Endemic and Native Marine Algae

Marine Limu

SPECIES STATUS:
This fact sheet is inclusive to all the native and endemic limu species listed in Appendix B.

SPECIES INFORMATION

Marine algae, or limu, are categorized into three main groups: brown algae (*Phaeophyceae*), green algae (*Chlorophyta*), and red algae (*Rhodophyta*). While all groups contain chlorophyll for photosynthesis, their distinctive colors come from other pigments. Limu play several vital roles in coral reef ecosystems. These roles include stabilizing the reef, cycling nutrients, supporting primary productivity (photosynthesis that produces oxygen), generating sand, and serving as a key food source for many marine species.

Crustose coralline algae (CCA) are tough algae that incorporate calcium carbonate into their cell walls. They play a crucial role in holding the reef together and protecting its structure from erosion and damage, promoting both reef stability and growth. CCA also stimulate coral larvae to settle by releasing chemical signals, providing an ideal surface for corals to attach and grow. *Halimeda kanaloana*, a green algae species composed of calcified segments, thrives in sandy environments and forms extensive meadows at depths of up to 260 feet. After dying, its calcified remains significantly contribute to the sand and sediment composition of coral reefs. Limu pālahalaha (*Ulva fasciata*), or sea lettuce, is another green algae species that helps prevent erosion, produces oxygen, creates sand, and serves as a vital food source for marine animals, forming the foundation of the food chain in local fisheries.

Limu also have deep cultural and historical significance in Hawaiian society, playing a major role in the traditional diet and serving various medicinal, religious, and cultural purposes. While men typically fished offshore in canoes, women gathered food from the nearshore environment, women were the primary gatherers and experts in limu. Due to kapu (sacred restrictions) that limited their diet, women became specialists in limu, collecting and preparing it for the community, because limu was considered noa (free of restriction).

limu pālahalaha and limu kohu (*Asparagopsis taxiformis)* hold significant roles in traditional diets, rituals, and practices. Limu pālahalaha is a staple food often consumed with fish or poi, valued for its mild flavor and high nutritional content. It also carries symbolic importance in representing sustainability and the connection between land and sea. Limu pālahalaha was used to make leis and other ornamentations for hula dancers. Limu kohu, a prized delicacy, is cherished for its strong, spicy flavor and reddish color. It was traditionally served during special occasions and feasts. Both limu types have spiritual and medicinal roles, with limu kohu believed

to have healing properties and both limu representing abundance, balance, and prosperity in Hawaiian culture.

Sargassum echinocarpum, or limu kala, is a brown algae species that was designated as the official state limu in 2023 and holds significant cultural importance. It is traditionally used in hoʻoponopono, or forgiveness ceremonies, where participants receive a piece of limu kala, offer prayers, and consume it at the ceremony's conclusion. Additionally, kahu (priests) used it for cleansing rituals, mixing it with turmeric and salt water to purify individuals, objects, or places. Limu kala is also linked to ʻopelu, playing a role in rituals performed by fishers at the start of the ʻopelu fishing season. Additionally, this species grows in free floating mats which provides microhabitats, protection, and breeding ground for many marine species.

DISTRIBUTION:
All species are native or endemic to the Main Hawaiian Islands. *Polysiphonia rubrorhiza,* is a limu species that is endemic to the North Western Hawaiian Islands.

ABUNDANCE:
Hawaiʻi's endemic marine algae include red algae (16.7%), green algae (6.6%), and brown algae (2.8%), which totals 26.1% of the total marine flora in Hawaiʻi. Many native limu species, such as limu kohu and limu pālahalaha, are not as abundant as they once were and have declined due to urban development, unsustainable harvesting, non-native species, climate change, and the decline of traditional knowledge and practices.

LOCATION AND CONDITION OF KEY HABITAT:
Red algae, the most diverse and abundant in Hawaiʻi, thrive in habitats from shallow waters to deep depths, up to 100 meters, due to their ability to absorb blue light. Green algae prefer shallow, well-lit environments like tide pools and rocky shores, requiring high light levels for photosynthesis. Brown algae, less common in Hawaiʻi, inhabit cooler waters and rocky coastlines at intermediate depths with moderate wave action.

THREATS:
- Habitat loss via changing coastlines with shoreline development, bloom-forming algae encroaching on shoreline habitat and climate change.
- Alien and invasive species.
- Land-derived pollutants.
- Anthropogenic induced reductions in surface and groundwater flow to the nearshore environment.

CONSERVATION ACTIONS:
Actions include the continuation of the following:
- Protecting and restoring key marine habitats, including coral reefs and tide pools.
- Conducting outreach and education of the cultural and ecological importance of marine limu.
- Continuing to control, manage, and prevent introduced alien and invasive algae.
- Repopulating native species.

RESEARCH PRIORITIES:
Actions include the continuation of the following:

- Figuring out methods and techniques to restore culturally significant algal species.
- Water quality research.
- Biodiversity and DNA sequencing studies.
- Invasive species monitoring.
- Cultivating limu in controlled environments like fishponds (loko iʻa) to study growth rates and optimize propagation.

References:

Abbott, I.A. (1962). Some Liagora-inhabiting species of Acrochaetium. Occasional Papers Bernice Pauahi

Abbott, I. A. (1996). Limu: An ethnobotanical study of some Hawaiian seaweeds. Pacific Science, 50(4), 343–361.

Abbott, I. A. (1999). Marine Red Algae of the Hawaiian Islands. Bishop Museum Press.

Algae in coral reefs. Link to dlnr. (n.d.). https://dlnr.hawaii.gov/holomua/algae-in-coral-reefs/

Huisman, J. M., Abbott, I. A., & Smith, C. M. (2007). Hawaiian reef plants.

IUCN 2025. The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org

Krauss, B. H. (1993). Plants in Hawaiian culture. University of Hawaii Press.

Lobban, C. S., & Harrison, P. J. (1994). Seaweed Ecology and Physiology. Cambridge University Press.

M.D. Guiry (n.d). AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. https://www.algaebase.org; searched on 13 December 2024.

McDermid, K. J., & Stuercke, B. (2003). Nutritional composition of edible Hawaiian seaweeds. Journal of Applied Phycology, 15(6), 513–524.

Sherwood, A. R., & Guiry, M. D. (2023). Inventory of the Seaweeds and Seagrasses of the Hawaiian Islands. Biology, 12(2), 215. https://doi.org/10.3390/biology12020215.

CHAPTER 8: IMPLEMENTATION, MONITORING, AND ADAPTIVE MANAGEMENT

IMPLEMENTATION OF HAWAIʻI'S SWAP

Global biodiversity is being lost at an unprecedented rate in human history, threatening ecosystem services, national economies, food security, and the well-being of societies. Island ecosystems are particularly vulnerable, and native ecosystems of the Hawaiian Islands are no exception. Over 60% of habitats have been destroyed or severely degraded, leading to the extinction of hundreds of species, with hundreds more at risk.

More than 6,000 species are identified in this Hawaii State Wildlife Action Plan (SWAP) as Species of Greatest Conservation Need (SGCN) and more than 500 hundred species are endangered or at risk of extinction. The threats facing these species, detailed in Chapter 4 of the SWAP, are numerous and widespread, affecting virtually every SGCN and native ecosystem type. The conservation lands identified in Chapter 6 for targeted conservation actions encompass over two million acres of public and private lands across the archipelago, including remote and rugged terrain. The extensive number of species, the range of interrelated threats, and scale and complexity of conservation lands pose significant logistical and financial challenges for effectively managing threats to biodiversity.

The effectiveness of conservation management varies depending on the biology and status of the species, the type and number of threats, the condition of the habitat, and the scale at which conservation actions are implemented. Some threats, such as ungulate control and fencing, can be addressed at relatively large spatial scales covering thousands of acres. Others, however, such as mammalian predators and invertebrate pests, can typically only be managed at small spatial scales, leading to exceedingly high per-unit costs. Still others are interrelated, requiring that management be done concurrently or sequentially. For most species, controlling a wide range of threats at multiple spatial scales is essential for preventing species extinction and achieving recovery goals.

Given current funding limitations, it is not currently feasible to manage all threats across all areas where SGCN exist. Therefore, conservation efforts must be guided by a strategic approach that optimizes cost-effective actions in essential habitats. Effective planning is critical to ensuring the protection and recovery of species and the ecosystems on which they depend. However, even the best plans can be difficult to implement when dealing with hundreds of at-risk species spanning plants, invertebrates, and vertebrates. Conservation planning is further complicated by novel threats, the accelerating effects of climate change, and limited financial resources. Thus, a conservation approach needs to include clear guidance for effective implementation.

The Maui Nui Landscape Conservation Plan

To address these challenges, the Hawaiʻi Department of Land and Natural Resources, in collaboration with a broad coalition of public and private agencies, organizations, landowners, and conservation experts, is developing an innovative approach to implementation planning for biodiversity conservation in Hawaii. Initially focused on Maui Nui, the Maui Nui Landscape Conservation Plan (MNLCP) provides a systematic, climate-resilient approach to landscape-scale conservation. It integrates species-specific recovery goals into spatially explicit, multi-species conservation areas while optimizing cost-effective actions to enhance biodiversity at both population and ecosystem scales.

The MNLCP advances conservation efforts by:

- Identifying species at risk in addition to those that are federally and state listed, using objective criteria based on population status.
- Aligning species recovery objectives with a geospatial framework to maximize overlap and complementarity of conservation actions.
- Defining the total reserve area needed to conserve all at-risk species.
- Identifying priority areas for species and ecosystem recovery.
- Determining the most effective conservation actions to implement first.
- Incorporating monitoring and adaptive management to refine conservation strategies over time.

This innovative approach provides a more spatially explicit, actionable framework to guide implementation of programs for the conservation of biodiversity through the development of analytical methods that enable managers to optimize selection of focal management areas and actions that yield the greatest conservation gains per cost. The approach is systematic, based on population ecology, suitable habitat, recovery targets, and ecosystem status. The framework is comprehensive, providing guidance to prevent extinctions and fully recover every species at risk and every major ecosystem type. The plan is integrative, covering all conservation partners and lands dedicated to or available for biodiversity management across Maui Nui. By optimizing the selection of multi-species conservation areas and mitigating priority threats at efficient scales, the MNLCP significantly improves conservation outcomes.

Key Strategies of the MNLCP

The MNLCP enhances conservation planning and implementation using four key strategies:

1. Spatial Planning for Species at Risk

Conservation managers face challenges in efficiently implementing landscape-scale recovery efforts due to the diverse threats impacting at-risk species. Effective conservation requires both population-level and landscape-scale interventions, while also addressing practical management constraints. The MNLCP employs a novel spatial conservation prioritization approach**,** emphasizing transparency, flexibility, and expert engagement in recovery planning for Maui Nui. Unlike conventional spatial conservation prioritization tools, this framework integrates:

- Habitat suitability models
- Population recovery targets
- Logistical advantages and constraints
- Biogeographical representation requirements

By applying the MNLCP methodology, managers can develop optimal spatial recovery plans that integrate species-specific recovery targets at local population scales into a comprehensive multispecies action plan. This approach enhances decision-making by preserving species-specific information, allowing managers to visualize and assess trade-offs, and adapting conservation actions to local contexts. Compared to single-species planning approaches, this framework enables substantial efficiency gains through complementary management while maintaining high-quality habitat selection.

2. Conservation Action Planning for Species at Risk

Spatial planning tools provide opportunities for species recovery, but successful implementation requires targeted actions to mitigate diverse threats. The effectiveness of these actions varies spatially and temporally, impacting costs and conservation outcomes. To ensure cost-effective use of limited resources, the MNLCP has developed cost-benefit analyses for species at risk**.** This analysis helps managers:

- Estimate the benefits per cost of conservation actions.
- Identify the most efficient recovery strategies.
- Optimize resources to maximize the number of species that benefit from threat abatement measures.

3. Ecosystem Planning for Biodiversity

With over 60% of native ecosystems degraded, their protection and restoration are critical for stabilizing SGCN and biodiversity. However, different ecosystems face unique threats, requiring tailored management approaches. The MNLCP improves conservation effectiveness by:

- Providing an updated assessment of the status of each major ecosystem type.
- Establishing conservation targets by ecosystem type to stabilize ecosystem function.
- Prioritizing restoration actions based on impact, spatial configuration, connectivity, feasibility, cost-effectiveness, and opportunity.

This systematic approach ensures that conservation actions are aligned with ecosystem restoration priorities and long-term biodiversity goals.

4. Monitoring and Adaptive Management

Robust monitoring and adaptive management are essential to evaluating conservation success, ensuring that actions achieve intended outcomes, and refining strategies as needed. The MNLCP provides managers with a structured system of performance metrics, including:

- Geospatially explicit recovery targets for each species at designated sites.
- Ecosystem-specific recovery targets tailored to conservation areas.
- Integrated monitoring frameworks that align with recovery and restoration objectives.

This data-driven approach allows managers to track progress, assess effectiveness, and adjust conservation efforts dynamically to improve outcomes.

Implementation and Future Expansion

While the full suite of MNLCP tools and applications is still in development—expected for completion in 2025—preliminary products are already guiding conservation efforts in Maui Nui. On Maui, conservation actions are being implemented using the MNLCP guidance to recover over 100 species at risk within 20 designated management units. Each site supports high numbers of at-risk species that share common threats, allowing managers to implement complementary threat abatement measures across multiple species efficiently. The methods and approach to implementation planning developed by the MNLCP are being developed for the rest of the Hawaiian Islands, further advancing statewide biodiversity conservation efforts.

While the planning tools described above will improve the cost effectiveness of conservation actions to implement this SWAP, a wide range of actions are currently in progress and will continue. As outlined in Chapters 5 and 6 in the discussion on current management of species and habitats, multiple partners in conservation are already taking actions that protect Hawai‘i’s Species of Greatest Conservation Need (SGCN) and to implement the SWAP. These efforts will be continued and enhanced where possible during implementation of the SWAP using a variety of funding sources.

In the coming years, the State Wildlife Grant (SWG) program will specifically fund projects to implement the following objectives:

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive:

- Forest bird habitat restoration on Maui;
- Development of predator-proof fencing to protect endangered land and tree snails on

O‘ahu; and
Seabird habitat management on Kaua‘i

2) Combat invasive species through a three-tierd approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication:
   - Predator control for O‘ahu ‘elepaio (*Chasiempis sandwichensis ibidis*) and seabirds on O‘ahu; and
   - Monitoring and control of remnant axis deer (*Axis axis*).

3) Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs:
   - Analysis of information from statewide forest bird surveys to determine population status and trends;
   - Endangered forest bird research and management on Maui, Kaua‘i, O‘ahu, and Hawai‘i;
   - Surveys for nest colony locations of ‘ua‘u and ‘a‘o;
   - Research on Blackburn's sphinx moth populations; and
   - Survey and monitoring of population status of, threats to, and the success of predator control efforts to protect native terrestrial snails on O‘ahu.

In addition, other sources of state and federal funding are being used to address all seven objectives in the next fiscal year. For example, the DLNR general fund budget supports management of existing NARs and watershed management projects, and the State Legislature included a line-item of 4 million dollars in the state budget for each of Fiscal Years 2015 and 2016 to address invasive species issues. Federal funds through grant programs administered by USFWS, NOAA, and U.S. Forest Service are used to protect habitat and control invasive species. A variety of funding sources are used to support research and outreach efforts. The successful partnerships and collaboration on SWAP projects will continue.

ADAPTIVE MANAGEMENT AND THE TEN-YEAR REVISION

Evaluation of Hawai‘i’s SWAP is linked to practicing adaptive management. Adaptive management results in effective monitoring and evaluation of the Strategy because it allows for structured learning by doing and altering strategies in response to changing circumstances (e.g., political, environmental, economic, etc.) to ensure success in achieving conservation objectives. It is also important to recognize that there are barriers to implementation that must be accounted for as part of adaptive management. Institutional barriers include the slow nature of changing policy and regulations, difficulties in getting conservation tools approved in a timely manner, and special interests preventing implementation of needed conservation actions.

As a part of the adaptive management process, the State DOFAW and DAR will conduct annual reviews to assess Hawai‘i’s SWAP program implementation and determine if any changes need to be made. This review will include identification of new or altered threats; review of recent surveys, data, and research; evaluation of the effectiveness of conservation actions; identification of urgent conservation actions needed for other taxa; and consideration of issues that are preventing implementation of the SWAP. This annual review will also include the annual process of determining priorities for using SWG funding. Because Hawai‘i’s list of SGCNs is broad and generally covers all native taxa, consideration of potential additions or removals to the list would be done during major reviews conducted at ten-year intervals (see below), unless the annual review process identified an imminent need. Review of progress and planning for implementation of conservation projects also occurs at partner-organization meetings. The island -based watershed

partnerships, invasive species committees, and statewide coordinating groups such as the Hawai‘i Invasive Species Council, Coordinating Group on Alien Pests, and Papahānaumokuākea Monument Management Board hold annual or more frequent meetings that discuss conservation project implementation, issues, and needs. DOFAW and DAR are members of these organizations and obtain valuable input through these collaborations. The SWAP website and partner contact database are additional tools that will be used to update and continue the engagement of partners in implementing, monitoring, and evaluating Hawai‘i’s SWAP.

Part of measuring the success of, and adaptively managing, Hawai‘i’s SWAP is represented by the formal ten-year revision. Each ten-year review and revision will be initiated by DLNR and will involve many of the same steps as were performed for this 2015 plan update, including comprehensively reviewing management plans and research, working closely with partners, and engaging the public to identify and incorporate new information. Ongoing monitoring and the annual reviews by DOFAW and DAR also will assist in identifying necessary revisions. The major ten-year revision should start in 2024, at least 18 months before deadline, beginning with an internal review and continuing with an outreach effort and solicitation of input from agencies, conservation partners, technical experts, and the public during the course of the 18 month review. This review will consist of analyzing the strengths and weaknesses of the SWAP, identifying barriers that prevented successful implementation, updating species and habitat information, assessing and updating the primary threats, evaluating the continued viability of the identified conservation objectives and strategies, and conducting outreach for ideas and input from partners, interested parties and public. To solicit public input on the revision, a series of public scoping meetings will be held on each island early in the 18-month process, to get the word out that the plan is being updated, and give stakeholders, conservation partners, agencies and the public ample time to review, participate in the process and provide input. The draft plan will be posted on the website and made available for public review for 60 days. The 2025 ten- year revision will provide the opportunity for continued adaptive management to ensure preservation of Hawai‘i’s SGCNs and native habitats and to expand the vision of malama ‘āina (protecting the land) for future generations.

MONITORING

The need for monitoring is a consistent theme throughout Hawai‘i’s State Wildlife Action Plan (SWAP) and is referenced in several previous chapters (Chapters 4, 5, 6, and 7). Chapter 8 addresses monitoring specifically in the following ways: it provides a summary of current monitoring efforts at both the taxa and habitat levels; it outlines monitoring needs and recommendations; and it discusses the implementation, monitoring, and evaluation of statewide conservation objectives as defined in Chapter 4. It also outlines processes for the next ten-year revision of the SWAP. In doing so, this chapter addresses required elements 5, 6, and 7.

PURPOSE AND VALUE OF MONITORING

A well planned and executed monitoring program is key to the success of conservation efforts, especially in light of the scarcity of personnel and funds needed to protect and recover native wildlife resources in Hawai‘i. Monitoring programs are essential to guide plans and implement adaptive changes to those plans, and for management and recovery programs to be most cost-effective and achieve their goals. Monitoring does this by providing ways to track population trends, to assess threats and limiting factors, and to evaluate progress of actions to improve native wildlife status. Monitoring programs are also tools with which to communicate conservation achievements, helping to develop support for conservation actions with decision-

makers such as legislators, funding organizations, non-profit organizations, and the general public.

CURRENT ASSESSMENT OF MONITORING

Monitoring is integral to most existing conservation programs and partnerships in Hawai‘i. Monitoring protocols are varied and depend upon the nature of the resource being monitored, set objectives and goals, and staff and funding capabilities and commitments. This assessment distinguishes between taxa-based programs and habitat-based programs and identifies the current monitoring programs and plans that are in place.

SUMMARY OF MONITORING EFFORTS AND CHALLENGES IN THE STATE

Monitoring in Hawai‘i is conducted at multiple scales by various entities and at differing LEVELS of frequency and quality. Monitoring, both at the taxa and habitat levels, is conducted by state and federal agencies. Examples include monitoring of state and federal fisheries, the statewide waterbird surveys, and the Forest Bird Surveys. Monitoring of taxa and habitats by state and federal agencies also occurs on a program or area specific level and often as part of the management plan for managed areas. Examples include monitoring in Natural Area Reserves (NARs), State Wildlife Sanctuaries and Marine Refuges, National Parks, National Wildlife Refuges (NWRs), military lands, marine managed areas, the National Marine Sanctuary, the Papahānaumokuākea Marine National Monument, and the Coral Reef Ecosystem Reserve. Private landowners involved with conservation also conduct monitoring on their lands. Examples include private preserves managed by The Nature Conservancy (TNC) of Hawai‘i and Maui Land and Pineapple, Inc. Additionally, private landowners conduct monitoring when participating in conservation programs such as the State’s Landowner Incentive Program and federal landowner assistance programs managed by the Natural Resources Conservation Service and the U.S. Fish and Wildlife Service (USFWS). Public-private partnerships such as the watershed partnerships also conduct monitoring. All of these areas are considered managed lands. Additionally, monitoring is conducted by academic researchers as well as organizations such as the island invasive species committees.

Species-specific monitoring in the state generally takes place as a part of implementing USFWS and National Marine Fisheries Service recovery plans for endangered species or as part of management plans for both listed and non-listed species (usually for state, federal, private, and public-private partnership lands and waters mentioned previously). Often, these plans are developed for five to ten year cycles, with evaluation points for assessments and adaptive management purposes. Species-specific monitoring is also done by private landowners, companies, or permit holders as part of meeting the requirements of applicable habitat conservation plans or safe harbor agreements.

Finally, there are also citizen monitoring programs. Examples include the Hawai‘i Audubon Society, which has conducted annual Christmas bird counts on O‘ahu, Kaua‘i, Maui, Hawai‘i, Midway, Laysan, and French Frigate Shoals, the yearly whale counts conducted by the Hawaiian Islands Humpback Whale National Marine Sanctuary and the Pacific Whale Foundation during the months of January-March, and the monitoring of reef fishes by Reefcheck.

The State has several tools and resources available to assist with monitoring. Examples include databases and information warehouses such as the Hawai‘i Biodiversity and Mapping Program and the Pacific Basin Information Node. There are also inter-agency efforts, such as the Western

Pacific Fisheries Information Network, the Coral Reef Information Service, and the U.S. Geological Service's (USGS's) Hawai‘i Forest Bird Interagency Database Project, which analyzes information collected during yearly forest bird surveys to determine conservation needs of these species.

The challenges facing implementation of effective monitoring are similar to those challenges faced in implementing conservation actions as discussed in Chapter 4: inadequate funds, lack of trained personnel to carry out monitoring, requirements for advanced technical expertise for identification of many invertebrate taxa, insufficient tools for monitoring (e.g., practical or standardized monitoring protocols and equipment), inability to use the information collected (e.g., survey forms or collected data are never entered into a database for later data analysis), and gaps in information sharing. The biggest challenges are to design precise and efficient monitoring programs to best measure the outcomes of conservation actions and progress toward recovery goal and to have adaptive management respected and funded at a level commensurate with it's importance to conservation. For example, while monitoring relatively populous species can be fairly straightforward, the cost and difficulty of monitoring rare or highly fluctuating populations presents difficult trade-offs between money applied toward gaining precise knowledge of population status and money needed for species and habitat improvement or restoration.

TAXON MONITORING

Most monitoring in the state consists of counting individuals and reproductive success. For many taxa, appropriate monitoring programs are specified in recovery or management plans. The level of detail of management recommendations provided in the plans varies among taxa. The following outlines existing monitoring efforts and resources for taxa as well as identifies gaps and needs.

Terrestrial Mammal

The ʻōpeʻapeʻa (*Lasiurus cinereus semotus* [Hawaiian hoary bat]) is the only land mammal native to the Hawaiian archipelago. The USFWS recovery plan for the bat was developed in 1998 and outlines the monitoring requirements for this species. Specific recommendations center on the need for island-wide surveys and monitoring to determine bat population levels and distribution, as well as associated key habitats and potential threats affecting populations. USGS has been conducting systematic acoustic monitoring on Hawai‘i for five years and collected bat occupancy data at study sites by season and across annual cycles. Acoustic monitoring with similar goals is underway on Maui, Kaua‘i, and O‘ahu, with the intent to obtain data on seasonal and annual patterns of bat habitat use. The wide range of habitat and the limited technology available to detect bat presence makes monitoring this species difficult. USGS is currently coordinating Hawaiian bat research efforts with USFWS, the Division of Forestry and Wildlife (DOFAW), the U.S. Department of Defense, the National Park Service (NPS), private landowners, and the forest products industry to improve monitoring of this species.

Forest Birds

Hawai‘i's native forest birds are perhaps the best monitored species in the state. However, monitoring efforts for even these species could be improved, particularly life history monitoring for specific species. Standardized forest bird surveys have been conducted annually since 1976 by agencies and private landowners including the DOFAW, USFWS, NPS, the NWRs, Kamehameha School, and TNC of Hawai‘i. Additionally, monitoring is guided by the USFWS Revised Recovery Plan for Hawaiian Forest Birds, which includes five-year implementation

plans identifying monitoring needs for identified critical species. Elements of monitoring from these plans are conducted by USFWS, DOFAW, and their partners; however, the full range of monitoring recommendations has yet to be implemented. Refinement of species-specific survey protocols is needed to provide managers with the best possible information, such as how best to survey the Maui parrotbill (*Pseudonestor xanthophrys*).

For non-endangered forest birds such as ʻiʻiwi (*Vestiaria coccinea*), ʻapapane (*Himatione sanguinea*), and ʻamakihi (*Hemignathus virens*), monitoring occurs during the forest bird surveys and during monitoring conducted on managed lands. Significant monitoring can be focused on assessing the trend status of birds targeted for listing (i.e., the i'iwi). For the more common birds, their potential dispersal in lower elevations may require different monitoring protocols. There are no wild populations of ʻalalā (*Corvus hawaiiensis* [Hawaiian crow])—all existing populations are in captive propagation facilities, which are closely monitored by staff. Monitoring protocols for the release of ʻalalā into the wild have been developed and will be used for planned releases in 2016.

Raptors

There is no systematic island-wide monitoring for pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]). Population assessments are based on surveys conducted on an opportunistic or piece-meal basis, such as research surveys by graduate students, surveys of species on various managed lands, and Hawaiʻi Audubon counts. USFWS conducted intensive monitoring for ʻio (*Buteo solitarius* [Hawaiian hawk]) during 2007 and found that the population has been stable for at least 20 years and occupies 59 percent of the island. USFWS proposed that the ʻio be delisted and has developed a post-delisting monitoring plan for the species. That plan will involve island-wide variable circular-plot surveys, employing playback recordings, and conducted every five years if implemented.

Waterbirds

All endemic Hawaiian waterbirds are the subject of USFWS recovery plans that outline monitoring needs and actions. A draft recovery plan and conservation action plan for the nēnē (*Branta sandvicensis* [Hawaiian goose]) (USFWS 2004, 2012) discusses monitoring and identifies the need to standardize monitoring protocols and share data. Monitoring methods also are provided in the 2011 *Revised Recovery Plan for Hawaiian Waterbirds,* addressing the monitoring needs of koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ʻalae ʻula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), ʻalae keʻokeʻ (*Fulica alai* [Hawaiian coot]), and aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]). DOFAW conducts twice-annual statewide waterbird surveys, covering both private and public land, that include these species as well as the ʻaukuʻu (*Nycticorax nycticorax* [black-crowned night-heron]). Additionally, these species are monitored on various managed lands such as NWRs, military special management areas, and State Wildlife Sanctuaries as part of ongoing management or as part of research. Although the twice-annual waterbird count conducted by DOFAW is considered the best tool available for estimating relative abundance of waterbirds, it could be improved with greater standardization and consistency among islands. Areas that need attention include identification of koloa maoli, mallards, and hybrids; greater consistency in coverage of wetlands each year; development of more accurate methods of surveying ʻalae ʻula (such as using playbacks); and coverage of montane stream habitats to better detect koloa maoli populations.

Seabirds

The majority of Hawai‘i’s seabird populations are in the Northwestern Hawaiian Islands. Monitoring of these species is conducted by USFWS at Midway, Laysan, and French Frigate Shoals and by DOFAW at Kure Atoll. Extensive work is being done to control and eradicate invasive weeds and increase monitoring capacity at Kure. Banding and monitoring of seabirds is an element of the natural resources science plan for Papahānaumokuākea Marine National Monument.

In the Main Hawaiian Islands, seabirds nest mostly on offshore islands and islets. Monitoring of these populations is conducted on some islands by DOFAW as well as by an interagency organization. Seabirds also are monitored in known nesting areas on managed lands, and through DOFAW’s twice-annual statewide waterbird surveys. Monitoring during the nesting season occurs at seabird management sites on the main islands, such as within the predator-proof area at Kaena Point NAR, on O‘ahu, and in managed colonies of ‘a‘o (*Puffinus newelli* [Newell’s shearwater]) on Kaua‘i, where monitoring is conducted by the Kaua‘i Endangered Seabird Recovery Project (KESRP). KESRP annually monitors known Newell’s shearwater and ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]) breeding burrows in remote locations on Kaua‘i, bands adults and juveniles, and collects data on fledging success rates, reasons for failure, and site fidelity. KESRP continues using radar to survey seabird numbers and estimate attendance at nesting colonies and is gathering acoustic information near ‘a‘o and ‘ua‘u colonies by deploying field data loggers. Also, the USFWS Refuges program monitors seabirds at Kilauea Point NWR where a 3-hectare (8-acre) predator exclusion fence was installed in 2014 to protect native plants and habitat and encourage seabird recovery efforts. DOFAW has also developed a monitoring program to protect and manage the ‘ua‘u colony on Lana‘ihale, which was rediscovered as an important ‘ua‘u breeding site in 2006.

Citizen monitoring occurs via the Hawai‘i Audubon counts throughout the state and at the Freeman Seabird Preserve on O‘ahu. Lastly, USFWS has developed the *Seabird Conservation Plan—Pacific Region* that details monitoring needs at a larger scale and addresses inter-state and international levels of monitoring.

Migratory Shorebirds and Waterfowl

Regular migrants are monitored under existing programs already mentioned for other avian species groups. Examples include DOFAW’s twice-annual statewide waterbird surveys, Hawai‘i Audubon counts, and monitoring on various managed lands. The DOFAW statewide waterbird surveys protocol was revised in 2005 to improve its utility for monitoring populations of migratory shorebirds. Additionally, USFWS’s *Seabird Conservation Plan—Pacific Region* details monitoring needs at a larger scale, including inter-state and international levels.

Northwestern Hawaiian Islands Passerines and Waterbird

Given the small population levels and restricted range of these species, monitoring is intensively conducted by USFWS through the NWR system, and on Kure Atoll by DOFAW. Monitoring programs were developed and implemented in association with translocation programs for Laysan duck (*Anas laysanensis*) and the Nihoa millerbird (*Acrocephalus familiaris kingi*). The USFWS *Revised Recovery Plan for the Laysan Duck* (2009) identifies the monitoring protocol. Monitoring in association with the translocations is ongoing.

Terrestrial Invertebrates

In contrast to the limited, but relatively consistent monitoring of terrestrial vertebrates, terrestrial

invertebrate populations are not adequately monitored. Limited baseline densities have been obtained for some taxa in a few locations. As an offshoot of the 2005 Comprehensive Wildlife Conservation Strategy, DOFAW and conservation partners developed an Invertebrate Conservation Strategy (ICS) in 2009 and identified conservation needs for species and habitats across the state. ICS member parties conducted one-day "bioblitz" surveys of invertebrate fauna at select conservation areas in the state in 2010 and 2011. In 2011, DOFAW funded the development of a statewide invertebrate database to be managed by Bishop Museum. DOFAW also created a Snail Extinction Prevention (SEP) program in partnership with USFWS to protect imperiled snail fauna. As part of the SEP program, DOFAW conducts monitoring, predator abatement, and habitat protection for snails facing extinction.

Inventories of some areas have been conducted by the Bishop Museum. Also, some surveys and monitoring have been conducted for certain threatened and endangered species on Department of Defense lands; at TNC's preserves; in certain DOFAW NARs, Forest Reserves, and Wildlife Sanctuaries; and on National Park and NWR lands. DOFAW has conducted surveys and monitoring for Blackburn's sphinx moth (*Manduca blackburni*) at Puʻu Waʻawaʻa and Puʻu Anahulu on Hawaiʻi island. Surveyors looked for eggs and larvae and documented host plant use to estimate the density and distribution of *M. blackburni* and develop survey methods that may be applied elsewhere in the state. DOFAW invertebrate biologists also conducted surveys for yellow-faced bees (*Hylaeus* spp.) on lands adjacent to military installations on Oʻahu and Hawaiʻi. Staff with the SEP program have begun monitoring tree and land snails in protected predator-proof exclosures in the Koʻolau and Waiʻanae Mountains on Oʻahu. Additionally, TNC monitors snail populations in its preserves. Surveys also are conducted by academic researchers, whose data could be incorporated into the statewide invertebrate database as a requirement of collecting permits.

USFWS draft recovery plans discuss the monitoring needs of Oʻahu tree snails (*Achatinella* spp.), Blackburn's sphinx moth, and the Kauaʻi cave arthropods (*Adelocosa anops* and *Spelaeorchestia koloana*). The challenge of adequately monitoring terrestrial invertebrates lies in the sheer number of species (over 5,000) that exist in Hawaiʻi, the fact that these species are quite small (averaging less than 5 millimeters in size), and the limited number of people who are trained to identify these species.

Plants and Algae

Systematic monitoring of rare plant populations occurs in selected management areas such as Forest Reserves, NARs, National Parks, NWRs, TNC preserves, and other protected areas. No systematic statewide monitoring occurs for these species. Various land managers individually monitor the status of the plants on their lands. In highly managed areas, the existence and condition of rare plants may be well known (e.g., if rare plants are identified within fenced enclosures in an NAR or Forest Reserve or within Special Ecological Units in a National Park). For more remote or less actively managed areas under protection (e.g., many Forest Reserves), historical surveys may indicate the previous existence of rare plants, but information on their current status is limited. Finally, information regarding rare plant distribution or abundance is not always shared with the Hawaiʻi Biodiversity and Mapping Program and may remain solely within the control of a landowner or land management agency.

USFWS has established a Hawaiʻi and Pacific Plants Recovery Coordinating Committee, which recently completed a third draft of an Integrated Plan for the Conservation of Hawaiʻi's Unique

Plants and Their Ecosystems. This draft plan recognizes the importance of monitoring to rare plant conservation and identifies areas needing further field surveys to determine the current status of rare plants, totaling approximately 13 percent of the state (202,000 hectares or 500,000 acres). Marine algae are systematically monitored in the Northwestern Hawaiian Islands by the National Oceanic and Atmospheric Administration (NOAA). Other marine plants or freshwater algae would be surveyed in association with preparation of an environmental assessment or other requirement for project development.

Freshwater Species

The State Division of Aquatic Resources (DAR), Department of Land and Natural Resources (DLNR) Water Commission, NPS, and the University of Hawai‘i conducted comprehensive surveys of 376 perennial streams across Hawai‘i for the Hawai‘i Stream Assessment Project (Commission on Water Resources Management 1990). The assessment collected data on presence of native species and evaluated the stream for developed a database on stream condition that is maintain and used today for monitoring stream conditions. In its monitoring program, DAR collects information on native and non-native species of fish, crustaceans, mollusks, insects, and algae and enters it into the database. Stream assessments are done on an individual project basis to evaluate impacts of project developments and do not occur statewide on a regular basis. DAR continues to maintain the stream assessment database. These data are used in monitoring, assessing, managing, and protecting the freshwater aquatic resources of the state. Techniques used include point quadrat count method, drift sampling, larval trapping, and other scientific surveys (insects, algae) by other institutions or organizations. There is no systematic statewide survey of freshwater species.

Anchialine Pond Fauna

Hawai‘i has a large number of anchialine ponds, but very few (such as at ‘Āhihi-Kīna‘u, Maui, and Lua o Palahemo, Hawai‘i) have been systematically surveyed. Threats to anchialine pool ecosystems include changes in water quality and quantity because of groundwater withdrawal, accidental and deliberate introduction of non-indigenous species including alien plants, fish, arthropods, and molluscs, and historical loss of pool complexes following coastal resort development. USFWS and NPS have identified anchialine pools as priority ecosystems in need of research to better understand the habitat requirements of endemic pool biota and how they will respond to current and future changes in pool ecosystems. USGS is conducting surveys of anchialine pools, focusing primarily on three national parks on Hawai‘i island with significant pool resources: Hawai‘i Volcanoes, Kaloko-Honokōau, and Pu‘uhonua o Hōaunau. Information collected includes physical and biological habitat characteristics and the relative densities of rare anchialine pool invertebrates at individual pools. Assessments of many anchialine pond fauna and habitat have occurred over the years, but no systematic monitoring takes place.

Marine Species

Routine marine monitoring has been a component of DAR’s activities for over 50 years. Early efforts concentrated on using in-water visual assessments to measure resource fish stocks and changes to those stocks within marine protected areas and at artificial reef sites. For the past 15 to 20 years, efforts have been made to improve upon research methods, increase the frequency of surveys, expand the number of areas covered by assessments, and study changes associated with new management initiatives. Current efforts are focused on annual assessments of coral reef ecosystems across a range of management areas. Surveys document the abundance of resource fish and herbivorous fish, smaller cryptic fish and recruits, urchins and larger mobile

invertebrates, benthic habitat cover, coral health, and biological diversity. Sea turtle nesting and monk seal pupping are monitored by NOAA. The Hawaiian Islands Humpback Whale National Marine Sanctuary is responsible for long-term monitoring of humpback whales in Hawai‘i. NOAA and the Western Pacific Fisheries Management Council monitor commercial fisheries species. DAR, NOAA, and USFWS monitor resources in the Papahānaumokuākea Marine National Monument. DAR monitors fishes in Marine Life Conservation Districts, Fishery Management Areas, and Fish Replenishment Areas where the aquarium fishery and other fishing activity is closely monitored and regulated. DAR conducts statewide creel surveys of gamefish harvest by recreational and commercial fishers. Species- specific programs are in place for ulua (*Caranx* spp.), bottomfish, and precious corals. Reefcheck and other volunteer organizations gather data on reef fishes. The Hawai‘i Institute of Marine Biology (HIMB) routinely monitors reefs and marine habitats in Kāne‘ohe Bay, Oah‘u, and conducts research in Papahānaumokuākea Marine National Monument. No systematic surveys are conducted for non-commercially regulated marine invertebrates or deep water species.

HABITAT MONITORING

The underlying philosophy of habitat monitoring is to preserve native habitats and monitor for area coverage and intactness. Monitoring of the ten terrestrial habitat types outlined in Chapter 3 is conducted on managed lands through existing management plans for these areas. Most management entities monitor habitat as it relates to native habitat preservation and restoration, rare plant management, threats such as encroachment by invasive species (e.g., plants, mammalian predators, or ungulates) or wildfire risks, and management actions such as ungulate removal and fencing; also, some monitoring of invasive invertebrates has begun. Additionally, habitat monitoring relates to species-specific needs as outlined in USFWS recovery plans. Managed areas with existing management plans and monitoring efforts are discussed in Chapters 5 and 6 in the Management Needs sections.

For monitoring habitats that are outside state lands, and not in managed areas or addressed by recovery plans, the land coverage analysis developed by the Hawai‘i Gap Analysis Program (HI-GAP) will be a helpful tool. However, monitoring gaps will still exist for habitats such as streams, lava tube and cave systems, and anchialine ponds, because these are not easily identified by HI-GAP due to technological limitations.

DAR monitors selected stream areas and lakes while the State Department of Health and the U.S. Environmental Protection Agency monitor water quality. NOAA monitors coral reefs in the Northwestern Hawaiian Islands and collaborates with DAR to monitor less accessible areas of the Main Hawaiian Islands. DAR monitors many coral reef areas in the Main Hawaiian Islands. The Coral Reef Assessment and Monitoring Program, a multi-agency and University of Hawai‘i collaboration, monitors other coral reef areas. NOAA and the Western Pacific Regional Fisheries Management Council regulate and monitor Essential Fish Habitat for managed commercial fisheries. NOAA’s National Estuarine Research Reserve (NERR) System is in the process of designating a NERR in the He‘eia estuary in Kāne‘ohe. HIMB will be conducting and coordinating monitoring at that site. Funding will become available for monitoring once the site is officially designated by NOAA. Currently, there is no monitoring of estuaries, sandy bottoms, and pelagic habitats. Additional habitat monitoring efforts include systematic invasive species monitoring conducted by the invasive species committees and watershed partnerships on each island for targeted species. Individual project-based monitoring is conducted in connection with various other work, such as the vegetation monitoring conducted along forest bird survey

transects.

MONITORING NEEDS AND RECOMMENDATIONS

Though Hawai‘i has a foundation for monitoring of species and habitats, this foundation needs to be expanded by strengthening existing efforts and developing new ones. Specific monitoring needs are identified at the taxa level in Chapter 7 and at the habitat level in Chapters 5 and 6 in the Management Needs sections. Additionally, monitoring needs are outlined in Chapter 4 in the Threats and Statewide Objectives and Strategies sections.

This section addresses specific monitoring gaps for species groupings as well as statewide initiatives. Where new efforts are required, the approach will be to focus on relevant, realistic, and effective monitoring and evaluation that is cost-effective, sustainable, and has minimal adverse impacts on native ecosystems. The recommendations are discussed below.

DEVELOP MONITORING WORKING GROUPS

The establishment of statewide monitoring working groups for different species, habitats, or threats will help to facilitate the development and implementation of needed monitoring actions. These working groups will provide expert advice to guide monitoring of species and habitats in the state. The working groups will help identify monitoring gaps, prioritize needs, develop strategies and recommended actions to address monitoring issues, and guide implementation of monitoring actions.

IMPROVE MONITORING FOR ALL TAXA

The following monitoring needs, based on species groupings, are listed in order from the groups that are not systematically monitored to those needing improved monitoring efforts.

- Most invertebrate populations are neither well-characterized nor adequately monitored. Coordinated efforts are needed to develop and implement plans to increase inventory and monitoring statewide. Taxa requiring these efforts include terrestrial arthropods, land and tree snails, anchialine pond species, non-coral and non-regulated marine invertebrates, and deep water coral species. For host-specific terrestrial invertebrates, rare plant surveys are necessary. For land and tree snails, information is needed on the status and distribution of populations and occurrences of predators.
- For freshwater fishes and aquatic invertebrates, systematic monitoring needs to be expanded to all important watersheds and areas.
- For plants, coordination of different efforts and development of survey priorities is needed.
- For anchialine pond fauna, monitoring of populations and distribution in known and likely habitats should continue as well as development of quantitative survey methods and methods to monitor associated interstitial and hypogeal habitats.
- For the ‘ōpe‘ape‘a, established methods and protocols for larger-scale monitoring of bat populations, and for detecting the presence of roosting individuals in thick vegetation, are needed.
- For avian species, improvements are needed to expand the scope and frequency of monitoring, data management and analysis, and reporting (e.g., needs include demographic data for constructing population models and reproductive data for determining greatest threats to productivity).

- For migratory species such as shorebirds, marine mammals, marine reptiles, and seabirds, monitoring needs to be coordinated at regional and international levels.

Development of standardized survey methods, particularly for inadequately monitored species, should explore the use of cost-effective partnerships with landowners, volunteers, and citizen monitoring programs, such as the Audubon Christmas bird count, community-based monitoring in marine areas, and educational programs.

IMPROVE MONITORING FOR ALL HABITATS

Priority habitat monitoring needs are to support monitoring efforts already underway, to identify additional informational needs, and to expand resources for increased monitoring at appropriate geographic and spatial levels. Additionally, for habitats in less-managed areas, mechanisms need to be identified to monitor the quantity and quality of these habitats and the importance of these habitats to species' survival. Other habitats that need consistent monitoring include anchialine pools, tide pools, sandy bottom habitats, and deep water habitats. Monitoring of land use adjacent to stream channels is also needed.

IMPROVE ECOSYSTEM MONITORING

One goal for managers is to go beyond post-hoc monitoring towards ecological prediction and forecasting. Though most monitoring is conducted on a species and habitat level, some additional monitoring occurs for abiotic factors and the emergent properties of ecosystems. More attention needs to be focused on these levels, integrating information from different sources to evaluate trends and assess threats or conservation actions. For example, comprehensive habitat monitoring will need to consider integration of indicators of global climate change. Similarly, the use of remote sensing and indicators of ecosystem properties needs to be better utilized. For terrestrial monitoring, a related issue of improving integration of monitoring is encouraging the use of inter-disciplinary teams in fieldwork (e.g., including botanists and entomologists during forest bird surveys).

DEVELOP STANDARDIZED MONITORING PROTOCOLS

Due to insufficient coordination, non-standardized monitoring efforts exist that affect comparisons among sites and the ability to estimate the size and trend of species' abundance. There is a lack of appropriate data management at appropriate geographic scales, and monitoring at the island and statewide levels is typically non-existent and a critical gap. The first step is to develop standardized monitoring protocols that will allow data collected by researchers, managers, and landowners to analyze island and statewide trends. Existing efforts that can assist this process (but need additional coordination) are the recently developed Inventory and Monitoring program developed by NPS, Pacific Basin Information Node, Hawai‘i Forest Bird Interagency Database Project, the Hawai‘i Biodiversity and Mapping Program, and HI-GAP. Nationwide initiatives such as the USGS monitoring locator and protocols library can help provide information on monitoring and inventorying protocols. Managers and researchers from state and federal agencies and the private sector are working together to standardize survey and monitoring techniques for the Hawaiian hoary bat. The establishment of a statewide monitoring working group will facilitate the development of this initiative.

FACILITATE INFORMATION SHARING STATEWIDE

Effective monitoring of species or habitats often requires cooperation between adjacent landowners to determine what is happening to the population without regard to property boundaries. Support and participation in existing forums, such as the Hawai‘i Conservation

Conference, annual coral reef conference, and meetings of the Hawai‘i Association of Watershed Partnerships, and the development of new forums on specific topics as needed, provide opportunities for the sharing of information and enhance the ability for adaptive management.

One major need is for better sharing and accessibility of data sets across the state for all taxa. Much data is being collected by individual land managers and not necessarily going into a centralized data set as part of a statewide program. The state needs a central depository to which anyone can gain access, either for providing data or for viewing and using data. Such a tool would enable managers to obtain relevant data on species of interest, enabling better-informed decisions and further promoting the sharing of information and tools.

Bibliography:

Coordinated Bird Monitoring Working Group of the International Association of Fish and Wildlife Agencies. 2004. Monitoring Avian Conservation: Rationale, Design, and Coordination.

Commission on Water Resources Management. 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii's Stream Resources. Hawaii Department of Land and Natural Resources. Honolulu.

Dresler P. General concepts for a monitoring program. US Geological Service.

East Maui Watershed Partnership 2005. Draft East Maui Watershed monitoring review and recommendations.

Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources. 2015. Streams Survey Data and freshwater database. http://dlnr.hawaii.gov/dar/habitat/streams/survey-data/ (accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communications with staff. 2005.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Snail extinction prevention program. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/sep/ (Accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Blackburn's Sphinx moth project. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/projects/ (accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Yellow-Faced Bee Survey Project. Available at: http:ellow-faced bee survey project. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/projects/yellow-faced-bee/ (Accessed June 30 2015).

Holthausen, et al. Principal findings of the Forest Service strategic monitoring committee for wildlife populations and habitats. U.S. Forest Service.

International Association of Fish and Wildlife Agencies. 2005. Comprehensive wildlife conservation strategies: monitoring strategies.

Teaming with Wildlife. State wildlife strategy drafts and outline. Available at: http://www.teaming.com/cwcs_drafts.htm (last accessed 4 August 2005).

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2006. Revised recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service. 622 pp.

U.S. Fish and Wildlife Service. 2008. Draft Post-Delisting monitoring plan for the Hawaiian hawk, or Io (Buteo solitaries). Available at: http://www.fws.gov/pacificislands/CH_Rules/HawaiianhawkdraftPDMPlan%20December%202008%20-%20approved%20by%20RO.pdf (Accessed June 30, 2015)

and evaluation.

Jacobi J. 2005. Preliminary draft overview of species and habitat monitoring. U.S. Geological Survey.

Margoluis R, Salafsky N. 1998. Measures of success: designing, managing, and monitoring conservation and development projects. Washington DC: Island Press.

National Park Service. Inventory and monitoring program. Available at: http://science.nature.nps.gov/im/monitor/index.htm.

Pacific Basin Information Node. Available at: http://pbin.nbii.gov/.

Salafsky N, et al. 2003. Draft conventions for defining, naming, measuring, combining, and mapping threats in conservation: an initial proposal for a standard system.

Schoonmaker P, Luscome W. 2005. Habitat monitoring: an approach for reporting status and trends for state comprehensive wildlife conservation

GLOSSARY

Ahupua'a: land division usually extending from the uplands to the sea, so called because the boundary was marked by a heap (*ahu*) of stones surmounted by the image of a pig (*pua'a*), or because the pig or other tribute was laid on the altar as a tax to the chief.

Ballast Water: water carried in ballast tanks in the hold of ships to help keep the ship stable. Water is usually discharged and taken up in port, which can facilitate the spread of invasive species.

Biological Diversity or Biodiversity: the variety of all biological life – plants, animals, fungi, and microorganism – and the ecosystems on land or in water where they live; the diversity of life on earth or in a particular location.

Biological Integrity: defined by the Environmental Protection Agency as "the ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region."

Congener: belonging to the same genus.

Conspecific: belonging to the same species.

Critical Habitat: term defined in the Endangered Species Act. Critical habitat is defined as (1) the specific areas within the geographic area occupied by a species at the time it is listed, on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations and (2) specific areas outside the geographical area occupied by the species at the time it is listed upon a determination that such areas are essential for the conservation of the species. Section 7 of the Endangered Species Act prohibits the destruction or adverse modification of critical habitat with regard to actions carried out, funded, or authorized by a Federal agency.

Depredate: prey on.

Ecosystem: an ecological unit that is composed of interacting organisms in their environment.

Endemic: adjective or noun used to describe species found only within a specified region or locality and thus unique to that area.

Epiphytes: a plant growing on another plant for support or anchorage rather than for water or nutrients.

Euryhaline: adjective indicating ability to tolerate a large range of salinities.

Eutrophication: water pollution caused by excessive nutrients that stimulate excessive plant growth.

Extant: alive, existing, not extinct.

Extirpate: not existing, extinct, wipe out or destroy completely.

Feral: adjective used to describe domesticated animal that has reverted to an untamed state.

Habitat: the area or type of environment where an organism or a biological population lives or occurs.

Holotype: the single specimen for which a species is named and described.

Hull Fouling: the attachment and/or colonization of ship hulls by organisms such as barnacles and mussels; can be a major vector for invasive species introduction.

Hypogeal: underground. Used to describe the underground, water-filled spaces where anchialine fauna live in addition to anchialine ponds.

Indigenous: species that occur naturally in a particular area (e.g., not introduced by humans or human activity). All endemic species are considered indigenous species; however, the term "indigenous" is sometimes used to describe native species that are not endemic or whose endemic status is unknown.

Interstitial: space between structures. Used to refer to the spaces where anchialine fauna are found in the hypogeal environment.

Introduced Species: species that do not arrive into ecosystems through natural means (e.g., air, wind, water, animals), but through human-assisted activities. The terms "alien," "non-native," or "exotic" species may also be used interchangeably with introduced species.

Invasive Species: an animal pest or weed that negatively impacts indigenous species and ecosystems.

Kūpuna: grandparent, ancestor, relative or close friend of the grandparent's generation, grandaunt, granduncle.

Loʻi: irrigated terrace, especially for taro, but also for rice: paddy.

Maui Nui: the islands of Molokaʻi, Lānaʻi, Maui, and Kahoʻolawe.

Native: species that occur naturally in a particular area (e.g., not introduced by humans or human activity). The term "native" is commonly used to describe both endemic and non-endemic indigenous species.

Niche: the function or role of an organism in an ecosystem or the habitat an organism occupies in the ecosystem.

Non-Point Source Pollution: water pollution that comes from many diffuse sources rather than from a specific point, such as an outfall pipe, and is often the result of human activities.

Phenology: temporal aspects of a species' biology (e.g., timing of a species' reproductive cycle).

Philopatry: the characteristic of remaining near or returning to a particular area (e.g., natal territory). Used to describe species that tend to remain in, or return to, their home area.

Phytophagous: same as herbivorous (plant eating), but often associated with insects that pierce and suck liquids from plants.

Phytoremediation: the process of cleaning up pollutants especially in water or soil using plants.

PEPP: Plant Extinction Prevention (PEP) Program

Point Source Pollution: pollution from any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including, (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels.

Precocial: offspring that exhibit a high level of independent activity from hatching. Usually applies to birds or mammals.

Recovery Habitat: term used by the U.S. Fish and Wildlife Service for areas identified in Recovery Plans and determined to be necessary for long-term survival and recovery of endangered species.

Shield Volcano: defined by the U.S. Geological Service to refer to volcanoes with broad, gentle slopes, built by the eruption of fluid basalt lava.

Species: a group of closely related, interbreeding organisms that produce fertile offspring.

Stochastic: unpredictable or by chance.

Subsidence: the downward movement of the earth's surface in relation to a reference point such as sea level.

Taxa (plural of taxon): groupings of organisms given formal taxonomic names such as species, genus, family, etc.

Ungulates: hooved animals such as cattle, goats, deer, sheep, and pigs.

BIBLIOGRAPHY

Ainley DG, Telfer TC, Reynolds MH. 1997. Newell's shearwater (*Puffinus auricularis*). *In* The Birds of North America, No. 297 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Anderson DJ. 1993. Masked booby (*Sula dactylatra*). *In* The Birds of North America, No. 73 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Association of Fish and Wildlife Agencies, Teaming With Wildlife Committee, State Wildlife Action Plan (SWAP) Best Practices Working Group. 2012. Best Practices for State Wildlife Action Plans—Voluntary Guidance to States for Revision and Implementation. Washington, D.C.

Asquith A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Museum Occasional Papers 40:1–81.

Atkinson, C. T., & LaPointe, D. A. 2009a. Ecology and pathogenicity of avian malaria and pox. In M. T. K. Pratt, M. C. T. Atkinson, M. P. C. Banko, M. J. D. Jacobi, & M. B. L. Woodworth (Eds.), Conservation biology of Hawaiian forest birds: Implications for island avifauna (pp. 234–252). New Haven, CT: Yale University Press.

Atkinson, CT, RB Utzurrum, DA LaPointe, RJ Camp, LH Crampton, JT Foster, and TW Giambelluca. 2014. Changing Climate and the Altitudinal Range of Avian Malaria in the Hawaiian Islands - an Ongoing Conservation Crisis on the Island of Kaua‘i. Global Change Biology 20, 2426–2436, doi: 10.1111/gcb.12535.

Austin JE, Custer CM, Afton AD. 1998. Lesser scaup (*Aythya affinis*). *In* The Birds of North America, No. 338 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Austin JE, Miller MR. 1995. Northern pintail (*Anas acuta*). *In* The Birds of North America, No. 163 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Bailey-Brock JH, Brock RE. 1993. Feeding, reproduction, and sense organs of the Hawaiian anchialine shrimp, *Halocaridina rubra*. Pacific Science 47(4):338-345.

Bailey-Brock JH, Brock V, Brock RE. 1999. Intrusion of anchialine species in the marine environment: the appearance of an endemic Hawaiian shrimp, *Halocaridina rubra* on the south shore of O‘ahu (Hawaiian Islands). Pacific Science 53:367-369.

Baird RW. Cascadia Research Collective. Personal Communication.

Baird RW. (In Press). Sightings of dwarf (*Kogia sima*) and pygmy (*K. breviceps*) sperm whales from the Main Hawaiian Islands. Pacific Science 59(3):461-466.

Baird RW, Ligon AD, Hooker SK, Gorgone AM. 2001. Subsurface and nighttime behavior of pantropical spotted dolphins in Hawai‘i. Canadian Journal of Zoology 79:988-996.

Baird, RW, Gorgone AM, McSweeney DJ, Ligon AD, Deakos MH, Webster DL, Schorr GS, Martien KK, Salden DR, and Mahaffy SD. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands. Marine Mammal Science 25:251-274.

Baker PE, Baker H. 2000. Kākāwahie (*Paroreomyza flammea*) and O‘ahu alauahio (*Paroreomyza maculata*). *In* The Birds of North America, No. 503 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Baker H, Baker PE. 2000. Maui ‘alauahio (*Paroreomyza montana*). *In* The Birds of North America, No. 504 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Bakutis A, et al. 2002. Draft comprehensive wildlife management plan. Honolulu (HI): University of Hawai‘i.

Balazs GH. 1980. Synopsis of the biological data on the green turtle in the Hawaiian Archipelago. Prepared for National Marine Fisheries Service, Honolulu (HI): Technical Report NOAA-NMFS- SWFSC-7. 150 pp.

Balazs GH, Chaloupka M. 2004. Spatial and temporal variability in somatic growth of green sea turtles (*Chelonia mydas*) resident in the Hawaiian Archipelago. Marine Biology 145(5):1043-1059.

Balazs GH, Forsyth RG, Kan AH. 1987. Preliminary assessment of habitat utilization by Hawaiian green turtles in their resident foraging pastures. Prepared for National Marine Fisheries Service, Honolulu (HI): Technical Report NOAA-NMFS-SWFSC-71. 116 pp.

Banko PC, Ball DL, Banko WE. 2002. Hawaiian crow (*Corvus hawaiiensis*). *In* The Birds of North America, No. 648 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Banko PC, Black JM, Banko WE. 1999. Hawaiian goose (*Branta sandvicensis*). *In* The Birds of North America, No. 434 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Banko PC, Johnson L, Lindsey GD, Fancy SG, Pratt TK, Jacobi JD, Banko WE. 2002. Palila (*Loxioides bailleui*). *In* The Birds of North America, No. 679 (Poole A, Gill F, editors.).

Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Bannor BK, Kiviat E. 2002. Common moorhen (*Gallinula chloropus*). *In* The Birds of North America, No. 685 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Barnard JL. 1977. The caverniculous fauna of Hawaiian lava tubes 9. Amphipoda from brackish lava ponds on Hawai'i and Maui. Pacific Insects 17:267-299.

Barnes RD. 1980. Invertebrate zoology, 4th edition. Philadelphia (PA): Saunders College Publishing.

Bazúa-Durán C, Au W. 2004. Geographic variations in the whistles of spinner dolphins (*Stenella longirostris*) of the Main Hawaiian Islands. Journal of Acoustical Society of America 116(6):3757-3269.

Behnke, L. 2014. Habitat use and conservation implications for Akikiki (*Oreomystsis bairdi)* and Akekee (*Loxops caeruleirostris)*, two endangered Hawaiian honeycreepers. M.S. Thesis. Colorado State University, Fort Collins, CO.

Benning, T. L., LaPointe, D., Atkinson, C. T., & Vitousek, P. M. 2002. Interactions of climate change with biological invasions and land use in the Hawaiian Islands: Modeling the fate of endemic birds using a geographic information system. Proceedings of the National Academy of Sciences, 99(22), 14246–14249. doi:10.1073/pnas.162372399

Benson, L. Personal communication.

Benson LK, Fitzsimons JM. 2002. Life history of the Hawaiian fish *Kuhlia sandvicensis* as inferred from daily growth rings of otoliths. Environmental Biology of Fishes. 65(2):131-137.

Berger AJ. 1981. Hawaiian birdlife. Honolulu: University of Hawai'i Press. 260 pp.

Berlin KE, VanGelder EM. 1999. 'Akohekohe (*Palmeria dolei*). *In* The Birds of North America, No. 400 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Bernard HJ, Reilly SB. 1999. Pilot whales *Globicephala lesson*, 1828. Pp. 245-279 *In*: Handbook of marine mammals, volume 6 (Ridgeway S, Harrison R, editors). The second book of dolphins and the porpoises. London, UK: Academic Press.

Bettridge S, Baker CS, Barlow J, Clapham PJ, Ford M, Gouveia D, Mattila DK, Pace III RM, Rosel PR, Silber GK, Wade PR. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-540.

Blackledge TA, Binford GJ, Gillespie RG. 2003. Resource use within a community of Hawaiian spiders (Araneae: Tetragnathidae). Annales Zoologici Fennici 40:293–303.

Bishop, R.C., D.J. Chapman, B.J. Kanninen, J.A. Krosnick, B. Leeworthy, and N.F. Meade. 2011. Total Economic Value for Protecting and Restoring Hawaiian Coral Reef Ecosystems: Final Report. Silver Spring, MD: NOAA Office of National Marine Sanctuaries, Office of Response and Restoration, and Coral Reef Conservation Program. NOAA Technical Memorandum CRP 16. 406 pp.

Blackledge TA, Gillespie RG. 2004. Convergent evolution of behavior in an adaptive radiation of Hawaiian web-building spiders. Proceedings of the National Academy of Sciences USA 101:16228-16233.

Bousefield EL. 1990. A new genus and species of hadzioidean amphipod crustacean from anchialine pools in Hawaii. Beaufortia 41(4):25-30.

Brainard R, Friedlander A, Gulko D, Hunter C, Kelty R, Maragos J. 2002. Status of coral reefs in the Hawaiian Archipelago. Pp. 237-248. *In*: Status of coral reefs of the world 2002. Australia: Australian Institute of Marine Science.

Brasher AM. 1997. Habitat use by fish (‘o‘opu), snails (hihiwai), shrimp (‘opae) and prawns in two streams on the island of Moloka‘i. Technical Report. Honolulu (HI): Cooperative National Park Resources Studies Unit University of Hawai‘i at Manoa. Report no 116. 92 pp.

Brasher AM. 2003. Impacts of human disturbances on biotic communities in Hawaiian streams. BioScience 53(11):1052-1060.

Brindle A. 1980. The cavernicolous fauna of Hawaiian lava tubes. 12. A new species of blind troglobitic earwig (Dermaptera: Carcinophoridae), with a revision of the surface living earwigs of the Hawaiian Islands. Pacific Insects 21:261-274.

Brinck KW, Camp RJ, Gorresen PM, Leonard DL, Mounce HL, Iknayan KJ, Paxton EH. 2012. 2011Kiwikiu (Maui Parrotbill) and Maui Alauahio abundance estimates and the effect of sampling effort on power to detect a trend. Hawaii Cooperative Studies Unit, University of Hawaii at Hilo. Technical Report HCSU-035.

Brock RE. 2004. Anchialine resources in two Hawai‘i state NARs: A report prepared for US Fish and Wildlife Service. Honolulu (HI): Environmental Assessment, LLC.

Brock RE, Bailey-Brock JH. 1998. An unique anchialine pool in the Hawaiian Islands. International Reviews in Hydrobiology 83:65-75.

Brock RE, Richard E. 2004. Anchialine resources in two Hawai’i State Natural Area reserves: ‘Ahihi –Kina‘u, Maui Island and Manuka, Hawai’i Island with recommendations for their management. Honolulu (HI): Pacific Islands Coastal Program, US Fish and Wildlife Service.

Brown E. Personal communication, Marine Ecologist, Kalaupapa National Historic Park.

Brown S, et al. 2001. United States shorebird conservation plan. Manomet (MA): Manomet Center for Conservation Sciences.

Brusca R. 1997. Tree of life project [Internet]. Available at: http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida.

Burgett J, et al. 2001. The Hawaiian endangered bird conservation program: Five-year workplan (2001 – 2005).

Cabin RJ, Weller SG, Lorence DH, Flynn TW, Sakai AK, Sandquist D, Hadway LJ. 2000. Effects of long-term ungulate exclusion and recent alien species control on the preservation and restoration of a Hawaiian tropical dry forest. Conservation Biology 14(2):439-453.

Camp RJ, Brinck KW, Banko PC. 2014. Palila abundance estimates and trend. HCSU Technical Report HCSU-053. 18 pp.

Captive Breeding Specialist Group, Species Survival Commission/IUCN-The World Conservation Union. 1992. Hawaiian forest birds conservation assessment and management plan workshop and population and habitat viability assessment workshops for Palila, ʻAlala, and Crested Honeycreeper. Hilo, Hawaiʻi.

Carretta JV, Oleson E, Weller DW, Lang AR, Forney KA, Baker J, Hanson B, Martien K, Muto MM, Orr AJ, Huber H, Lowry MS, Barlow J, Lynch D, Carswell L, Brownell, Jr. RL, Mattila DK. 2014. U.S. Pacific Marine Mammal Stock Assessments, 2013. La Jolla, California: National Marine Fisheries Service, Southwest Fisheries Science Center. NOAA-TM-NMFS-SWFSC-532.

Cave Conservancy of Hawaiʻi. 2003. Kipuka Kanohina Cave Preserve management plan. Cave Conservancy of Hawaiʻi.

Cesar H, Beukering P, Pintz S, Dierking J. 2002. Economic valuation of the coral reefs of Hawaiʻi. Hawaiʻi Coral Reef Initiative Research Program. Available at: http://www.hawaii.edu/ssri/hcri/rp/cesar/noaa_final_report_01-02/cesar_final_report-01-02.htm.

Chai DL, Cuddihy C, Stone C. 1989. An inventory and assessment of anchialine pools in Hawaiʻi Volcanoes National Park from Waha‘ula to Kaʻaha, Puna and Kaʻu, Hawaii. Technical Report #69. Cooperative National Park Resources Studies Unit. National Park Service Contract No. CA 8015-2-0001. 37 pp.

Chardine JW, Morris RD. 1996. Brown noddy (*Anous stolidus*). *In* The Birds of North America, No. 220 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Chong CT, et al. 2000. Species interactions between estuarine detritivores: inhibition or facilitation? Hydrobiologia 434:11-16.

Chu, P.-S., Chen, Y.R., Schroeder, T.A. 2010. Changes in precipitation extremes in the Hawaiian Islands in a warming climate. J. Climate 23: 4881-4890.

Chung DJ, Cowie RH. 1991. An archival inventory of the land snails of the state of Hawai‘i Natural Area Reserves System. Honolulu (HI): Bernice Pauahi Bishop Museum.

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan, 2013: Sea Level Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Clarkson KE, Laniawe LP. 2000. Hawaiian hawk (*Buteo solitarius*). *In* The Birds of North America, No. 523 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA.

Commission on Water Resources Management. 1990. Hawaii Stream Assessment: A Preliminary Appraisal of Hawaii’s Stream Resources. Hawaii Department of Land and Natural Resources. Honolulu.

Constantine R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatusi)* due to long-term exposure to swim-with-dolphin tourism. Marine Mammal Science 17(4):689-702.

Constantine R, Brunton DH, Dennis T. 2004. Dolphin-watching tour boats change bottlenose dolphin (*Tursiops truncatus*) behaviour. Biological Conservation 117(3):299-307.

Coordinated Bird Monitoring Working Group of the International Association of Fish and Wildlife Agencies. September 2004. Monitoring Avian Conservation: Rationale, Design, and Coordination.

Cowie RH, Evenhuis NL, Christensen CC. 1995. Catalog of the Land and Freshwater Molluscs of the Hawaiian Islands. Leiden (Netherlands): Backhuys Publishers.

Crow GL, Crites J. 2002. Sharks and rays of Hawai‘i. Honolulu (HI): Mutual Publishing. 203 pp.

Curry, PA and NW Yeung. 2013. Predation on endemic Hawaiian land snails by the invasive snail *Oxychilus alliarius*. Biodiversity and Conservation 22:3165-3169.

Dalton M, Kohley R and Heindl B. 2014. Trip Report: Population Monitoring of Millerbirds on Laysan, June 28-September 28, 2014. Unpublished report for the American Bird Conservancy and U.S. Fish and Wildlife Service. 45pp.

Daly HV, Magnacca KN. 2003. Insects of Hawai‘i Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. Honolulu: University of Hawai‘i Press.

Dames and Moore. July 1997. Kaho‘olawe ocean management plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

Davidson K, Hamnett M, Minato C editors. 2003. Economic valuation of Hawai‘i’s nearshore reefs. Honolulu: Social Science Research Institute. University of Hawai‘i at Manoa, 8.

Davies RG. 1988. Outlines of entomology. New York (NY): Chapman and Hall. 408 pp.

Davis SD, Heywood VH, Hamilton AC, editors. 1995. Centres of Plant Diversity. Oxford, United Kingdom. 550 pp.

Davis WE. 1993. Black-crowned night-heron (*Nycticorax nycticorax*). *In* The Birds of North America, No. 74 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington, D.C.: The American Ornithologists’ Union.

Dayer AA, Manfredo MJ, Teel TL, and Bright AD. 2006. State Report for Hawai`i from the Research Project entitled “Wildlife Values in the West.” Project Rep. No. 68. Project Report for Hawai`i Department of Land and Natural Resources. Colorado State University, Human Dimensions in Natural Resources Unit, Fort Collins, Colorado.

Decision Analysts Hawai‘i, Inc. and Research Solutions, LLC. 2002. Draft economic analysis of proposed Critical Habitat designations for threatened and endangered plants on Kaua‘i and Ni‘ihau. Hawai‘i revised determination. Honolulu (HI): Available at: http://www.fws.gov/pacific/pacificislands/CHRules/KauaiPlantsEA4-30.pdf.

Department of Land and Natural Resources – Division of Forestry and Wildlife, Snail Extinction Prevention Program. 2014. Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Department of Land and Natural Resources, Honolulu, Hawai‘i.

Devick WS, Fitzsimons JM, Nishimoto RT. 1995. Threatened fishes of the world: *Lentipes concolor* Gill, 1860 (Gobiidae). Environmental Biology of Fishes 44:325-326.

Donohue MJ, Boland RC, Sramek CM, Antonelis GA. 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: diving surveys and debris removal in 1999 confirm threat to coral reef ecosystems. Marine Pollution Bulletin 42(12):1301-1312.

Dresler P. General concepts for a monitoring program. US Geological Service.

Dubowy PL. 1996. Northern shoveler (*Anas clypeata*). *In* The Birds of North America, No. 217 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Duvall, F. Wildlife Biologist, Division of Forestry and Wildlife. Personal communication. 2005.

East Maui Watershed Partnership. 2004. Draft environmental assessment: East Maui Watershed Partnership fence extensions in the East Maui Watershed.

East Maui Watershed Partnership. 2005. Draft East Maui Watershed monitoring review and recommendations.

East Moloka‘i Watershed Partnership. East Moloka‘i Watershed Partnership Strategic Plan: for the south slope FY1998-FY2003 Summary, FY2004-2009 Projections.

Eldredge LG and Evenhuis NL. 2002. Hawai‘i’s Biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. Bishop Museum Occasional Papers 76:1-28.

Eldredge L, Miller S. 1995. How many species are there in Hawai‘i? Bishop Museum Occasional Papers 41:3-18.

Ellis S, et al. “‘Alala, ‘Akohekohe, and Palila population and habitat assessments.” Hilo (HI): Captive Breeding Specialist Group, Species Survival Commission/IUCN-The World Conservation Union. 1992.

Ellis S, et al. 1992. Hawaiian forest birds conservation assessment and management plan. Hilo (HI): Captive Breeding Specialist Group, Species Survival Commission/IUCN-The World Conservation Union.

Endangered species information page. Available at: http://hbs.bishopmuseum.org/endangered/extinct.html (accessed October 2004).

Engilis A, Naughtond M. 2004. U.S. Pacific Islands regional shorebird conservation plan. U.S. Shorebird Conservation Plan. Portland (OR): U.S. Department of the Interior; Fish and Wildlife Service.

Engilis A Jr., Uyehara KJ, Giffin, JG. 2002. Hawaiian duck (*Anas wyvilliana*). *In* The Birds of North America, No. 694 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Englund, R.A. 2001. Long-term monitoring of one the most restricted insect populations in the United States, *Megalagrion xanthomelas* (Selys-Longchamps), at Tripler Army Medical Center, Oahu, Hawaii (Zygoptera: Coenagrionidae). Odonatologica 30 (3): 255-263.

Englund, R.A. 2002. The loss of native biodiversity and continuing nonindigenous species introductions in freshwater, estuarine, and wetland communities of Pearl Harbor, Oahu, Hawaiian Islands. Estuaries 25(3): 418-430.

Englund, R.A. and D.A. Polhemus. 2001. Evaluating the effects of introduced rainbow trout (*Oncorhynchus mykiss*) on native stream insects on Kauai Island, Hawaii. Journal of Insect Conservation 5: 265-281.

Englund, RA, Wright, MG and Polhemus, DA. 2007. Aquatic insect taxa as indicators of aquatic species richness, habitat disturbance and invasive species impacts in Hawaiian Streams. Biology of Hawaiian Streams and Estuaries (NL Evenhuis, ed). Bishop Museum Bulletin in Cultural and Environmental Studies 3: 207-232.

Evenhuis NL, Eldredge LG, editors. 2004. Natural history of Nihoa and Necker Islands. Honolulu (HI): Bishop Museum Press. 222 pp.

Explore Biodiversity. Major orders of the insecta. Lepidoptera: butterflies and moths. Available at: http://www.explorebiodiversity.com/Hawaii/BiodiversityForgotten/Wildlife/Inverts/Insects/Lepidoptera.htm.

Fancy SG, Ralph CJ. 1997. ‘Apapane (*Himatione sanguinea*). *In* The Birds of North America, No. 296 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Fancy S G, Ralph CJ. 1998. ‘I‘iwi (*Vestiaria coccinea*). *In* The Birds of North America, No. 327 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Fenner D. 2005. Corals of Hawai‘i. Honolulu (HI): Mutual Publishing. 144 pp.

Fiedler GC. 2002. The influence of social environment on sex determination in harlequin shrimp (*Hymenocera picta*: Decapoda, Gnathophyllidae). Journal of Crustacean Biology 22(4):750-761.

Fishbase. [Internet] online data. http://fishbase.sinica.edu.tw/Summary/SpeciesSummary.cfm?genusname =Elops&speciesname=hawaiensis (accessed May 2005).

Flint, B., Leary, P., & Klavitter, J. (2011). Briefing paper to the US delegation to the Agreement on the Conservation of Albatrosses and Petrels (ACAP) presented at the Population Status and Trends and Breeding Sites Working Group meeting, Guayaquil, Ecuador.

Foote D, Carson H. *Drosophila* as monitors of change in Hawaiian ecosystems. Available at: http://biology.usgs.gov/s+t/noframe/t233.htm (last accessed 3 December 2004).

Fortini, L.B., Price, J., Jacobi, J., Vorsino, A., Burgett, J., Brinck, K., Amidon, F., Miller, S., ʼOhukaniʼohiʼan III, S., Koob, G., Paxton, E. 2013. A landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Technical Report 044, Hawaiʼi Cooperative Studies Unit. University of Hawaiʼi, Hilo, HI, 45 pp.

Foster JT, Scott JM, Sykes PW. 2000. ʻAkikiki (*Oreomystis bairdi*). *In* The Birds of North America, No. 552 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Foster JT, Tweed EJ, Camp RJ, Woodworth BL, Adler CD, Telfer T. 2004. Long-term population changes of native and introduced birds in the Alakaʻi swamp, Kauaʻi. Conservation Biology 18:716-725.

Fullaway DT. New species of *Sierola* with explanatory notes. Bishop Museum Occasional Papers 7(7):57-159.

Gagne WC. 1997. Insular evolution, speciation, and revision of the Hawaiian genus *Nesiomiris*. Bishop Museum Bulletins in Entomology 7. Honolulu (HI): Bishop Museum Press.

Garb JE. 1999. An adaptive radiation of Hawaiian Thomisidae: biogeographic and genetic evidence. Journal of Arachnology 27:71-78.

Gaudioso JM, LaPointe DA, Hart PJ. 2009. Knemidokoptic mange in Hawaii Amakihi (Hemignathus virens) on the Island of Hawaii. Journal of Wildlife Diseases. 45:497-501.

Gauger VH. 1999. Black noddy (*Anous minutus*). *In* The Birds of North America, No. 412 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Giffard WM. 1925. A review of the Hawaiian Cixiidae, with descriptions of species. Proceedings of the Hawaiian Entomological Society 6(1):51–171.

Giffin, J. Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communication.

Giffin J. 2003. Puʻu Waʻawaʻa biological assessment. State of Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife.

Gill RE, McCaffery BJ, Tomkovich PS. 2002. Wandering tattler (*Heteroscelus incanus*). *In* The Birds of North America, No. 642 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Gillespie RG. 1991. Hawaiian spiders of the genus Tetragnatha: I. Spiny leg clade series. Journal of Arachnology 19:174-209.

Gillespie RG. 1992. Hawaiian spiders of the genus Tetragnatha: II. Species from natural areas of windward East Maui. Journal of Arachnology 20:1-17.

Gillespie RG. 1994. Hawaiian spiders of the genus Tetragnatha: III. *T. acuta* clade. Journal of Arachnology 22:161-168.

Gillespie RG. 2002. Hawaiian spiders of the genus Tetragnatha: IV. New, small species in the spiny leg clade. Journal of Arachnology 30:159-172.

Gillespie RG. 2003. Hawaiian spiders of the genus Tetragnatha: V. Elongate web-builders from Oahu. Journal of Arachnology 31:8-19.

Gillespie RG. 2004. Community assembly through adaptive radiation in Hawaiian spiders. *Science* 303:356-359.

Gillespie R. 2005. The ecology and evolution of Hawaiian spider communities. American Scientist 93:122-131.

Gillespie RG, Reimer N. 1993. The effect of alien predatory ants (Hymenoptera: Formicidae) on Hawaiian endemic spiders (Araneae: Tetragnathidae). Pacific Science 47:21-33.

Gorreson, PM, Camp RJ, Reynolds MH, Woodworth BL, Pratt TK. 2009. Status and Trends of Native Hawaiian Songbirds. *In* Conservation Biology of Hawaiian Forest Birds (Pratt TK, Atkinson CT, Banko PC, Jacobi JD, Woodworth BL, editors). Yale University Press.

Grigg R, Opresko D. 1977. Order Antipatharia. Pp. 242-261. *In* Reef and shore fauna of Hawaii. Bishop Museum Special Publication 64. Honolulu (HI): Bishop Museum.

Groombrigde JJ, Massey JG, Bruch JC, Malcolm T, Brosius CN, Okada MM, Sparklin B, Fretz JS, and VanderWerf, EA. 2004. An attempt to recover the Po'ouli by translocation and an appraisal of recovery strategy for bird species of extreme rarity. Biological Conservation 118(3):365-375.

Gruner DS. 2004. Attenuation of top-down and bottom-up forces in a complex terrestrial community. Ecology 85:3010-3022.

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu (HI): Hawai'i Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawai'i endemic species status chart spreadsheet. Honolulu (HI): Hawai'i Division of Aquatic Resources.

Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu (HI): Mutual Publishing. 128 pp.

Ha PY, Kinzie R. 1996. Reproductive biology of *Awaous guamensis*, an amphidromous Hawaiian goby. Environmental Biology of Fishes 45:383-396.

Hadway LJ, Hadfield MG. 1998. Assessment of the current status of *Partulina* tree-snail species on the island of Hawai‘i with comments on additional land snail species. Honolulu: Department of Zoology, University of Hawai‘i.

Haight WR. 2004. [Internet]. Seafood watch seafood reports. International Maritime Alliance and Monterey Bay, Aquarium. Available at: http://www.mbayaq.org/cr/cr_seafoodwatch/sfw_factsheet.aspx?fid=168 (accessed May 2005).

Haleakalā National Park. Annual performance plan fiscal year 2004. National Park Service, 2004. Available at: http://www.nps.gov/hale/pphtml/documents.html (accessed 24 March 2005).

Hammond, RL, Crampton, LH, and Foster, JT. 2015. Breeding biology of two endangered forest birds on the island of Kaua'i. Condor 117: 31-40.

Hardy DE. 1965. Diptera: Cyclorrhapha. II, Series Schizophora, Section Acalypterae I. Family Drosophilidae. *In* Insects of Hawaii 12.

Hardy, DE and Delfinado, MD. 1980. Diptera: Cyclorhhapha III. Insects of Hawaii 13: 1-451.

Harrison, C.S. 1990. Seabirds of Hawai‘i: Natural History and Conservation. Cornell University Press.

Hart, PJ. USGS. Personal communication.

Harter, D.E.V., S.D.H. Irl, B. Seo, M.J. Steinbauer, R. Gillespie, K.A. Triantis, J.-M. Fernández-Palacios, C. Beierkuhnlein. 2015. Impacts of global climate change on the floras of oceanic islands – Projections, implications and current knowledge. Perspectives in Plant Ecology, Evolution and Systematics 17: 160-183.

Hau S. 1996. Post-larval migration of three native gobies (*Lentipes concolor, Awaous guamensis,* and *Sicyopterus stimpsoni*) in Iao stream on the island of Maui. Proceedings of the October 1994 Hawai’i Stream Restoration Symposium; 1994. Honolulu: Hawai‘i. State of Hawai‘i, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

Hau, S. Hawai‘i Division of Aquatic Resources. Personal communication.

Hawai‘i Audubon Society. 1993. Hawaii’s birds. Honolulu: Hawai‘i Audubon Society.

Hawai‘i Coastal Zone Management Program and Department of Health. 2000. Hawai‘i implementation plan for polluted runoff control. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Conservation Alliance. 2004. Draft Hawai‘i biodiversity strategy.

Hawai‘i Conservation Biology Initiative. 1992. Hawaii’s forest birds: an inventory of research conducted 1992-1998. Workshop.

Hawai‘i Coral Reef Initiative. 2002. The first four years: Hawai‘i coral reef initiative research program 1998-2002. Available at: www.hawaii.edu/ssri/hcri/rp/publications.htm.

Hawai‘i Department of Agriculture. 2002. Kahului airport pest risk assessment. Maui. Available at: http://www.hawaiiag.org/PQ/KARA%20Report%20Final.pdf (accessed last 17 August 2005).

Hawai‘i Department of Business, Economic Development, and Tourism (DBEDT). 1991. Hawai‘i ocean resources management plan. Honolulu (HI): DBEDT. 50 pp.

Hawai‘i Department of Business, Economic Development & Tourism. 2013. The State of Hawaii Data Book—A Statistical Abstract. Available at: http://files.hawaii.gov/dbedt/economic/databook/db2013/db2013.pdf (accessed June 27, 2015).

Hawai‘i Department of Business, Economic Development & Tourism. 2015. Visitor Statistics—Annual Visitor Research Report. Available at: http://dbedt.hawaii.gov/visitor/visitor-research/ (accessed June 27, 2015).

Hawai‘i Department of Health. 2004. List of impaired waters. Available at: http://www.hawaii.gov/health/environmental/env-planning/wqm/wqm.html.

Hawai‘i Department of Health, Hawai‘i Coastal Zone Management Program, and U. S. Natural Resources Conservation Service. 1998. Hawai‘i unified watershed assessment. Available at: http://www.state.hi.us/dbedt/czm/UWAreport.htm.

Hawai‘i Department of Health. 2014. 2014 State of Hawaii Water Quality Monitoring and Assessment Report. Available at: http://health.hawaii.gov/cwb/files/2014/11/Final-2014-State-of-Hawaii-Water-Quality-Monitoring-and-Assessment-Report.pdf (accessed 30 June 30, 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. Undated. Fact sheets on Hawaiian noddy tern, masked booby, Bulwer's petrel, brown booby, red-tailed tropicbird, noddy tern, great frigatebird, red-footed booby. Available by request from the Department of Land and Natural Resources Division of Forestry and Wildlife, Honolulu, HI.

Hawai‘i Department of Land and Natural Resources. Draft management guidelines. Available at: http://www.state.hi.us/dlnr/dofaw/guidelines/mg_jw03/index.html.

Hawai‘i Department of Land and Natural Resources. Undated. Interim State of Hawai‘i strategic plan for invasive species prevention, control, research and public outreach. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources. 1983. Hawai‘i wildlife plan. Honolulu (HI): DLNR.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Hono o Na Pali Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Kuia Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Laupahoehoe Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Pu‘u Maka‘ala Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Pu‘u ‘O Umi Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, US Fish and Wildlife Service, and The Nature Conservancy of Hawai‘i. 1992. Hawai‘i's extinction crisis: a call to action.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Kahaualea Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Manuka Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 1993. Kipahoehoe Natural Area Reserve management plan. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife, March 1993. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Hawai‘i Department of Land and Natural Resources (DLNR). 2003. Ahihi-Kinau NAR/Keoneo‘io plan of action draft for discussion purposes.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife and Division of State Parks. 2003. Management plan for the Ahupua‘a of Pu‘u Wa‘awa‘a and the Makai lands of Pu‘u Anahulu. State of Hawai‘i.

Hawai‘i Department of Land and Natural Resources (DLNR). 2004. Statewide report on invasive species. Honolulu (HI): DLNR.

Hawai‘i Department of Land and Natural Resources (DLNR). 2004. Hawai‘i's priority invasive species. Honolulu (HI): DLNR.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Conservation education and outreach program strategic plan - DRAFT. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Forest legacy: amended assessment of needs, State of Hawai‘i. Honolulu (HI).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communications with staff. 2005.

Hawai‘i Department of Land and Natural Resources and Division of Aquatic Resources (DAR). 2005. Marine protected areas in Hawai‘i. Honolulu (HI): DAR. 14pp. Available at: http://www.hawaii.gov/dlnr/dar/pubs/M(PA)pub.pdf.

Hawai‘i Department of Land and Natural Resources. 2013. Division of Forestry and Wildlife Snail Extinction Puu Maka‘ala Natural Area Reserve (NAR) Management Plan. Honolulu.

Hawai‘i Department of Land and Natural Resources (DLNR). 2014. Makai Watch Briefing to the Board of Land and Natural Resources. Available at: http://dlnr.hawaii.gov/makaiwatch/2014/11/26/makai-watch-briefing-to-the-board-of-land-and-natural-resources/ (accessed June 27, 2015).

Hawai‘i Department of Land and Natural Resources. 2014a. http://dlnr.hawaii.gov/reefresponse/2014/10/06/latest-info-coral-bleaching/

Hawai‘i Department of Land and Natural Resources. 2014b. http://www.hawaiicoralreefstrategy.com/index.php/local-action-strategies/climate-change-and-marine-disease/

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2014. Report to the Twenty-Seventh Legislature Regular Session of 2014. Budgetary and Other Issues Regarding Invasive Species, Honolulu.

Hawai‘i Department of Land and Natural Resources. 2014. Division of Forestry and Wildlife Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Honolulu.

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Legacy Land Conservation Program Projects. Available at: http://dlnr.hawaii.gov/ecosystems/files/2013/09/Legacy-Land_Projects-Map.pdf (accessed June 30, 2015).

Hawai‘i Department of Land and Natural Resources, Division of Aquatic Resources. 2015. Streams Survey Data and freshwater database. http://dlnr.hawaii.gov/dar/habitat/streams/survey-data/ (accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Snail extinction prevention program. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/sep/ (Accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Blackburn’s Sphinx moth project. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/projects/ (accessed June 30 2015).

Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife. 2015. Yellow-Faced Bee Survey Project. Available at: http:ellow-faced bee survey project. Available at: http://dlnr.hawaii.gov/ecosystems/nicp/projects/yellow-faced-bee/ (Accessed June 30 2015).

Hawai‘i Division of Aquatic Resources. Fishery statistics. [Internet]. Available at: http://www.hawaii.gov/dlnr/dar/stats.htm (accessed May 2005).

Hawai‘i Division of Aquatic Resources. Stream database. Honolulu (HI): DAR.

Hawai‘i Division of Aquatic Resources. Hawaii's marine life conservation districts. Available at: http://www.hawaii.gov/dlnr/dar/mlcd/index.htm.

Hawai‘i Division of Aquatic Resources. 1992. Marine life conservation district plan. Honolulu (HI): DAR. 18 pp.

Hawai‘i Division of Aquatic Resources, State of Hawai‘i. Commercial marine landings data. 1997-2003. Honolulu (HI): Division of Aquatic Resources.

Hawai‘i Division of Aquatic Resources; Bottomfish fishing regulations. 2002. Available at: http://www.hawaii.gov/dlnr/dar/bottomfish/index.htm.

Hawai‘i Division of Aquatic Resources. 2003. State of Hawai‘i aquatic invasive species management plan. Honolulu (HI): DAR. 205 pp. Available at: http://www.hawaii.gov/dlnr/dar/pubs/ais_mgmt_plan_final.pdf.

Hawai‘i Division of Aquatic Resources. 2004. Fishing regulations. Available at: http://www.hawaii.gov/dlnr/dar/fish_regs/index.htm.

Hawai‘i Division of Forestry and Wildlife. Ahihi-Kinau Natural Area Reserve. Available at: http://www.dofaw.net/nars/images.php?reserve=010.

Hawai‘i Division of Forestry and Wildlife. 1992. ‘Ahihi-Kinau NAR management plan. Draft. Honolulu (HI): DOFAW. 18 pp.

Hawai‘i Ecosystems at Risk [Internet]. 2005. Available at: http://www.hear.org.

Hawaiian Hoary Bat Research Cooperative. Available at: http://www.dofaw.net/fbrp/projects.php?id=39.

Hawaii’s Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs. 2004. Plan prepared jointly by EPA, USGS, USFWS, NOAA, CZM, DOH, DLNR. Available at: http://www.hawaii.gov/health/environmental/water/cleanwater/reports/reports.html.

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawai‘i, Center for Conservation Research and Training. Honolulu, HI.[1]

Hawai‘i Natural Heritage Program [now known as the Hawai‘i Biodiversity and Mapping Program]. 2005. Hawai‘i GAP Analysis. Personal communication.

Hawai‘i Office of Planning. 2013. Hawai‘i Ocean Resources Management Plan. Hawai‘i Coastal Zone Management Program. 57 pp.

Hawai‘i Revised Statutes. Chapters 171, 183, 183D, 187A, 188, 190, 195, 195D. Honolulu (HI).

Hawai‘i State Legislature. 2005. House Bill 100, Conference Draft 1 (State Budget). Honolulu (HI). Available at: http://www.capitol.hawaii.gov/sessioncurrent/bills/hb100_cd1_.htm (accessed on May 25, 2005).

Henry AR. 2005. Pacific coast joint venture Hawai‘i: strategic plan for wetland conservation in Hawai‘i review draft. Honolulu (HI): Pacific Coast Joint Venture.

Hobson K. Canadian Wildlife Service. Personal communication.

Holmes N, Friefeld H, Duvall F, Penniman J, Laut M, Creps N. 2011. Newell’s Shearwater and Hawaiian Petrel Recovery: A Five-Year Action Plan. Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu, HI; Pacific Cooperative Studies Unit, Honolulu, HI; and U.S. Fish and Wildlife Service, Honolulu, HI.

[1] The Hawai‘i Natural Heritage Program is dependent on the research and observations of many scientists and individuals. In most cases this information is not the result of comprehensive site-specific field surveys, and is not confirmed by the Heritage staff. Many areas in Hawai‘i have never been thoroughly surveyed, and new plants and animals are still being discovered. Database information should never be regarded as final statements or substituted for on-site surveys required for environmental assessments. Data provided by the Heritage Program do not represent a position taken by the Center for Conservation Research and Training or The Nature Conservancy of Hawai‘i. Heritage information is only for the intended use of the individual or organization who requested it. It may not be distributed in any way without the consent of the Hawai‘i Natural Heritage Program.

Holt DW, Leasure SM. 1993. Short-eared owl (*Asio flammeus*). *In* The Birds of North America, No. 62 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Holt JD. 1985. The art of featherwork in old Hawai‘i. Honolulu: University of Hawai‘i Press.

Holthausen, et al. Principal findings of the Forest Service strategic monitoring committee for wildlife populations and habitats. U.S. Forest Service.

Honebrink RR. 2000. A review of the biology of the family Carangidae, with emphasis on species found in Hawaiian waters. DAR Technical Report 20-01. Honolulu (HI): Division of Aquatic Resources. 43 pp.

Hoover J. 1993. Hawaii’s fishes. Honolulu (HI): Mutual Publishing. 183 pp.

Hoover JP. 1998. Hawaii’s sea creatures, a guide to Hawaii’s marine invertebrates. Honolulu (HI): Mutual Publishing. 366 pp.

Hormiga G. 2002 Orsonwelles, a new genus of giant linyphiid spiders (Araneae) from the Hawaiian Islands. Invertebrate Systematics 16:369-448.

Hormiga G, Arnedo MA, Gillespie RG. 2003. Speciation on a conveyor belt: sequential colonization of the Hawaiian Islands by *Orsonwelles* spiders (Araneae: Linyphiidae). Systematic Biology 52(1):70-88.

Howarth FG. 2002. An assessment of the conservation status of the terrestrial cave fauna occurring on the Islands of Maui and Moloka‘i, Hawai‘i. Honolulu (HI): U.S. Fish and Wildlife Service, Pacific Islands Office.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai‘i Press.

Howe JC. 1993. A comparative analysis of the feeding apparatus in pomacanthids, with special emphasis of oesophageal papillae in *Genicanthus personatus.* Journal of Fish Biology 43(4):593-602.

Hughes G. Natural Resource Manager, National Park Service. Personal communication.

Industrial Economics, Incorporated. 2002. Draft economic analysis of proposed Critical Habitat designation for the Kaua‘i Cave Wolf Spider and the Kaua‘i Cave Amphipod Island of Kaua‘i, Hawaii. Honolulu (HI). Available at: http://www.fws.gov/pacific/pacificislands/CHRules/KauaiCaveEA110802.pdf.

International Association of Fish and Wildlife Agencies. 2005. Comprehensive wildlife conservation strategies: monitoring and evaluation.

IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

Jacobi J. 2005. Preliminary draft overview of species and habitat monitoring. U.S. Geological Survey.

Jokiel, P.L. and E. Brown. 2004. Global warming, regional trends and inshore environmental conditions influence coral bleaching in Hawaii. Global Change Biology 10, 1627–1641.

Johnson OW, Connors PG. 1996. Pacific golden-plover (*Pluvialis fulva*). *In* The Birds of North America, No. 201-202 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Joyce, TW. 2013. Personal communication. Scripps Institute of Oceanography, La Jolla, California.

Juvik JO, Juvik S, editors. 1998. Atlas of Hawai‘i Third Edition. Honolulu: University of Hawai‘i Press.

Kaho‘olawe Island Reserve Commission. Available at: http://www.state.hi.us/kirc/ (accessed 9 March 2005).

Kaho‘olawe Island Reserve Commission. 1997. Ocean resources management plan. Available at: http://kirc.state.hi.us/public/komp.doc.

Kaiser B, Krause N, Roumasset J. 1999. Environmental valuation and the Hawaiian economy. Honolulu: University of Hawai‘i Economic Research Organization.

Kakahaia National Wildlife Refuge. Available at: http://www.fws.gov/pacific/pacificislands/wnwr/mkakahaianwr.html (accessed 22 March 2005).

Kalaupapa National Historic Park. Available at: http://www.nps.gov/kala/docs/start.htm (accessed 7 April 2005).

Kanaio Natural Reserve Project. 2003. Hawai’i Department of Land and Natural Resources.

Kanciruk P. 1980. Ecology of juvenile and adult Palinuridae (spiny lobsters). Pp. 59-66 *In* The Biology and Management of Lobsters, Volume II (Cobb JS, Phillips BF, editors).

Kane, H.H., C.H. Fletcher, L.N. Frazer, and M.M. Barbee. 2014. Critical elevation levels for flooding due to sea-level rise in Hawai‘i. Reg Environ Change. DOI 10.1007/s10113-014-0725-6.

Kaneko JJ and Bartram PK. 2008. What if you don’t speak "CPUE-ese"? Pelagic Fisheries Research Program Newsletter, University of Hawai‘i. 13(2):1-3.

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Kawakatsu M, Mitchell R. 1984. *Oahuhawaiiana kazukolinda*, a new genus, new species turbellaria (Tricladia, Maricola): a new freshwater planarian from Honolulu Island [sic] Hawai‘i USA. Zoological Science (Tokyo) 1(3):487-500.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawai‘i, section 4: Mollusca. Honolulu (HI): Bishop Museum Press. 653 pp.

Kealia Pond National Wildlife Refuge. Available at: http://www.fws.gov/pacific/pacificislands/wnwr/mkealianwr.html (accessed 24 March 2005).

Keener, V.W., J.J. Marra, M.L. Finucane, D. Spooner and M.H. Smith. 2012. Climate Change and Pacific Islands: Indicators and Impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Island Press, Washington DC.

Keith P. 2003. Biology and ecology of amphidromous Gobiidae of the Indo-Pacific and the Caribbean regions. Journal of Fish Biology 63:831-847.

Kido MH, Heacock DE, Asquith A. 1999. Alien rainbow trout *(Oncorhynchus mykiss*) (Salmoniformes: Salmonidae) diet in Hawaiian streams. Pacific Science 53(3):242-251.

Kilpatrick AM. 2006. Facilitating the evolution of resistance to avian malaria in Hawaiian birds. Biol. Cons. 128:475-485.

King CS, Gilmartin WG, Hau S, Bernard HJ, Canja SM, Nakai G, Grady MJ, Williams S, Hebard AG. 2008. Nesting hawksbill turtles (*Eretmochelys imbricata*) on the Island of Maui, Hawai′i from 1996-2003. *In* Mast RB, Hutchinson BJ, and Hutchinson AH, compilers. Proceedings of the Twenty-fourth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-567.

Kinzie RA III. 1990. Species profiles: life histories and environmental requirements of coastal vertebrates and invertebrates, Pacific Ocean region; Report 3, Amphidromous macrofauna of island streams. Technical Report EL-89-10. Vicksburg (MS): US Army Engineer Waterways Experiment Station.

Kinzie R, Ford J. 1977. A limnological survey of Lower Palikea and Pipiwai Streams, Kipahulu, Maui. Technical Report #17. Cooperative National Park Resources Studies Unit. 44 pp.

Kirtman, B., S.B. Power, J.A. Adedoyin, G.J. Boer, R. Bojariu, I. Camilloni, F.J. Doblas-Reyes, A.M. Fiore, M. Kimoto, G.A. Meehl, M. Prather, A. Sarr, C. Schär, R. Sutton, G.J. van Oldenborgh, G. Vecchi and H.J. Wang, 2013: Near-term Climate Change: Projections and Predictability. In: Climate Change 2013: The Physical Science Basis. Contribution of

Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Klavitter JL. 2000. Survey methodology, abundance, and demography of the endangered Hawaiian hawk: is delisting warranted? MS Thesis, Seattle: University of Washington.

Kohala Mountain Watershed Partnership. 2007. Kohala Mountain Watershed Management Plan. Available at: http://kohalawatershed.org/wp-content/uploads/janKWPmanagement_plan.pdf (Accessed June 30, 2015)

Kondratieff BC (coordinator). 2000. Dragonflies and Damselflies (Odonata) of the United States. Jamestown (ND): Northern Prairie Wildlife Research Center Online. Available at: http://www.npwrc.usgs.gov/resource/distr/insects/dfly/dflyusa.htm (Version 12DEC2003).

Ko‘olau Mountains Watershed Partnership. 2002. Ko‘olau Mountains Watershed Partnership management plan. Available at: http://www.state.hi.us/dlnr/dofaw/wmp/koolau/KMWPMP.PDF (accessed on April 18, 2005).

Krushelnycky PD, Gillespie RG, Loope LL, Liebherr JK. 2005. Rediscovery and uncertain future of high-elevation Haleakala carabid beetles (Coleoptera). Pacific Science 59:399-410.

Kushlan JA, et al. 2002. Waterbird Conservation for the Americas: The North American waterbird conservation plan, Version 1 Waterbird Conservation for the Americas, Washington, DC. 78pp. Available at: www.waterbirdconservation.org.

Lammers MO. 2004. Occurrence and behavior of Hawaiian spinner dolphins (*Stenella longirostris*) along Oahu’s leeward and south shores. Aquatic Mammals 30(2):237-250.

Lapoint RT, O’Grady PM, and Whiteman NK. 2013. Diversification and dispersal of the Hawaiian Drosophilidae: the evolution of Scaptomyza. Molecular Phylogenetics and Evolution 69(1):95-108

Lau T. Nature Conservancy Moloka‘i. Personal communication.

Leblanc L, O’Grady PM, Rubinoff D, and Montgomery SL. 2009. New Immigrant Drosophilidae in Hawaii, and a Checklist of the Established Immigrant Species.

Lee DS, Walsh-McGehee M. 1998. White-tailed tropicbird (*Phaeton lepturus*). *In* The Birds of North America, No. 353 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Leeward Haleakalā Watershed Restoration Partnership. 2004. Restoration of hardwood watershed koa (*Acacia koa* gray) forests for enhancement of economic, cultural, and biological resources on leeward Haleakalā Volcano, Hawai‘i.

Leonard, DL. 2008. Recovery expenditures for birds listed under the U.S. Endangered Species Act: the disparity between mainland and Hawaiian taxa. Biological Conservation 141:2054-2061.

Lepidoptera. Available at: http://www.explorebiodiversity.com/Hawaii/BiodiversityForgotten/Wildlife/Inverts/Insects/Lepidoptera.htm (accessed last 22 August 2005).

Lepson JK. 1997. ‘Anianiau (*Hemignathus parvus*). *In* The Birds of North America, No. 312 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Lepson JK, Freed LA. 1997. ‘Akepa (*Loxops coccineus*). *In* The Birds of North America, No. 294 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Lepson JK, Johnston SM. 2000. Greater ‘akialoa (*Hemignathus ellisianus*) and lesser ‘akialoa (*Hemignathus obscurus*). *In* The Birds of North America, No. 512 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Lepson JK, Pratt HD. 1997. ‘Akeke‘e (*Loxops caeruleirostris*). *In* The Birds of North America, No. 295 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Lepson JK, Woodworth BL. 2001. Hawai‘i creeper (*Oreomystis mana*). *In* The Birds of North America, No. 680 (A. Poole and Fr. Gill, eds.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Liebherr JK. 2004. Patterns of endangerment or pathways to enlightenment? Reconstructing the Fauna Hawaiiensis. Sysematics and Biodiversity 2:175-189.

Liebherr JK, Zimmerman EC. 2002. Insects of Hawai’i: Volume 16 Hawaiian Carabidae (Coleoptera) Part 1: Introduction and Tribe Platynini. Honolulu: University of Hawai‘i Press.

Lindsey GD, VanderWerf EA, Baker H, Baker PE. 1998. Hawai‘i (*Hemignathus virens*), Kaua‘i (*Hemignathus kauaiensis*), O‘ahu (*Hemignathus chloris*) and greater ‘amakihi (*Hemignathus sagittirostris*). *In* The Birds of North America, No. 360 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Lindsey GD, et al. 1997. Technical options and recommendations for faunal restoration of Kahoʻolawe. Kahoʻolawe Island Reserve Commission.

Loomis I. 2005. Saving Maui: Maui taxpayers are fighting off development by buying land for conservation. Honolulu Magazine, January 24.

Loope LL. Status and trends of the nation's biological resources: Hawai'i and the Pacific Ocean. U. S. Geological Survey. Available at: http://biology.usgs.gov/s+t/SNT/noframe/pi179.htm (accessed 7 December 2004).

Maciolek J. 1983. Distribution and biology of Indo-Pacific insular hypogeal shrimps. Bulletin of Marine Science 33:606-618.

Macwhirter B, Austin-Smith P, Kroodsma D. 2002. Sanderling (*Calidris alba*). In The Birds of North America, No. 653 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, Hylaeus (Nesoprosopis) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, Foote, D, O'Grady, PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. Zootaxa 1728:1–58.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on Oʻahu and Hawai'i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai'i, Honolulu, Hawai'i. 39 pp.

Magnacca, KN, Price, DK. In press. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing Drosophila (Diptera: Drosophilidae). Molecular Phylogenetics and Evolution.

Maragos J. 1977. Order Scleractinia. Pp. 158-241. In Reef and shore fauna of Hawaii. Honolulu (HI): Bishop Museum Special Publication 64.

Maragos J, Gulko D, editors. 2002. Coral reef ecosystems of the Northwestern Hawaiian Islands: interim results emphasizing the 2000 surveys. Honolulu (HI): U. S. Fish and Wildlife Service and Hawai'i Department of Land and Natural Resources. 46 pp.

Margoluis R, Salafsky N. 1998. Measures of success: designing, managing, and monitoring conservation and development projects. Washington DC: Island Press.

Markow T, and O'Grady PM. 2006. Drosophila: A Guide to Species Identification and Use. Academic Press, London, United Kingdom. McDermid KJ, McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48:790-794.

Marks JS, Tibbitts L, Gill RE, Jr., McCaffery B. 2002. Bristle-thighed curlew (Numenius tahitiensis). In The Birds of North America, No. 705 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Maui Land and Pineapple Company, Ltd. 1999. Pu‘u Kukui Watershed Management Area: Fiscal year 1999 Progress Report. Department of Land and Natural Resources: Natural Area Partnership Program.

Mauna Kea Watershed Alliance. 2010. Mauna Kea Watershed Management Plan. Prepared by M.C. Steward. Hawaii Division of Forestry & Wildlife. Honolulu.

Maynard, J., R. van Hooidonk, C.M. Eakin, M. Puotinen, M. Garren, G. Willams, S.F. Heron, J. Lamb, E. Weil, B. Willis, and C.D. Harvell. 2015. Projections of climate conditions that increase coral disease susceptibility and pathogen abundance and virulence. Nature Climate Change. DOI: 10.1038/NCLIMATE2625.

McDermid K J, and McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

McIntosh MD, Benbow M, Burky AJ. 2002. Effects of stream diversion on riffle macroinvertebrate communities in a Maui, Hawai‘i, stream. River Research and Applications 18(6):569-581.

McRae MG. Louisiana State University. Personal communication.

Medeiros AC, Loope LL, Chimera CG. Kanaio Natural Area Reserve biological inventory and management recommendations. Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources, March 1993. http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Meadows DW. 2004. Behavior of green sea turtles in the presence and absence of recreational snorkelers. Marine Turtle Newsletter. 103:1-4.

Medville, D. Personal communication.

Megyesi JL, O’Daniel DL. 1997. Bulwer’s petrel (*Bulweria bulwerii*). *In* The Birds of North America, No. 281 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Metz VG, Schreiber EA. 2002. Great frigatebird (*Fregata minor*) *In* The Birds of North America, No. 681 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Migura KA, Meadows DW. 2002. Short-finned pilot whales (*Globicephala macrorhynchus*) interact with melon-headed whales (*Peponocephala electra*) in Hawaii. Aquatic Mammals 28(3):294-297.

Misaki E. Nature Conservancy Moloka‘i. Personal communication.

Mitchell, C, Ogura C, Meadows DW, Kane A, Strommer L, Fretz S, Leonard D, and McClung A. 2005. Hawaii’s Comprehensive Wildlife Conservation Strategy. October. Department of Land and Natural Resources, Honolulu, Hawai‘i. 722 pp.

Montgomery, S. Personal communication.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 22(1):65–103.

Morin M., Conant S. 2002. Laysan finch (*Telespiza cantans*) and Nihoa finch (*Telespiza ultima*). *In* The Birds of North America, No. 639 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Morin M, Conant S. 2002. Laysan millerbird (*Acrocephalus familiaris familiaris*) and Nihoa Millerbird (*Acrocephalus familiaris kingi*). *In* The Birds of North America, No. 302 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: the American Ornithologists’ Union.

Mostello CS, Conant S. In prep. Diets of native and alien apex predators in Hawai‘i.

Mostello CS, Palaia NA, Clapp RB. 2000. Gray-backed tern (*Sterna lunata*). *In* The Birds of North America, No. 525 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Moulton DW, Marshall AP. 1996. Laysan duck (*Anas laysanensis*). *In* The Birds of North America, No. 242 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Mounce HL, Leonard DL, Swinnerton KJ, Becker CD, Berthold LK, Iknayan KJ, Groombridge JJ. 2013. Determining productivity of Maui Parrotbills, an endangered Hawaiian honeycreeper. Journal of Field Ornithology 84(1):32-39.

Mounce, HL, Iknayan, KJ, Leonard, DL, Swinnerton, KJ, and Groombridge, JJ. 2014. Management implications derived from long term re-sight data: annual survival of the Maui Parrotbill *Pseudonestor xanthophrys*. Bird Conservation International 24:316-326

Mounce HL, Raisin C, Leonard DL, Wickenden H, Swinnerton KJ, Groombridge JJ. 2015. Spatial genetic architecture of the critically-endangered Maui Parrotbill (Psuedonestor

xanthophrys): management considerations for reintroduction strategies. Conservation Genetics Volume 16, Issue 1: Page 71-84.

Mowbray T. 1999. American wigeon (*Anas americana*). *In* The Birds of North America, No. 401 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Mundy BC, Everson AR. Marine resources. *In* Status and trends of the nation's biological resources. U.S. Geological Service. Available at: http://biology.usgs.gov/s+t/SNT/noframe/mr181.htm.

Mundy B. In press. A checklist of the fishes of the Hawaiian Archipelago. Bishop Museum Bulletin of Zoology, Honolulu (HI): Bishop Museum Press. 1340 pp.

Murphy, CA. Personal communication.

National Atlas of the United States. First.gov. Available at: http://nationalatlas.gov/articles/mapping/a_general.html#six accessed 11 July 2005.

National Marine Fisheries Service. 1988. Critical Habitat, Hawaiian Monk Seal; Endangered Species Act. Federal Register 53(102): 18988-18996.

National Marine Fisheries Service. 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). Silver Spring (MD): Humpback whale recovery team for the National Marine Fisheries Service. 105 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. [NMFS and USFWS]. 1998. Recovery Plan for U.S. Pacific populations of the green sea turtle (*Chelonia mydas*). Silver Spring (MD).

National Marine Fisheries Service and U.S. Fish and Wildlife Service. [NMFS and USFWS]. 1998. Recovery Plan for U.S. Pacific populations of the hawksbill sea turtle (*Eretmochelys imbricata*). Silver Springs (MD).

National Marine Fisheries Service and U.S. Fish and Wildlife Service. [NMFs and USFWS]. 1998. Recovery Plan for U.S. Pacific populations of the leatherback turtle (*Dermochelys coriacea*). Silver Springs (MD).

National Marine Fisheries Service and U.S. Fish and Wildlife Service. [NMFS and USFWS]. 1998. Recovery Plan for U.S. Pacific populations of the loggerhead turtle (*Caretta caretta*). Silver Springs (MD).

National Marine Fisheries Service and U.S. Fish and Wildlife Service. [NMFS and USFWS]. 1998. Recovery Plan for U.S. Pacific populations of the olive ridley turtle (*Lepidochelys olivacea*). Silver Springs (MD).

National Marine Fisheries Service. 2004. Fisheries off West Coast States and in the Western Pacific; Western Pacific Pelagic Fisheries; Pelagic Longline Fishing Restrictions, Seasonal Area Closure, Limit on Swordfish Fishing Effort, Gear Restrictions, and Other Sea Turtle Take Mitigation Measures. Federal Register 69:17329-17354.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Green sea turtle (*Chelonia mydas*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Springs, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Loggerhead sea turtle (*Caretta caretta*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Springs, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Olive ridley turtle (*Lepidochelys olivacea*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Springs, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

National Marine Fisheries Service. 2007. Recovery Plan for the Hawaiian monk seal (*Monachus schauinslandi*). Second Revision. Silver Spring (MD): National Marine Fisheries Service.

National Marine Fisheries Service. 2012. Taking of Marine Mammals Incidental to Commercial Fishing Operations; False Killer Whale Take Reduction Plan. Final Rule. 77 Federal Register 71260-71286.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2013. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Springs, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2013. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: summary and evaluation. National Marine Fisheries Service, Silver Springs, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2015. Endangered and Threatened Species; Identification and Proposed Listing of Eleven Distinct Population Segments of Green Sea Turtles (*Chelonia mydas*) as Endangered or Threatened and Revision of Current Listings. 80 FR 15272-15337.

National Oceanic and Atmospheric Administration (US) [NOAA]. 1988. Critical habitat, Hawaiian monk seal, Endangered Species Act. Federal Register 53(102):18988-18998.

National Oceanic and Atmospheric Administration. National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division. 2001. Sensitivity of coastal environments and wildlife to spilled oil: Hawai‘i atlas. Seattle (WA): National Oceanic and Atmospheric Administration.

National Oceanic and Atmospheric Administration (US) [NOAA]. 2004. Hawaiian Islands Humpback Whale National Marine Sanctuary. Available at: http://hawaiihumpbackwhale.noaa.gov/about/about_sanctuary.html.

National Oceanic and Atmospheric Administration. (US) [NOAA]. 2005. NWHI Coral Reef Ecosystem Reserve. Final Reserve Operations Plan. Honolulu (HI).

National Oceanic and Atmospheric Administration (US) [NOAA]. 2013. Papahānaumokuākea Marine National Monument Permitted Activities 2013 Annual Report.

National Oceanic and Atmospheric Administration. 2015. National Marine Sanctuaries. Web site about Hawaiian Islands Humpback Whale National Marine Sanctuary. Available at: http://hawaiihumpbackwhale.noaa.gov/management/mgmt_overview.html (accessed 1 July 1, 2015).

National Oceanic and Atmospheric Administration. 2015. National Ocean Services. Web site about Papahānaumokuākea National Monument. Available at: http://www.papahanaumokuakea.gov (accessed 1 July 1, 2015).

National Park Service. Inventory and monitoring program. Available at: http://science.nature.nps.gov/im/monitor/index.htm.

National Park Service (US) [NPS]. Hawai‘i Volcanoes National Park. Available at: http://www.nps.gov/havo/index.htm.

National Park Service (US) [NPS]. Kalaupapa National Historic Park. Available at: http://www.nps.gov/kala/index.htm.

National Park Service (US) [NPS]. Koloko-Honokohau Hawai‘i Volcanoes National Historic Park. Available at: http://www.nps.gov/kaho/index.htm.

National Park Service (US) [NPS]. 2015. Kalaupapa National Historic Park, Draft General Management Plan and Environmental Impact Statement. Pacific West Region, Park Planning and Environmental Compliance.

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. Final Environmental Assessment: Natural Resources Conservation.

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. Olokui Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources, March 1991. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 6 April 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife. 1991. Pu‘u Alii Natural Area Reserve management plan. Hawai‘i Department of Land and Natural

Resources. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 6 April 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife. West Maui Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources, December 1988. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. 1989. Hanawī Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources.

Natural Area Reserves System Program, Division of Forestry and Wildlife. 1992. ‘Ahihi -Kinau Natural Area Reserve management plan. Hawai‘i Department of Land and Natural Resources. Available at: http://www.dofaw.net/nars/about.php?content=008 (accessed 24 March 2005).

Natural Area Reserves System Program, Division of Forestry and Wildlife, Department of Land and Natural Resources. 2003. Final environmental assessment: natural resources conservation project, Kanaio Natural Reserve. Hawai‘i Department of Land and Natural Resources.

Nature Conservancy. Undated. Honouliuli Preserve master plan. Honolulu (HI).

Nature Conservancy of Hawai‘i. Hawaiian High Islands Ecoregional Plan.

Nature Conservancy of Hawai‘i. 1999. Waikamoi Preserve: long range management plan fiscal years 2001-2006. Honolulu (HI): Department of Land and Natural Resources.

Nature Conservancy of Hawai‘i. Kamakou Preserve, Moloka‘i, Hawai‘i: long range management plan fiscal years 2001-2006. Honolulu, Hawai‘i: Department of Land and Natural Resources.

Nature Conservancy of Hawai‘i. Moomomi Preserve, Moloka‘i, Hawai‘i: long range management plan fiscal years 2001-2006. Honolulu, Hawai‘i: Department of Land and Natural Resources.

Nature Conservancy of Hawai‘i. 2003. Kapunakea Preserve: long range management plan fiscal years 2004-2009. Honolulu, Hawai‘i: Department of Land and Natural Resources, 2nd revision. Available at: http://www.state.hi.us/dlnr/dofaw/pubs/LRPKapunakea_rev2.pdf (accessed 24 March 2005).

Nature Conservancy of Hawai‘i. 2003. Pelekunu Preserve, Moloka‘i, Hawai‘i: long range management plan fiscal years 2004-2009. Honolulu (HI): Department of Land and Natural Resources, 2nd revision. Available at: http://www.state.hi.us/dlnr/dofaw/pubs/LRPPelekunu_rev2.pdf (accessed 6 April 2005).

Nature Conservancy of Hawai‘i. 2003. Last Stand: the Vanishing Hawaiian Forest.

Nature Conservancy. 2004. Kanepu‘u Natural Area Partnership Preserve long range management plan FY 2005-2010. Honolulu (HI).

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (March 10, 2005).

NatureServe. [Internet]. 2005. NatureServe Explorer: An online encyclopedia of life. Version 4.3. Arlington (VA): NatureServe. Available at: http://www.natureserve.org/explorer.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, VI. Available at: http://explorer.natureserve.org. (Accessed May 2015).

Nelson, JS. 1994. Fishes of the world. 3rd edition. New York (NY): John Wiley and Sons, Inc. 600 pp.

Nettleship DN. 2000. Ruddy turnstone (*Arenaria interpres*). *In* The Birds of North America, No. 537 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Newell’s Shearwater Working Group. 2004. Draft Newell’s shearwater five-year workplan.

Nicol, S., C. Menkes, J. Jurado-Molina, P. Lehodey, T. Usu, B, Kumasi, B. Muller, J. Bell, L. Tremblay-Boyer, K. Briand. 2014. Oceanographic characterisation of the Pacific Ocean and potential impact of climate variability on tuna stocks and their fisheries. Secretariat of the Pacific Community (SPC), 2014 ISBN: 978-982-00-0737-6. CIP data.

Niethammer KR, Patrick-Castilaw LB. 1998. White tern (*Gygis alba*). *In* The Birds of North America, No. 371 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Nishida GM, editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu.

Odell DK, McClune KM. 1999. False killer whale – *Pseudoorca crassidens* (Owen, 1846). Pp. 213-244. *In*: S Ridgeway and Sir R Harrison editors. Handbook of marine mammals. Volume 6. The second book of dolphins and the porpoises. London, UK: Academic Press.

Office of Hawaiian Affairs 2015. Wao Kele O Puna. Website about Wao Kele O Puna forest legacy reserve. Available at: http://www.oha.org/aina/waokele-o-puna (accessed 1 July 1, 2015).

Offshore Island Restoration Committee. Available at: http://www.botany.hawaii.edu/gradstud/eijzenga/OIRC/ (last accessed 9 February 2005).

O'Grady, PM and Pak, N. in press. Studies in Hawaiian Diptera III: New distributional records for Canacidae and a new endemic species of Procanace. Biodiversity Data Journal

O'Grady PM, and DeSalle R. 2008. Out of Hawaii: the biogeographic history of the genus *Scaptomyza* (Diptera: Drosophilidae). Biology Letters 4(2):195-199.

O'Grady PM, Magnacca KN, and Lapoint RT. 2010. Taxonomic relationships within the endemic Hawaiian Drosophilidae. Records of the Hawaii Biological Survey 108:3-35.

O'Grady PM, Lapoint RT, Bonacum J, Lasola J., Owen E., Wu Y., and DeSalle R. 2011. Phylogenetic and ecological relationships of the Hawaiian Drosophila inferred by mitochondrial DNA analysis. Molecular Phylogenetics and Evolution, 58:244-256.

Oleson EM, Boggs CH, Forney KA, Hanson MB, Kobayashi DR, Taylor BL, Wade PR, Ylitalo GM. 2010. Status review of Hawaiian insular false killer whales (*Pseudorca crassidens*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-22.

Ort BS, Bantay RM, Pantoja NA, and O'Grady PM. 2012. Fungal diversity associated with Hawaiian *Drosophila* host plants. PLoS One, 10.1371/journal.pone.0040550.

Osborn H. 1935. Cicadellidae of Hawaii. Bernice P. Bishop Museum Bulletin 134:1–62.

Ostman-Lind J, Driscoll-Lind AD, Rickards SH. 2004. Delphinid abundance, distribution, and habitat use off the western coast of the island of Hawaii. Seattle (WA): National Oceanic and Atmospheric Administration, Western Administration Support Center. NOAA Contract No. AB133F-02-CN-0123. 29 pp.

Oxford GS, Gillespie RG. 2001 Portraits of evolution: studies of coloration in Hawaiian spiders. BioScience 51:521-528.

PBR Hawai‘i. December 1995. Kaho‘olawe use plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

Pacheco C. Hawai‘i Forest and Trail. Personal communication.

Pacheco R. Hawai‘i Forest and Trail. Personal communication.

Pacific Basin Information Node. Available at: http://pbin.nbii.gov/.

Pacific Missile Range Facility, Barking Sands. 1998. Pacific Missile Range Facility enhanced capability biological assessment. Kauaʻi (HI). Available at: http://www.smdcen.us/pubdocs/files/pmrf_biological_assessment_final.pdf.

Paine JR. 1991. IUCN directory of protected areas in Oceania. Gland: International Union for Conservation of Nature and Natural Resources.

Palmer DD. 2003. Hawaii's ferns and fern allies. Honolulu: University of Hawaiʻi Press.

Paxton, EH, Camp, RJ, Gorresen, PM, Crampton, LH, Leonard, DL, & VanderWerf, EA. 2016. Collapsing avian community on a Hawaiian island. *Science Advances*, *2*(9). https://doi.org/10.1126/sciadv.1600029

Paxton, EH, Gorresen, PM, Camp RJ. 2013. Abundance, distribution, and population trends of the iconic Hawaiian Honeycreeper, the ʻIʻiwi (*Vestiaria coccinea*) throughout the Hawaiian Islands: U.S. Geological Survey Open-File Report 2013-1150.

Paxton, EH., Laut, M, Enomoto, S, & Bogardus, M. 2022. *Hawaiian Forest Bird Conservation Strategies for Minimizing the Risk of Extinction: Biological and Biocultural Considerations*. *96720*(808). http://hdl.handle.net/10790/5386

Pejchar L. Stanford University postdoctoral researcher. Personal communication.

Pejchar L. 2005. Home range size varies with habitat type in a Hawaiian honeycreeper: implications for native *Acacia koa* forestry. Ecological Applications 15:1053-1061.

Perkins RC. 1903. Verebrata. Pp. 365-466 *In* Fauna Hawaiiensis. Volume 1, Part IV (Sharp D, editor). Cambridge, UK: University Press.

Polhemus DA. "Damsels in distress: a review of the conservation status of Hawaiian Megalagrion damselflies." Available at: http://www.bishopmuseum.org/research/natsci/ento/Megalagrion/htmlPages/Mega01.shtml (accessed 12 February 2004).

Polhemus DA. 1993. Damsels in distress: a review of the conservation status of Hawaiian Megalagrion damselflies. Aquatic Conservation: Marine and Freshwater Ecosystems 3:343-49.

Polhemus DA, Asquith A. 1996. Hawaiian damselflies: a field identification guide. Honolulu (HI): Bishop Museum Press.

Polhemus DA. 2002. An initial review of *Orthotylus* in the Hawaiian Islands, with descriptions of twenty-one new species (Heteroptera: Miridae). Journal of the New York Entomological Society 110(3–4):270–340.

Polhemus DA. 2004. Critical species of Odonata in the Hawaiian Islands. International Journal of Odonatology 7(2):133-138.

Polhemus DA. 2004. Further studies on the genus *Orthotylus* (Heteroptera: Miridae) in the Hawaiian Islands, with descriptions of thirty-four new species. Journal of the New York Entomological Society 112(4):227–333.

Polovina JJ, Kleiber P, Kobayashi DR. 1999. Application of TOPEX-POSEIDON satellite altimetry to simulate transport dynamics of larvae of spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands, 1993-1996. Fisheries Bulletin 97:132-143.

Polovina, J.J., Dunne, J.P., Woodworth, P.A., and Howell, E.A. 2011. Projected expansion of the subtropical biome and contraction of the temperate and equatorial upwelling biomes in the North Pacific under global warming. ICES Journal of Marine Science. DOI: 10.1093/icesjms/fsq198.

Pratt DH, Brisbin IL. 2002. Hawaiian coot (*Fulica alai*). *In* The Birds of North America, No. 697 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Pratt DH, Bruner PL, Berrett DG. 1987. Field guide to the birds of Hawai‘i and the tropical Pacific. Princeton (NJ): Princeton University Press.

Pratt TK, Fancy SG, Ralph CJ. 2001 ‘Akiapola‘au (*Hemignathus munroi*) and nukupu‘u (*Hemignathus lucidus*). *In* The Birds of North America, No. 600 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Pratt TK, Kepler CB, Casey TLC. 1997. Po‘ouli (*Melamprosops phaesoma*). *In* The Birds of North America, No. 272 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Preston DK, McShane MK, Evenhuis NL, Samuelson GA, Arakaki KT, Polhemus DA. 2004. Arthropod Survey of the Waiakea 1942 Lava Flow Natural Area Reserve and Selected Kipuka Within the Mauna Loa Kipuka Mosaic, Hawai‘i. Contribution No. 2004-009 to the Hawai‘i Biological Survey, Honolulu (HI): Bishop Museum.

Price JP. 2004. Floristic biogeography of the Hawaiian Islands: influences of area, environment and paleogeography. Journal of Biogeography 31(3):487-500.

Price JP, Wagner WL. 2004. Speciation in Hawaiian angiosperm lineages: cause, consequence, and mode. Evolution 58(10):2185-2200.

Puaiohi Working Group and Hawaiian Forest Bird Recovery Team. 2002. Draft Puaiohi five-year recovery work plan. Honolulu, HI.

Public Access Shoreline Hawaii versus Hawaii County Planning Commission, 79 Haw. 425 (1995), *cert. denied* 517 U.S. 1163 (1996).

Pukui MK, Elbert SH. 1986. Hawaiian dictionary revised and enlarged edition. Honolulu: University of Hawai‘i Press.

Pyle RL. 2003. SIGHTINGS database *In* Occurrence and status of birds in Hawaii. Honolulu (HI): Bishop Museum; Database queried 25 February 2003.

Rana Productions and Planning Solutions. 2005. Preliminary draft – proposed operations manual. Save our Shearwaters Program. Calendar Year 2005. Honolulu, HI.

Randall JE. 1998. Shore fishes of Hawai‘i. Honolulu: University of Hawai‘i Press. 216 pp.

Rauzon M. 2001. Isles of refuge: wildlife and history of the Northwestern Hawaiian Islands. Honolulu: University of Hawai‘i Press.

Reeves RR, Smith BD, Crespo EA, Notabartolo di Sciara G. 2003. 2002-2010 Conservation action plan for the world’s cetaceans, dolphins, whales and porpoises. Gland, Switzerland: International Union for the Conservation of Nature.

Reeves RR, Stewart BS, Clapham PJ, Powell JA. 2002. Guide to marine mammals of the world. New York (NY): Alfred A. Knopf, Inc.

Reynolds MH. 2002. Habitat use and home range of the Laysan Teal on Laysan Island, Hawai‘i. Waterbirds 27:183-192.

Reynolds, M.H., P. Berkowitz, K.N. Courtot and C. M. Krause. 2012. Predicting sea-level rise vulnerability of terrestrial habitat and wildlife of the Northwestern Hawaiian Islands. Open-File Report 2012-1182, http://pubs.er.usgs.gov/publication/ofr20121182) (http://pubs.usgs.gov/of/2012/1182/of2012-1182.pdf)

Reynolds, M.R., K.N. Courtot, C. M. Krause, N.E. Seavy, P. Hartzell and J.S. Hatfield. 2013. Dynamics of seabird colonies vulnerable to sea-level rise at French Frigate Shoals, Hawai`i. Hawai‘i Cooperative Studies Unit Technical Report HCSU-037. https://pubs.er.usgs.gov/publication/70048507

Rich TD, et al. 2004. Partners in Flight North American landbird conservation plan. Ithaca (NY): Cornell Lab of Ornithology.

Richardson AM. Two new species of landhoppers (Crustacea: Talitridae) from O‘ahu, Hawaiian Islands, with redescription of *Platorchestia pickeringi* and key to landhoppers of O‘ahu Bishop Museum Occasional Papers 31:185-201 1991.

Richardson AM. 1992 Altitudinal distribution of native and alien landhoppers (Amphipoda: Talitradae) in the Ko‘olau Range, O‘ahu, Hawaiian Islands. Journal of Natural History 26(2):339-352.

Richmond, L., and Levine A. 2012. Institutional analysis of community-based marine resource management initiatives in Hawaii and American Samoa. U.S. Dep. Commerce., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-35, 48 p. + Appendices.

Rick Gaffney and Associates. 2000. Evaluation of the status of the recreational fishery for ulua in Hawai‘i and recommendations for future management. DAR Technical Report 20-02. Honolulu (HI): Division of Aquatic Resources. 35 pp.

Ricketts TH, et al. 1999. Terrestrial ecoregions of North America: a conservation assessment. Washington, DC: Island Press. 147 pp.

Rivera K. 1995. “Incidental catch of seabirds in longline fisheries” Juneau (AK): Waterbirds for the Americas.

Roberts AC, Meadows DW. 2003. Distribution and abundance of short-finned pilot whales (*Globicephala macrorhynchus*) and other odontocetes in the four-island region of Hawaii. Maui (HI): Pacific Whale Foundation. 19 pp.

Robinson JA, Reed JM, Skorupa JP, Oring LW. 1999. Black-necked stilt (*Himantopus mexicanus*). *In* The Birds of North America, No. 449 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Rosenberg, DM, Resh, VH and King, RS. 2008. Chapter 7: Use of Aquatic Insects in Biomonitoring. An Introduction to the Aquatic Insects of North America, 4th Edition (Merritt, RW, Cummins, KW and Berg, MB, eds.). Kendall Hunt Publishing, Dubuque, IA.

Roumasset J. 1999. Environmental evaluation and the Hawaiian economy. Honolulu: University of Hawai’i Economic Research Organization. Consultant report commissioned by the Nature Conservancy.

Rubinoff D. University of Hawai‘i. Personal communication. 2005.

Rubinoff D, Haines W. 2005. Web-spinning caterpillar stalks snails. Science 309:575.

Russo R. 1994. Hawaiian reefs. San Leandro (CA): Wavecrest Publications. 174 pp.

Russo CMA, Takezaki N, Nei M. 1995. Molecular phylogeny and divergence times of Drosophilid species. Molecular Biology and Evolution. 12:391-404.

Salafsky N, et al. 2003. Draft conventions for defining, naming, measuring, combining, and mapping threats in conservation: an initial proposal for a standard system.

Samuelson GA. 2003. Review of Hawaiian *Rhyncogonus*. Honolulu (HI): Bishop Museum Press.

Santos S. Auburn University. Personal communication.

Schoonmaker P, Luscome W. 2005. Habitat monitoring: an approach for reporting status and trends for state comprehensive wildlife conservation strategies.

Schreiber EA, Feare DJ, Harrington BA, Murray BG, Robertson WB, Robertson MJ, Woolfenden GE. 2002. Sooty tern (*Sterna fuscata*). *In* The Birds of North America, No. 665 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Schreiber EA, Norton RL. 2002. Brown booby (*Sula leucogaster*). *In* The Birds of North America, No. 649 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Schreiber EA, Schreiber RW. 1993. Red-tailed tropicbird (*Phaeton rubricauda*). *In* The Birds of North America, No. 43 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Schreiber EA, Schreiber RW, Schenk GA. 1996. Red-footed booby (*Sula sula*). *In* The Birds of North America, No. 241 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Schuster R, Murphy PW. 1991. The acari: reproduction, development and life-history strategies. New York (NY): Chapman and Hall. 554 pp.

Scott JM, Mountainspring S, Ramsey FL, Kepler CB. 1986. Forest bird communities of the Hawaiian islands: their dynamics, ecology and conservation. Lawrence (KS): Cooper Ornithological Society.

Scott MJ. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. United States Department of Interior, National Biological Survey. Available at: http://biology.usgs.gov/s+t/pdf/Hawai'i .pdf (accessed 3 December 2004).

Seto NWH. 2001. Christmas shearwater (*Puffinus nativitatis*). *In* The Birds of North America, No. 561 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Seto NWH, O'Daniel D. 1999. Bonin petrel (*Pterodroma hypoleuca*). *In* The Birds of North America, No. 385 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Shelley RM. 1999. Centipedes and millipedes with emphasis on North America fauna. The Kansas School Naturalist 45(3). Available at: http://www.emporia.edu/ksn/v45n3-march1999/intro.htm.

Simon JC, Baker PE, Baker H. 1997. Maui parrotbill (*Pseudonestor xanthophrys*). *In* The Birds of North America, No. 311 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Simons TR, Hodges CN. 1998. Dark-rumped petrel (*Pterodroma phaeopygia*). *In* The Birds of North America, No. 345 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Slotterback JW. 2002. Band-rumped Storm-petrel (*Oceandroma castro*). *In* The Birds of North America, No. 673 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Smith D. Wildlife Biologist. Division of Forestry and Wildlife. Personal communication.

Smith GC, Parrish JD. 2002. Estuaries as nurseries for the jacks *Caranx ignobilis* and *Caranx melampygus* (Carangidae) in Hawai‘i. Estuarine, Coastal and Shelf Science 55:347-359.

Snetsinger TJ, Reynolds MH, Herrmann CM. 1998 ‘O‘u (*Psittirostra psittacea*) and Lana‘i hookbill (*Dysmorodrepanis munroi*). *In* The Birds of North America, No. 335-336 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Snow NP, Witmer G. 2010. American bullfrogs as invasive species: a review of the introductions, subsequent problems, management options, and future direction. Proc. 24th Vertebr. Pest Conf. (R. M. Timm and K. A. Fagerstone, Eds.) Published at Univ. of Calif., Davis. 2010. Pp. 86-89.

Social Science Research Institute at the University of Hawai‘i at Manoa. 1998. Kaho‘olawe environmental restoration plan. Available at: http://kahoolawe.Hawai’i .gov/restoration/restoration_plan/restoration_plan.htm (accessed 9 March 2005).

Southwick Associates. 2013. The Conservation Economy in America: Direct Investments and Economic Contributions. The National Fish and Wildlife Foundation, Washington, D.C. Available at: http://www.avcrp.org/wp-content/uploads/2013/04/NFWF-Conservation-Economy-Rpt-Southwick-3-11-2013.pdf (accessed 30 June 30, 2015).

Spieth HT. 1981. History of the Hawaiian *Drosophila* project. Drosophila Information Service. 56: 6-14.

State of Hawai‘i, U.S. Department of the Interior, and the U.S. Department of Commerce. 2006. Memorandum of Agreement Promoting Coordinated Management of the Northwestern Hawaiian Islands Marine National Monument.

Stone CP, Pratt LW. 1994. Hawaii's plants and animals: biological sketches of Hawai'i Volcanoes National Park. Honolulu: Hawai'i Natural History Association.

Stone F. Personal communication.

Strommer L. University of Hawai'i graduate student. Unpublished data.

Sustainable Resources Group International, Inc. 2002. Marine Corps Base Hawai'i: invasive species management study: Draft Report. Honolulu, HI.

Suman TW. 1964. Spiders of the Hawaiian Islands: catalog and bibliography. Pacific Insects 6:665-687.

Suman TW. 1965. Spiders of the family Oonopidae in Hawaii. Pacific Insects 7:225-242.

Suman TW. 1970. Spiders of the family Thomisidae in Hawaii. Pacific Insects 12:773-864.

Sumiye J. 2002. Ko'olau Mountains Watershed Partnership management plan. Ko'olau Mountains Watershed Partnership.

Switzer R., Lieberman A, Nelson J, Crampton LH. 2013. Augmentation of the Puaiohi population through captive propagation and release on the Alakai Plateau, Kauai, Hawaii, USA. Reintroduction Specialist Group Book, IUCN.

Sykes PW, Kepler AK, Kepler CB, Scott JM. 2000. Kaua'i o'o (*Moho braccatus*), O'ahu 'o'o (*Moho apicalis*), Bishop's 'o'o (*Moho bishopi*), Hawai'i 'o'o (*Moho nobilis*), and kioea (*Chaetoptila angustipluma*). *In* The Birds of North America, No. 535 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Takumi RL. 1999. A systematic review of the Ectemnius (Hymenoptera: Sphecidae) of Hawai'i, University of California Press.

Tate DC. 1997. The role of behavioral interactions of immature Hawaiian stream fishes (Pisces: Gobiodei) in population dispersal and distribution. Micronesica 30(1) 51-70.

Teaming with Wildlife. Monitoring, evaluation, and performance measurement. Available at: http://www.teaming.com/cwcs_monitoring.htm (last accessed 5 August 2005).

Teaming with Wildlife. State wildlife strategy drafts and outline. Available at: http://www.teaming.com/cwcs_drafts.htm (last accessed 4 August 2005).

Teel TL, Dayer AA. 2005. Preliminary state-specific results from the research project entitled "Wildlife values in the west 2004." Fort Collins: Human Dimensions in Natural Resources Unit, Colorado State University.

TenBruggencate J. 2005 July 11. New coastal guidelines sought. Honolulu Advertiser. Available at: http://www.honoluluadvertiser.com/apps/pbcs.dll/article?AID=/20050711/NEWS11/507110333/1021/NEWS

Threatened and Endangered Species System. U.S. Fish and Wildlife Service Available at: http://ecos.fws.gov/tess_public/TESSWebpageUsaLists?state=HI (accessed 3 January 2005).

Timbol AS, Maciolek JA. 1978. Stream Channel Modifications in Hawaii, Part. A: statewide inventory of streams; habitat factors and associated biota. FWS/OBS-78/16, April 1978. Hawai'i Cooperative Fisheries Unit, University of Hawaii, Contract No. 14-16-0008-1199, U.S. Fish and Wildlife Service, U.S. Department of the Interior.

Tinker S. 1978. Fishes of Hawai‘i. Honolulu (HI): Hawaiian Service, Inc. 532 pp.

Titcomb M. 1972. Native use of fish in Hawai‘i. Honolulu: University of Hawai‘i Press.

Titcomb M. 1978. Native use of marine invertebrates in old Hawai‘i. Pacific Science 32:325-386.

Three Mountain Alliance. 2007. Three Mountain Alliance Management Plan. Available at: http://hawp.org/_library/documents/three-mountain-alliance/tma%20mgmt%20plan.final.2.pdf (Accessed June30, 2015).

Tweed, E. USGS. Personal communication.

Udvardy MD, Engilis, Jr., A. 2001. Migration of northern pintail across the Pacific with reference to the Hawaiian Islands. Studies in Avian Biology No. 22:124-132.

U.S. Army Garrison, Hawai‘i and U.S. Army Corps of Engineers. 2005. Integrated natural resources management plan and implementation plan for the U.S. Fish and Wildlife Service Biological Opinion, 2005-2010. Prepared by the Center for Ecological Management of Military Lands, Fort Collins: Colorado State University, and the Natural Resources Office, Pohakuloa Training Area, U.S. Army, Hawai‘i.

U.S. Department of Commerce, U.S. Census Bureau. 2010. National Park Service Visits and Acreage by State 2010. Available at: http://www.census.gov/compendia/statab/2012/tables/12s1254.pdf (accessed June 27, 2015).

U.S. Department of Commerce, U.S. Census Bureau. 2015. State and County Quick Facts. Updated as of 28 May 2015. Available at: http://quickfacts.census.gov/qfd/states/15/15003.html (accessed June 27, 2015).

U.S. Department of the Interior, U.S. Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Available at: https://www.census.gov/prod/2012pubs/fhw11-nat.pdf (accessed 27 June 27, 2015).

U.S. Environmental Protection Agency; Biocriteria [Internet]. 2005 May 9; Available from: www.epa.gov/waterscience/biocriteria/glossary.html.

U.S. Fish and Wildlife Service. Kealia Pond National Wildlife Refuge. Available at: http://refuges.fws.gov/profiles/index.cfm?id=12531.

U.S. Fish and Wildlife Service. Hawaiian Islands National Wildlife Refuge. Available at: http://refuges.fws.gov/profiles/index.cfm?id=12526.

U.S. Fish and Wildlife Service. 1984. Recovery plan for the Northwestern Hawaiian Islands passerines. Portland (OR): U.S. Fish and Wildlife Service. 66 pp.

U.S. Fish and Wildlife Service. 1986. Hawaiian Islands National Wildlife Refuge master plan, Environmental Impact Statement. Honolulu (HI): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O‘ahu Tree Snails of the genus *Achatinella*. Portland (OR): U.S. Fish and Wildlife Service. 64 pp. + 64 pp. of Appendices + 5 figures.

U.S. Fish and Wildlife Service. 1998. Laysan Island ecosystem restoration plan. Honolulu (HI): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland (OR): U.S. Fish and Wildlife Service. 50 pp.

U.S. Fish and Wildlife Service. 1999. Draft revised recovery plan for Hawaiian waterbirds, Second Revision. Portland (OR): U.S. Fish and Wildlife Service. 107 pp.

U.S. Fish and Wildlife Service. 2001. Determination of Critical Habitat for the Oahu Elepaio (*Chasiempis sandwichensis ibidis*): Final Rule. Honolulu (HI): U.S. Fish and Wildlife Service. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/elepaiofr.pdf.

U.S. Fish and Wildlife Service. 2002. Final economic analysis of designations of critical habitat for plant species from the NWHI. Honolulu (HI): Research Solutions, LLC.

U.S. Fish and Wildlife Service. 2002. Final Rule: Designation of Critical Habitat for the Newcomb’s Snail. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/newcombssnailfch82002.pdf.

U.S. Fish and Wildlife Service. 2003. A blueprint for the future of migratory birds: migratory bird program strategic plan 2004-2014. Portland (OR): U.S. Fish and Wildlife Service, Region 1. 16 pp.

U.S. Fish and Wildlife Service. 2003. Draft revised recovery plan for the ʻAlala (Corvus hawaiiensis). Portland (OR): U.S. Fish and Wildlife Service. Xi+78 pp.

U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn's Sphinx Moth: final rule. Federal Register 68:34710-34766.

U.S. Fish and Wildlife Service. 2003. Final Rule: designation of Critical Habitat for the Kauaʻi cave wolf spider and Kauaʻi cave amphipod. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/kauaicavefinal.pdf.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation of Critical Habitat for three plant species from the island of Lanai, Hawaiʻi.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation or non-designation of Critical Habitat for 95 plant species from the islands of Kauaʻi and Niʻihau, HI. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/kauaifinal.pdf.

U.S. Fish and Wildlife Service. 2003. Final designation and non-designation of Critical Habitat for 42 plant species from the islands of Molokai, Hawaiʻi; Final Rule. 68 FR 12982. Honolulu, HI.

U.S. Fish and Wildlife Service. 2003. Final Rule: final designation or non-designation of Critical Habitat for 101 plant species from the island of Oahu, Hawaiʻi. Honolulu, HI. Available at: http://www.fws.gov/pacific/pacificislands/CHRules/oahufinal.pdf.

U.S. Fish and Wildlife Service. 2004. Draft recovery plan for the Kauaʻi cave arthropods: the Kauaʻi cave wolf spider (*Adelocosa anops*) and the Kauaʻi cave amphipod *(Spelaeorchestia koloana*). Portland (OR): U.S. Fish and Wildlife Service. 55 pp.

U.S. Fish and Wildlife Service. 2004. Draft regional seabird conservation plan. Portland (OR): U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2004. Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose (*Branta sandvicensis*). Portland, Oregon. 148 pp.

U.S. Fish and Wildlife Service. 2004. Draft Regional Seabird Conservation Plan. Portland (OR): U.S. Fish and Wildlife Service Oregon.

U.S. Fish and Wildlife Service. Hawaiian Islands Animals: Listed and Candidate Species, as Designated under the U.S. Endangered Species Act. Updated May 10, 2004.

U.S. Fish and Wildlife Service. 2005. Pacific Islands – National Wildlife Refuges. Available at http://www.fws.gov/pacific/pacificislands/wnwr/kauainwrindex.html.

U.S. Fish and Wildlife Service. 2005. Recovery plan for the Blackburn's Sphinx Moth (*Manduca blackburni*). Portland, Oregon. 125 pp.

U.S. Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific Region. U.S. Fish and Wildlife Service, Migratory Birds and Habitat Programs, Pacific Region. Portland, Oregon.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71:26835–26852.

U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon. 622 pp.

U.S. Fish and Wildlife Service. 2006. Recovery plan for the Newcomb's snail *(Erinna newcomb*i). Portland, Oregon.

U.S. Fish and Wildlife Service and Association of Fish and Wildlife Agencies. 2007. Guidance for Wildlife Action Plan (Comprehensive Wildlife Conservation Strategy) Review and Revisions. Guidance Letter. Washington, D.C.

U.S. Fish and Wildlife Service. 2007. Newcomb's Snail (*Erinna newcombi*). 5-year Review: Summary and Evaluation. Honolulu, Hawai'i.

U.S. Fish and Wildlife Service. 2008. Draft Post-delisting Monitoring Plan for the Hawaiian Hawk, or Io (*Buteo solitarius*). Endangered Species Division, Pacific Island Fish and Wildlife Office, Honolulu, HI.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73:73734–73895.

U.S. Fish and Wildlife Service. 2008. Draft Post-Delisting monitoring plan for the Hawaiian hawk, or Io (Buteo solitaries). Available at: http://www.fws.gov/pacificislands/CH_Rules/HawaiianhawkdraftPDMPlan%20December%202008%20-%20approved%20by%20RO.pdf (Accessed June 30, 2015)

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; withdrawal of proposed reclassification of the Hawaiian hawk or io (*Buteo solitarius*) from endangered to threatened; proposed rule to remove the Hawaiian hawk from the federal list of endangered and threatened wildlife. Federal Register 73:45680–45689.

U.S. Fish and Wildlife Service. 2008. Short-tailed Albatross Recovery Plan. Anchorage, Alaska.

U.S. Fish and Wildlife Service. 2009. Blackburn's Sphinx Moth (*Manduca blackburni*) 5-Year Review: Summary and Evaluation. Pacific Islands Fish and Wildlife Office. Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2009. Revised Recovery Plan for the ‘Alalā (*Corvus hawaiiensis*). Portland, Oregon. xiv + 104 pages.

U.S. Fish and Wildlife Service. 2009. Revised Recovery Plan for the Laysan Duck (*Anas laysanensis*). U.S. Fish and Wildlife Service, Portland, Oregon. 114 pp.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; determination of endangered status for 48 species on Kauai and designation of critical habitat. Federal Register 75:18960–19008.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; listing the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly as endangered throughout their ranges. Federal Register 75:35990–36012.

U.S. Fish and Wildlife Service. 2010. Hawaiian coot or ‘alae ke‘oke‘o (*Fulica alai*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2010. Hawaiian stilt or Ae‘o (*Himantopus mexicanus knudseni*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2010. Hakalau Forest National Wildlife Refuge Comprehensive Conservation Plan. Portland Oregon.

U.S. Fish and Wildlife Service. 2010. Koloa maolo or Hawaiian duck (*Anas wyvilliana*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2010. ‘Ōpe‘ape‘a or Hawaiian Hoary Bat (*Lasiurus cinereus semotus):* 5-year Review: Summary and Evaluation. Pacific Islands Fish and Wildlife Office, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2010. Nihoa Millerbird (*Acrocephalus familiaris kingi*) 5-Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76:55170–55203.

U.S. Fish and Wildlife Service. 2011. Nene or Hawaiian goose (*Branta sanvicensis*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2011. Nihoa Finch (*Telespiza ultima*) 5-Year Review. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2011. Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2011. Newell’s shearwater (*Puffinus auricularis newelli*). 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77:57648–57862.

U.S. Fish and Wildlife Service. 2012. Laysan duck (*Anas laysanensis*) 5-year review: short form summary. U.S. Fish and Wildlife Service, Honolulu, HI.

U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered species status for 15 species on Hawaii Island. Federal Register 78:64638–64690.

U.S. Fish and Wildlife Service. 2014. Laysan Finch (*Telespiza cantans*) 5-Year Review, Short Form Summary. U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

U.S. Fish and Wildlife Service. 2014. Short-tailed Albatross (*Phoebastria albatrus*). 5-Year Review: Summary and Evaluation. Anchorage, Alaska.

U.S. Fish and Wildlife Service. 2014. Species Assessment and Listing Priority Assignment Form: *Oceandroma castro,* Band-rumped Storm-petrel. U.S. Fish and Wildlife Service, Region 1, Pacific Region.

U.S. Fish and Wildlife Service. 2015. Listed Species Believed to or Known to Occur in Hawaii. Endangered species lists by state report. Available at http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=HI&status=listed (accessed June 30, 2015).

U.S. Fish and Wildlife Service. 2015. Threatened and Endangered Species Lists., Available at http://ecos.fws.gov/ecp/ (accessed June 30, 2015).

U.S. Geological Service; Volcano Hazards Program- Reducing Volcanic Rick [Internet]. Menlo Park, CA: USGS; 4 Sept 2000. Available from: http://volcanoes.usgs.gov/Products/Pglossary/ShieldVolcano.html.

U.S. Marine Corps Base Hawai‘i. Natural resources conservation – small installations. FY01-03. Available at: https://www.denix.osd.mil/denix/Public/News/OSD/SecDef03/NRC/nrc_Hawai’i .pdf.

Usinger RL. 1942. The genus *Nysius* and its allies in the Hawaiian Islands (Hemiptera, Lygaeidae, Orsillini). Bernice P. Bishop Museum Bulletin 173:1–167.

VanderWerf EA. 1998. ‘Elepaio (Chasiempis sandwichensis). In The Birds of North America, No. 344 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

VanderWerf, EA. 2012. Hawaiian Bird Conservation Action Plan. Pacific Rim Conservation, Honolulu, HI.

VanderWerf EA, Rohrer JL. 1996. Discovery of an ‘I‘iwi population in the Ko‘olau Mountains of O‘ahu. ‘Elepaio 56:25–28.

VanderWerf EA, Rohrer JL, Smith DG, Burt MD. 2001. Current distribution and abundance of the O‘ahu ‘elepaio. Wilson Bulletin 113:10-16.

VanderWerf EA, Lohr MT, Titmus AJ, Taylor PE, Burt MD. 2013. Current distribution and abundance of the O‘ahu Elepaio (Chasiempis ibidis). Wilson Journal of Ornithology 125:600-608.

Vanderwerf, EA, LH Crampton, PK Roberts, JS Diegmann, and DL Leonard. 2014. Survival estimates of wild and captive-released Puaiohi, an endangered Hawaiian thrush. Condor 116: 609–618. DOI: 10.1650/CONDOR-14-18.1

Van Houtan KS, Hargrove SK, and Balazs GH. 2010. Land use, macroalgae, and a tumor-forming disease in marine turtles. PLoS ONE 5(9): e12900. doi:10.1371/journal.pone.0012900.

Van Houtan KS, Kittinger JN, Lawrence AL, Yoshinaga C, Born VR, and Fox A. 2012. Hawksbill sea turtles in the Northwestern Hawaiian Islands. Chelonian Conservation and Biology 11 (1):117-121.

Vandergast AG, Gillespie RG. 2004 Effects of natural forest fragmentation on a Hawaiian spider community. Environmental Entomology 33:1296-1305.

Vandergast AG, Gillespie RG, Roderick GK. 2004. Influences of volcanic activity on the population genetic structure of Hawaiian *Tetragnatha*. Molecular Ecology 13:1729-1743.

Vredevoe, Larisa. Background information on the biology of ticks. Available at: http://entomology.ucdavis.edu/faculty/rbkimsey/tickbio.html.

Wagner WL, Herbst DR, Sohmer SH. 1999. Manual of the flowering plants of Hawai‘i, Revised Edition, Volumes 1 and 2. Honolulu: University of Hawai‘i Press and Bishop Museum Press.

Wakelee KM, Fancy SG. 1999. ‘Oma‘o (*Myadestes obscurus*), kama‘o (*Myadestes myadestinus*), oloma‘o (*Myadestes lanaiensis*), and ‘amaui (*Myadestes woahensis*). *In* The Birds of North America, No. 460 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Waples RS, Randall JE. 1988. A revision of the Hawaiian USA lizardfishes of the genus *Synodus* with descriptions of four new species. Pacific Science 42:178-213.

Warren CW, Mounce HL. 2014. Home-range patterns of two Hawaiian honeycreepers, Kiwikiu (*Pseudonestor xanthophrys*) and Maui Alauahio (*Paroeomyza montana*). Presentation. Island Biology Conference, Honolulu, HI.

Warshauer R. USGS. Personal communication.

Way CM, et al. 1998. Reproductive biology of the endemic goby, *Lentipes concolor*, from Malamaka‘ole Stream, Maui and Waikolu Stream, Moloka‘i. Environmental Biology of Fishes 51:53- 65.

Wells SM, Pyle RM, Collins NM. 1983. IUCN invertebrate Red Data Book. Gland, Switzerland: International Union on the Conservation of Nature and Natural Resources.

West Maui Mountains Watershed Partnership. 2001. Final environmental assessment for the West Maui Mountains watershed protection project.

Western Pacific Fishery Information Network. online data. Available at: http://www.pifsc.noaa.gov/wpacfin/ (accessed May 2005).

Western Pacific Fisheries Management Council. Fishery management plan for the precious coral fisheries of the Western Pacific Region. Honolulu (HI): Western Pacific Fisheries Management Council. Available at: http://www.wpcouncil.org/precious.htm.

Western Pacific Regional Fishery Management Council. 2003. Annual report for the bottomfish and seamount groundfish management plan. Available at: http://www.wpcouncil.org/bottomfish.htm.

Weygoldt P. 1969. The biology of pseudoscorpions. Cambridge (MA): Harvard University Press. 145 pp.

Whittow GC. 1993. Black-footed albatross (*Diomeda nigripes*). *In* The Birds of North America, No. 65 (Poole A, Gill F, editors). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Whittow GC. 1993. Laysan albatross (*Diomedea immutabilis*). *In* The Birds of North America, No. 66 (Poole A, Gill F, editors.). Philadelphia: The Academy of Natural Sciences; Washington DC: The American Ornithologists' Union.

Whittow GC. 1997. Wedge-tailed shearwater (*Puffinus pacificus*). *In* The Birds of North America, No. 305 (Poole A, Gill F, editors.). Philadelphia (PA): The Academy of Natural Sciences; and Washington DC: The American Ornithologists' Union.

Wood KR, Polhemus J. Unpublished data.

Yamamoto M, Tagawa A. 2000. Hawai‘i's native and exotic freshwater animals. Honolulu (HI): Mutual Publishing. 200 pp.

Young FN, Kritksy G. 2002. A survey of entomology. Lincoln (NE): Writers Club Press. 308 pp.

Zhang Z-Q. 2003. Mites of greenhouses: identification, biology and control. Cambridge (MA): CABI Publishing. 256 pp.

Ziegler AC. 2002. Hawaiian Natural History, Ecology, and Evolution. Honolulu: University of Hawai‘i Press, 157 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2. Honolulu: University of Hawai‘i Press. 475 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai‘i Press.

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Mammals	T	*Lasiurus cinereus semotus*	Hawaiian hoary bat	ʻōpeʻapeʻa	ʻŌpeʻapeʻa	**X**		**X**	**X**		**X**		**X**		**E**	**E**
Forest Birds	T	*Moho braccatus*	Kauaʻi ʻōʻō	ʻōʻō ʻāʻā	Kauaʻi ʻōʻō	X									**E**	**E**
Forest Birds	T	*Moho bishopi*	Bishop's ʻōʻō	ʻōʻō	Bishop's ʻōʻō				X		X?					
Forest Birds	T	*Corvus hawaiiensis*	Hawaiian crow	ʻalalā	Hawaiian Crow								X		**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis sclateri*	Kauaʻi ʻelepaio	ʻelepaio	Kauaʻi ʻelepaio	**X**										
Forest Birds	T	*Chasiempis sandwichensis ibidis*	Oʻahu ʻelepaio	ʻelepaio	Oahu ʻelepaio			**X**							**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis sandwichensis*	Hawaiʻi ʻelepaio	ʻelepaio	Hawaiʻi ʻelepaio								**X**			
Forest Birds	T	*Myadestes myadestinus*	Large Kauaʻi thrush	kāmaʻo	Kāmaʻo	X									**E**	**E**
Forest Birds	T	*Myadestes lanaiensis*	Molokaʻi thrush	olomaʻo	Olomaʻo			X?	X	X	X?				**E**	**E**
Forest Birds	T	*Myadestes obscurus*	Hawaiʻi thrush	ōmaʻo	Ōmaʻo								**X**			
Forest Birds	T	*Myadestes palmeri*	Small Kauaʻi thrush	puaiohi	Puaiohi	**X**									**E**	**E**
Forest Birds	T	*Psittirostra psittacea*	ʻōʻū	ʻōʻū	ʻŌʻū	**X**		X	X	X	X		**X**		**E**	**E**
Forest Birds	T	*Loxioides bailleui*	Palila	palila	Palila								**X**		**E**	**E**
Forest Birds	T	*Pseudonestor xanthophrys*	Maui parrotbill	kiwikiu	Maui Parrotbill				X		**X**				**E**	**E**
Forest Birds	T	*Hemignathus virens*	Hawaiʻi ʻamakihi	ʻamakihi	Hawaiʻi ʻamakihi				**X**	X	**X**		**X**			
Forest Birds	T	*Hemignathus virens wilsoni*	Maui ʻAmakihi	ʻAmakihi	see: Hawaiʻi ʻamakihi					X	**X**					**E**
Forest Birds	T	*Hemignathus flavus*	Oʻahu ʻamakihi	ʻamakihi	Oʻahu ʻamakihi			**X**								
Forest Birds	T	*Hemignathus kauaiensis*	Kauaʻi ʻamakihi	alawī kihi	Kauaʻi ʻamakihi	**X**										
Forest Birds	T	*Hemignathus parvus*	Lesser ʻamakihi	ʻanianiau	ʻAnianiau	**X**										
Forest Birds	T	*Hemignathus procerus*	Kauaʻi ʻakialoa	ʻakialoa	Kauaʻi ʻakialoa	X									**E**	**E**
Forest Birds	T	*Hemignathus lucidus hanapepe*	Kauaʻi nuku puʻu	nuku puʻu	Kauaʻi nuku puʻu	X									**E**	**E**
Forest Birds	T	*Hemignathus lucidus affinis*	Maui nuku puʻu	nuku puʻu	Maui nuku puʻu						X				**E**	**E**
Forest Birds	T	*Hemignathus munroi*	ʻakiapōlāʻau	ʻakiapōlāʻau	ʻAkiapōlāʻau								**X**		**E**	**E**
Forest Birds	T	*Oreomystis bairdi*	Kauaʻi creeper	ʻakikiki	ʻAkikiki	**X**									**E**	**E**
Forest Birds	T	*Oreomystis mana*	Hawaiʻi creeper	ʻalawī	Hawaiʻi creeper								**X**		**E**	**E**
Forest Birds	T	*Paroreomyza maculata*	Oʻahu creeper	ʻalauahio	Oʻahu ʻalauahio			**X**							**E**	**E**
Forest Birds	T	*Paroreomyza flammea*	Molokaʻi creeper	kākāwahie	Molokaʻi creeper				X						**E**	**E**
Forest Birds	T	*Paroreomyza montana*	Maui creeper	ʻalauahio	Maui ʻalauahio					X	**X**					

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Forest Birds	T	*Loxops caeruleirostris*	Kaua'i 'ākepa	'akeke'e	'Akeke'e	**X**									**E**	**E**
Forest Birds	T	*Loxops coccineus ochraceus*	Mau'i 'ākepa	'ākepa	Maui 'ākepa						X				**E**	**E**
Forest Birds	T	*Loxops coccineus coccineus*	Hawai'i 'ākepa	'ākepa	'Ākepa								**X**		**E**	**E**
Forest Birds	T	*Vestiaria coccinea*	'i'iwi	'i'iwi	'I'iwi	**X**		**X**	**X**	X	**X**	X?	**X**			**E**
Forest Birds	T	*Palmeria dolei*	Crested honeycreeper	'ākohekohe	'Ākohekohe				X		**X**				**E**	**E**
Forest Birds	T	*Himatione sanguinea*	'apapane	'apapane	'Apapane	**X**		**X**	**X**	**X**	**X**		**X**			
Forest Birds	T	*Melamprosops phaeosoma*	Po'ouli	po'ouli	Po'ouli						**X**				**E**	**E**
Raptors	T	*Buteo solitarius*	Hawaiian hawk	'io	Hawaiian Hawk	X			X				**X**		**E**	**E**
Raptors	T	*Asio flammeus sandwichensis*	Hawaiian short-eared owl	pueo	Pueo	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		**E**
Waterbirds	T/F/A	*Nycticorax nycticorax hoactli*	Black-crowned night heron	'auku'u	Black-crowned Night Heron	**X**	**X**	**X**	**X**	**X**	**X**		**X**			
Waterbirds	T/F	*Branta sandvicensis*	Hawaiian goose	nēnē	Hawaiian goose	**X**	X		**X**	X	**X**	X	**X**		**E**	**E**
Waterbirds	T/F	*Anas wyvilliana*	Hawaiian Duck	koloa maoli	Hawaiian Duck	**X**	**X**	**X?**	X		**X?**		**X**		**E**	**E**
Waterbirds	T/F	*Anas laysanensis*	Laysan Duck	none	Laysan Duck	X		X	X		X		X	**X**	**E**	**E**
Waterbirds	T/F	*Gallinula chloropus sandvicensis*	Hawaiian common moorhen/gallinule	'alae 'ula	Hawaiian moorhen	**X**	X	**X**	**X?**		X		X		**E**	**E**
Waterbirds	T/F	*Fulica alai*	Hawaiian coot	'alae ke'oke'o	Hawaiian coot	**X**	**X**	**X**	**X**	**X**	**X**		**X**		**E**	**E**
Waterbirds	T/F/A	*Himantopus mexicanus knudseni*	Hawaiian stilt	ae'o	Hawaiian stilt	**X**	**X**	**X**	**X**	**X**	**X**		**X**		**E**	**E**
Seabirds	T	*Phoebastria immutabilis*	Laysan albatross	mōlī	Laysan Albatross	**X**		**X**						**X**		
Seabirds	T	*Phoebastria nigripes*	Black-footed albatross	ka'upu	Black-footed Albatross			**X**						**X**		
Seabirds	T	*Phoebastria albatrus*	Short-tailed albatross	none	Short-tailed Albatross									**X**	**E**	**E**
Seabirds	T	*Pterodroma sandwichensis*	Hawaiian petrel	'ua'u	Hawaiian Petrel	**X**		**X**	**X**	**X**	**X**	**X**	**X**		**E**	**E**
Seabirds	T	*Pterodroma hypoleuca*	Bonin petrel	none	Bonin Petrel	X		X	X	X	X	X	X	**X**		
Seabirds	T	*Bulweria bulwerii*	Bulwer's petrel	'ou	Bulwer's Petrel	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Seabirds	T	*Puffinus pacificus*	Wedge-tailed shearwater	'ua'u kani	Wedge-tailed Shearwater	**X**		**X**	**X**	**X**	**X**		**X**	**X**		

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Seabirds	T	*Puffinus nativitatis*	Christmas shearwater	none	Christmas Shearwater	**X**		**X**						**X**		
Seabirds	T	*Puffinus auricularis newelli*	Newell's shearwater	ʻaʻo	Newell's Shearwater	**X**		**X?**	**X**	**X?**	**X?**		**X**		**T**	**T**
Seabirds	T	*Oceanodroma castro*	Band-rumped storm petrel	ʻakēʻakē	Band-rumped Storm Petrel	**X**		X	X	X	**X**	**X**	**X**		**C**	**E**
Seabirds	T	*Oceanodroma tristrami*	Tristram's storm petrel	none	Tristram's Storm Petrel									**X**		
Seabirds	T	*Phaethon lepturus*	White-tailed tropicbird	koaʻe kea	White-tailed Tropicbird	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Seabirds	T	*Phaethon rubricauda*	Red-tailed tropicbird	koaʻe ʻula	Red-tailed Tropicbird	**X**		**X**		**X**		**X**		**X**		
Seabirds	T	*Sula dactylatra*	Masked (blue-faced) booby	ʻā	Masked (blue-faced) Booby			**X**			**X**			**X**		
Seabirds	T	*Sula leucogaster*	Brown booby	ʻā	Brown Booby	**X**		**X**						**X**		
Seabirds	T	*Sula sula*	Red-footed booby	ʻā	Red-footed Booby	**X**		**X**						**X**		
Seabirds	T	*Fregata minor*	Great frigatebird	ʻiwa	Great Frigatebird	**X**		**X**						**X**		
Seabirds	T	*Sterna lunata*	Gray-backed tern	pākalakala	Gray-backed Tern			**X**						**X**		
Seabirds	T	*Sterna fuscata*	Sooty tern	ʻewaʻewa	Sooty Tern			**X**						**X**		
Seabirds	T	*Anous stolidus*	Brown noddy	noio-kōhā	Brown Noddy			**X**			**X**			**X**		
Seabirds	T	*Anous minutus*	Black noddy	noio	Black Noddy	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Seabirds	T	*Procelsterna cerulea*	Blue-gray noddy	none	Blue-gray Noddy									**X**		
Seabirds	T	*Gygis alba*	White (Fairy) tern	manu-o-Kū	White (Fairy) Tern			**X**						**X**		**T**
Migratory Birds	T/F	*Anas americana*	American wigeon	none	American Wigeon	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Migratory Birds	T/F	*Anas clypeata*	Northern shoveler	koloa mōhā	Northern Shoveler	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Migratory Birds	T/F	*Anas acuta*	Northern pintail	koloa māpu	Northern Pintail	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Migratory Birds	T/F	*Aythya affinis*	Lesser scaup	none	Lesser Scaup	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Migratory Birds	T/F/A	*Pluvialis fulva*	Pacific golden plover	kōlea	Pacific Golden Plover	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Migratory Birds	T/F/A	*Heteroscelus incanus*	Wandering tattler	ʻūlili	Wandering Tattler	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		

T=terrestrial, F=freshwater, A=anchialine, M=marine

***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Migratory Birds	T/F	*Numenius tahitiensis*	Bristle-thighed curlew	kioea	Bristle-thighed Curlew	**X**	**X**	**X**	**X**		**X**	**X**	**X**	**X**		
Migratory Birds	T/F/A	*Arenaria interpres*	Ruddy turnstone	‘akekeke	Ruddy Turnstone	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Migratory Birds	T/F	*Calidris alba*	Sanderling	hunakai	Sanderling	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
NWHI passerines	T	*Acrocephalus familiaris kingi*	Nihoa millerbird	none	Nihoa Millerbird									**X**	**E**	**E**
NWHI passerines	T	*Telespyza cantans*	Laysan finch	none	Laysan finch									**X**	**E**	**E**
NWHI passerines	T	*Telespyza ultima*	Nihoa finch	none	Nihoa finch									**X**	**E**	**E**
Invertebrates - snails	T	Order Archaeogastropoda	Land snails	none	Land snails	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - snails	T	Order Stylommatophora	Land snails	none	Land snails	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	?		
Invertebrates - snails	T	*Achatinella spp.*	O‘ahu tree snail	none	*Achatinella spp.*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella apexfulva*	O‘ahu tree snail	none	*Achatinella apexfulva*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella bulimoides*	O‘ahu tree snail	none	*Achatinella bulimoides*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella byronii/ decepiens*	O‘ahu tree snail	none	*Achatinella byronii/ decepiens*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella concavospira*	O‘ahu tree snail	none	*Achatinella concavospira*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella fulgens*	O‘ahu tree snail	none	*Achatinella fulgens*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella fuscobasis*	O‘ahu tree snail	none	*Achatinella fuscobasis*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella lila*	O‘ahu tree snail	none	*Achatinella lila*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella livida*	O‘ahu tree snail	none	*Achatinella livida*			**X**							**E**	**E**

Hawaii's State Wildlife Action Plan
October 1, 2015

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - snails	T	*Achatinella mustelina*	O'ahu tree snail	none	*Achatinella mustelina*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella pupukanioe*	O'ahu tree snail	none	*Achatinella pupukanioe*			**X**							**E**	**E**
Invertebrates - snails	T	*Achatinella sowerbyana*	O'ahu tree snail	none	*Achatinella sowerbyana*			**X**							**E**	**E**
Invertebrates - snails	T	*Amastra cylindrica*	O'ahu terrestrial snail	none	*Amastra cylindrica*			**X**								
Invertebrates - snails	T	*Amastra spirizona*	O'ahu terrestrial snail	none	*Amastra spirizona*			**X**								
Invertebrates - snails	T	*Auriculella pulchra*	O'ahu tree snail	none	*Auriculella pulchra*			**X**								
Invertebrates - snails	T	*Cookeconcha hystricella*	O'ahu tree snail	none	*Cookeconcha hystricella*			**X**								
Invertebrates - snails	T	*Kaala subrutila*	O'ahu terrestrial snail	none	*Kaala subrutila*			**X**								
Invertebrates - snails	T	*Laminella aspera*	Maui terrestrial snail	none	*Laminella aspera*						**X**					
Invertebrates - snails	T	*Laminella sanguinea*	O'ahu terrestrial snail	none	*Laminella sanguinea*			**X**								
Invertebrates - snails	T	*Newcombia cumingi*	Newcomb's tree snail	none	*Newcombia cumingi*						**X**				**E**	**E**
Invertebrates - snails	T	*Partulina mighelsiana*	Molokai tree snail	none	*Partulina mighelsiana*				**X**							
Invertebrates - snails	T	*Partulina proxima*	Molokai tree snail	none	*Partulina proxima*				**X**							
Invertebrates - snails	T	*Partulina redfieldi*	Molokai tree snail	none	*Partulina redfieldi*				**X**							
Invertebrates - snails	T	*Partulina tessellata*	Molokai tree snail	none	*Partulina tessellata*				**X**							

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - snails	T	*Partulina semicarinata*	Lāna'i tree snail	pupu kani oe	*Partulina semicarinata*					**X**					**E**	**E**
Invertebrates - snails	T	*Partulina variabilis*	Lāna'i tree snail	pupu kani oe	*Partulina variabilis*					**X**					**E**	**E**
Invertebrates - arachnids	T	Order Acari	Mites and Ticks	none	Mites and Ticks	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - arachnids	T	Order Araneae	Spiders	none	Spiders	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - arachnids	T	*Nihoa hawaiiensis*	Mokumanamana trapdoor spider	none	Brushed trapdoor spiders									**X**		
Invertebrates - arachnids	T	*Nihoa mahina*	Nihoa trapdoor spider	none	Brushed trapdoor spiders									**X**		
Invertebrates - arachnids	T	Family Lycosidae	Wolf spiders	none	Wolf spiders	**X**		**X**	**X**		**X**		**X**	**X**		
Invertebrates - arachnids	T	*Adelocosa anops*	Kaua'i cave wolf spider	none	Kaua'i cave arthropods	**X**									**E**	**E**
Invertebrates - arachnids	T	Order Pseudoscorpionida	Pseudoscorpions	none	Pseudoscorpions	**X**		**X**			**X**		**X**	**X**		
Invertebrates - Springtiails	T	Class Collembola	Springtails	none	Springtails	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	Order Archaeognatha (Microcoryphia)	Jumping bristletails	none	Jumping bristletails	**X**		**X**	**X**	**X**	**X**		**X**	?		
Invertebrates - insects	T	Order Coleoptera	Beetles	none	Beetles	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Proterhinus* spp.	Primitive weevils	none	Primitive weevils	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Family Carabidae	Ground beetles	none	Ground beetles	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Family Curculionidae	Weevils	none	Weevils	**X**		**X**	**X**	**X**	**X**		**X**			

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Invertebrates - insects	T	*Rhynchogonus* spp.	Broad-nosed weevils	none	Broad-nosed weevils	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Superfamily Elateroidea	Click beetles	none	Click beetles	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Apterocyclus* spp.	Kaua'i flightless stag beetles	none	Kaua'i flightless stag beetles	**X**										
Invertebrates - insects	T	Order Dermaptera	Earwigs	none	Earwigs	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Order Diptera	True flies	none	True flies	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Procanace* spp.	Beach flies	none	Beach flies	**X**		**X**	**X**	**X**	**X**	X	**X**	X		
Invertebrates - insects	T	Family Dolichopodidae	Long-legged flies	none	Long-legged flies	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insets	T	Family Drosophilidae	Pomace flies	none	Pomace flies	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Drosophila digressa*	Hawaiian picture-wing fly	none	*Drosophila digressa*								**X**		**E**	**E**
Invertebrates - insects	T	*Drosophila sharpi*	Hawaiian picture-wing fly	none	*Drosophila sharpi*	**X**									**E**	**E**
Invertebrates - insects	T	*Drosophila aglaia*	picture-wing fly	none	*Drosophila aglaia*			**X**							**E**	**E**
Invertebrates - insects	T	*Drosophila differens*	picture-wing fly	none	*Drosophila differens*				**X**						**E**	**E**
Invertebrates - insects	T	*Drosphila hemipeza*	picture-wing fly	none	*Drosphila hemipeza*			**X**							**E**	**E**
Invertebrates - insects	T	*Drosophila heteroneura*	picture-wing fly	none	*Drosophila heteroneura*								**X**		**E**	**E**
Invertebrates - insects	T	*Drosophila montgomeryi*	picture-wing fly	none	*Drosophila montgomeryi*			**X**							**E**	**E**

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - insects	T	*Drosophila mulli*	picture-wing fly	none	*Drosophila mulli*								**X**		**T**	**T**
Invertebrates - insects	T	*Drosophila musaphila*	picture-wing fly	none	*Drosophila musaphilia*	**X**									**E**	**E**
Invertebrates - insects	T	*Drosphila neoclavisetae*	picture-wing fly	none	*Drosphila neoclavisetae*						**X**				**E**	**E**
Invertebrates - insects	T	*Drosphila obatai*	picture-wing fly	none	*Drosphila obatai*			**X**							**E**	**E**
Invertebrates - insects	T	*Drosphila ochrobasis*	picture-wing fly	none	*Drosphila ochrobasis*							**X**			**E**	**E**
Invertebrates - insects	T	*Drosphila substenoptera*	picture-wing fly	none	*Drosphila substenoptera*			**X**							**E**	**E**
Invertebrates - insects	T	*Drosphila tarphytrichia*	picture-wing fly	none	*Drosphila tarphytrichia*			**X**							**E**	**E**
Invertebrates - insects	T	*Lispocephala* spp.	Tiger flies	none	Tiger flies	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Suborder Heteroptera	True bugs	none	True bugs	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Nysius aa*	Maunaloa wēkiu bug	none	Wēkiu bugs								**X**			
Invertebrates - insects	T	*Nysius wekiuicola*	Maunakea wēkiu bugs	none	Wēkiu bugs								**X**			
Invertebrates - insects	T	Family Miridae	Leaf bugs	none	Leaf bugs	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	*Nabis* spp.	Damsel bugs	none	Damsel bugs	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Oechalia* spp.	Predatory stink bugs	none	Predatory stink bugs	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Suborder Auchenorrhyncha	Leafhoppers & planthopopers	none	Leafhoppers & Planthopopers	**X**	**X**	**X**	**X**	**X**	**X**		**X**			

Hawaii's State Wildlife Action Plan
October 1, 2015

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - insects	T	Family Cicadellidae	Leafhoppers	none	Leafhoppers	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Family Delphacidae	Planthoppers	none	Planthoppers	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	Suborder Sternorrhyncha	Psyllids, mealybugs, and scale insects	none	Psyllids, mealybugs, and scale insects	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Family Triozidae	Psyllids	none	Psyllids	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Order Hymenoptera	Bees and wasps	none	Bees and wasps	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Sierola* spp.	Flat wasps	none	Flat wasps	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Hylaeus* spp.	Yellow-faced bees	none	Yellow-faced bees	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Hylaeus anthracinus*	Anthricinan yellow-faced bee	none	*Hylaeus anthracinus*			**X**	**X**	X	**X**	**X**	**X**		**E**	**E**
Invertebrates - insects	T	*Hylaeus assimulans*	Assimulans yellow-faced bee	none	*Hylaeus assimulans*			X		**X**	**X**	**X**			**E**	**E**
Invertebrates - insects	T	*Hylaeus facilis*	Easy yellow-faced bee	none	*Hylaeus facilis*			**X**	**X**	X	X				**E**	**E**
Invertebrates - insects	T	*Hylaeus kuakea*	Hawaiian yellow-faced bee	none	*Hylaeus kuakea*			**X**							**E**	**E**
Invertebrates - insects	T	*Hylaeus longiceps*	Hawaiian yellow-faced bee	none	*Hylaeus longiceps*			**X**	**X**	**X**	**X**				**E**	**E**
Invertebrates - insects	T	*Hylaeus mana*	Hawaiian yellow-faced bee	none	*Hylaeus mana*			**X**							**E**	**E**
Invertebrates - insects	T	*Hylaeus hilaris*	Hilaris yellow-faced bee	none	*Hylaeus hilaris*				**X**	X	X				**E**	**E**

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Invertebrates - insects	T	*Ectemnius* spp.	Square-headed wasps	none	Square-headed wasps	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Euodynerus* spp.	Potter wasps	none	Potter wasps	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Nesodynerus* spp.	Potter wasps	none	Potter wasps	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Order Lepidoptera	Moths and butterflies	none	Moths and Butterflies	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	*Hyposmocoma* spp.	Cosmet moths	none	Cosmet moths	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Crambidae	Crambid snout moths	none	Crambid snout moths	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	Geometridae	Geometer moths	none	Geometer moths	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Philodoria* spp.	Painted leaf miners	none	Painted leaf miners	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	*Udara blackburni*	Butterflies	none	Butterflies	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Vanessa tameamea*	Butterflies	none	Butterflies	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates - insects	T	*Manduca blackburni*	Blackburn's sphinx moth	none	Blackburn's Sphinx Moth	X		X	X		**X**	**X**	**X**		**E**	**E**
Invertebrates - insects	T	*Tinostoma smaragdula*	Fabulous green sphinx	none	Fabulous green sphinx	**X**										
Invertebrates - insects	T	Tortricidae	Leaf roller moths	none	Leaf roller moths	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	Order Neuroptera	Lacewings, antlions	none	Lacewings and antlions	**X**		**X**	**X**	**X**	**X**	**X**	**X**			

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - insects	T-F	Order Odonata	Damselflies, dragonflies	none	Damselflies and Dragonflies	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T/F	*Megalagrion leptodemas*	crimson Hawaiian damselfly		crimson Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F	*Megalagrion nesiotes*	flying earwig Hawaiian damselfly		flying earwig Hawaiian damselfly						**X**		X		**E**	**E**
Invertebrates - insects	T/F	*Megalagrion nigrohamatum nigrolineatum*	blackline Hawaiian damselfly		blackline Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F	*Megalagrion oceanicum*	oceanic Hawaiian damselfly		oceanic Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F	*Megalagrion pacificum*	Pacific Hawaiian damselfly		Pacific Hawaiian damselfly	X		X	**X**		**X**		X		**E**	**E**
Invertebrates - insects	T/F/A	*Megalagrion xanthomelas*	Orangeblack Hawaiian damselfly		Orangeblack Hawaiian damselfly	X		**X**	**X**	X	**X**		**X**		**E**	**E**
Invertebrates - insects	T	Order Orthoptera	Grasshoppers, crickets, katydids	none	Crickets and Katydids	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**		
Invertebrates - insects	T	Order Phthiraptera	Lice	none	Lice			**X**			**X**		**X**	**X**		
Invertebrates - insects	T	Order Psocoptera	Bark Lice, psocids	none	Bark lice and Psocids	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Order Siphonaptera	Fleas	none	Fleas									**X**		
Invertebrates - insects	T	Order Thysanoptera	Thrips	none	Thrips	**X**		**X**	**X**	**X**	**X**	**X**	**X**			
Invertebrates - insects	T	*Hylaeus anthracinus*	Anthricinan yellow-faced bee	none	*Hylaeus anthracinus*			**X**	**X**	**X**	**X**	**X**	**X**		**C**	
Invertebrates - insects	T	*Hylaeus assimulans*	Assimulans yellow-faced bee	none	*Hylaeus assimulans*			**X**	**X**	**X**	**X**	**X**			**C**	

T=terrestrial, F=freshwater, A=anchialine, M=marine

***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Invertebrates - insects	T	*Hylaeus facilis*	Easy yellow-faced bee	none	*Hylaeus facilis*			**X**	**X**	**X**	**X**				**C**	
Invertebrates - insects	T	*Hylaeus kuakea*	Hawaiian yellow-faced bee	none	*Hylaeus kuakea*			**X**							**C**	
Invertebrates - insects	T	*Hylaeus longiceps*	Hawaiian yellow-faced bee	none	*Hylaeus longiceps*			**X**	**X**	**X**	**X**				**C**	
Invertebrates - insects	T	*Hylaeus mana*	Hawaiian yellow-faced bee	none	*Hylaeus mana*			**X**							**C**	
Invertebrates - insects	T	*Hylaeus hilaris*	Hilaris yellow-faced bee	none	*Hylaeus hilaris*				**X**	**X**	**X**				**C**	
Invertebrates - insects	T	*Manduca blackburni*	Blackburn's sphinx moth	none	Blackburn's Sphinx Moth	**X**		**X**	**X**		**X**	**X**	**X**		**E**	**E**
Invertebrates - insects	T/F	*Megalagrion nigrohamatum nigrolineatum*	blackline Hawaiian damselfly		blackline Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F	*Megalagrion nesiotes*	flying earwig Hawaiian damselfly		flying earwig Hawaiian damselfly						**X**		**X**		**E**	**E**
Invertebrates - insects	T/F	*Megalagrion oceanicum*	oceanic Hawaiian damselfly		oceanic Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F	*Megalagrion pacificum*	Pacific Hawaiian damselfly		Pacific Hawaiian damselfly	**X**		**X**	**X**		**X**		**X**		**E**	**E**
Invertebrates - insects	T/F	*Megalagrion leptodemas*	crimson Hawaiian damselfly		crimson Hawaiian damselfly			**X**							**E**	**E**
Invertebrates - insects	T/F/A	*Megalagrion xanthomelas*	Orangeblack Hawaiian damselfly		Orangeblack Hawaiian damselfly	**X**		**X**	**X**	**X**	**X**		**X**		**C**	
Invertebrates - insects	T	Order Orthoptera	Crickets, katydids	none	Crickets and katydids	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Order Phthiraptera	Lice	none	Lice			**X**			**X**		**X**	**X**		
Invertebrates - insects	T	Order Psocoptera	Bark lice	none	Bark lice	**X**		**X**	**X**	**X**	**X**		**X**	**X**		

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Invertebrates - insects	T	Order Siphonaptera	Fleas	none	Fleas									**X**		
Invertebrates - insects	T	Order Thysanoptera	Thrips	none	Thrips	**X**		**X**	**X**	**X**	**X**		**X**			
Invertebrates	T	*Spelaeorchestia koloana*	Kaua'i cave amphipod	none	Kauai cave arthropods	**X**									**E**	**E**
Invertebrates - crustaceans	T	Order Isopoda	Pill-bugs, sowbugs	none	Pill-bugs, Sowbugs, Woodlice, Isopods	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - myriapods	T	Order Geophilomorpha	Centipedes	none	Centipedes	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - myriapods	T	Order Lithobimorpha	Centipedes	none	Centipedes			**X**		**X**			**X**	**X**		
Invertebrates - myriapods	T	Order Polyxenida	Millipedes	none	Millipedes			**X**								
Invertebrates - myriapods	T	Order Spirostreptida	Millipedes	none	Millipedes	**X**		**X**	**X**	**X**	**X**	**X**		?		
Fishes	F	*Awaous guamensis*	none	ʻōʻopu nākea	Awaous guamensis	**X**		**X**	**X**		**X**		**X**			
Fishes	F	*Eleotris sandwicensis*	Hawaiian sleeper	ʻōʻopu akupa	Eleotris sandwicensis	**X**		**X**	**X**		**X**		**X**			
Fishes	F	*Lentipes concolor*	ʻOʻopu alamoʻo	ʻōʻopu alamoʻo	Lentipes concolor	**X**		**X**	**X**		**X**		**X**			
Fishes	F	*Sicyopterus stimpsoni*	ʻOʻopu nōpili	ʻōʻopu nōpili	Sicyopterus	**X**		**X**	**X**		**X**		**X**			
Fishes	F	*Stenogobius hawaiiensis*	ʻOʻopu naniha	ʻōʻopu naniha	Stenogobius	**X**		**X**	**X**		**X**		**X**			
Crustaceans	F	*Atyoida bisulcata*	Mountain ʻōpae	ʻōpae kalaʻole	Mountain Shrimp	**X**		**X**	**X**		**X**		**X**			
Crustaceans	F	*Macrobrachium grandimanus*	Hawaiian prawn	ʻōpae ʻoehaʻa	HI Prawn	**X**		**X**	**X**		**X**		**X**			
Molluscs	F	*Clithon cariosus*	none	pipiwai	Clithon Neritilia	**X**		**X**	**X**		**X**		**X**			
Molluscs	F	*Clithon neglectus*	none	hihiwai, pipipi, pipipi kai, pipipi wai	Clithon Neritilia	**X**		**X**	**X**		**X**		**X**			
Molluscs	F	*Erinna aulacospira*	none	none	Erinna Lymnaea	**X**			**X**		**X**		**X**			

Hawaii's State Wildlife Action Plan
October 1, 2015

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Molluscs	F	*Erinna newcombi*	Newcomb's snail	none	Newcomb's Snail	**X**									**T**	**T**
Molluscs	F	*Ferrissia sharpi*	none	none	Ferressia	**X**		**X**								
Molluscs	F	*Lymnaea producta*	none	none	Erinna Lymnaea	**?**		**?**	**?**		**?**		**?**			
Molluscs	F	*Lymnaea rubella*	none	none	Erinna Lymnaea	**?**		**?**	**?**		**?**		**?**			
Molluscs	F	*Neritina granosa*	none	hīhīwai or wi	Neritina Snails	**X**		**X**	**X**		**X**		**X**			
Molluscs	F	*Neritina vespertina*	none	hapawai or Hapakai	Neritina Snails	**X**		**X**	**X**		**X**		**X**			
Flatworm	F	*Oahuhawaiiana kazukolinda*	none	none	Worms			**X**								
Crustaceans	A	*Calliasmata pholidota*	none	none	Anchialine Shrimp						**X**		**X**			
Crustaceans	A	*Carnarimelita janstocki*	none	none	Anchialine Amphipod								**X**			
Crustaceans	A	*Grandidierella koa*	none	none	Anchialine Amphipod						**X**		**X**			
Crustaceans	A	*Grandidierella palama*	none	none	Anchialine Amphipod						**X**					
Crustaceans	A	*Halocaridina palahemo*	none	none	Anchialine Shrimp								**X**			
Crustaceans	A	*Holocaridina rubra*	none	‘ōpae ‘ula, ‘ōpae hiki	Anchialine Shrimp			**X**	**X**		**X**	**X**	**X**			
Crustaceans	A	*Liagoceradocus lonomaka*	none	none	Anchialine Amphipod						**X**		**X**			
Crustaceans	A	*Metabetaeus lohena*	none	none	Anchialine Shrimp						**X**		**X**		**C**	
Crustaceans	A	*Nuuanu amikai*	none	none	Anchialine Amphipod							**X**				
Crustaceans	A	*Palaemonella burnsi*	none	none	Anchialine Shrimp						**X**		**X**		**C**	
Crustaceans	A	*Paramoera lokowai*	none	none	Anchialine Amphipod								**X**			
Crustaceans	A	*Paramoera paakai*	none	none	Anchialine Amphipod								**X**			
Crustaceans	A	*Paramoera rua*	none	none	Anchialine Amphipod						**X**					

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Crustaceans	A	*Parhyale hawaiensis*	none	none	Anchialine Amphipod						**X**		**X**			
Crustaceans	A	*Procaris hawaiana*	none	none	Anchialine Shrimp						**X**		**X**		**C**	
Crustaceans	A	*Rotomelita ana*	none	none	Anchialine Amphipod						**X**					
Crustaceans	A	*Rotomelita lokoa*	none	none	Anchialine Amphipod								**X**			
Crustaceans	A	*Vetericaris chaceorum*	none	none	Anchialine Shrimp								**X**		**E**	**E**
Crustaceans	A	*Antecaridina lauensis*	none	none	Anchialine Shrimp						**X**		**X**			
Molluscs	A	*Neritilia hawaiiensis*	Anchialine pond snail	none	Clithon Neritilia	**?**		**?**	**?**		**X**		**X**			
Mammals	M	*Balaenoptera acutorostrata*	Minke whale	none	Baleen Whales											
Mammals	M	*Balaenoptera borealis*	Sei whale	none	Baleen Whales										**E**	
Mammals	M	*Balaenoptera edeni*	Bryde's whale	none	Baleen Whales											
Mammals	M	*Balaenoptera musculus*	Blue Whale	none	Baleen Whales										**E**	
Mammals	M	*Balaenoptera physalus*	Fin whale	none	Baleen Whales										**E**	**E**
Mammals	M	*Eubaleana japonica*	Northern right whale	none	Baleen Whales										**E**	
Mammals	M	*Feresa attenuata*	Pygmy killer whale	none	Toothed Whales											
Mammals	M	*Globicephala macrorhynchus*	Short-finned pilot whale	none	Pilot Whale											
Mammals	M	*Grampus griseus*	Risso's dolphin	none	Toothed Whales											
Mammals	M	*Indopacetus pacificus*	Longman's beaked whale	none	Toothed Whales											
Mammals	M	*Kogia breviceps*	Pygmy sperm whale	none	Toothed Whales											
Mammals	M	*Kogia sima*	Dwarf sperm whale	none	Toothed Whales											
Mammals	M	*Lagenodelphis hosei*	Fraser's dolphin	none	Toothed Whales											
Mammals	M	*Megaptera novaeangliae*	Humpback whale	koholā	Humpback Whale										**E**	**E**
Mammals	M	*Mesoplodon densirostris*	Blainesville's beaked whale or densebeaked whale	none	Toothed Whales											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Mammals	M	*Monachus schauinslandi*	Hawaiian monk seal	ʻīlio-holo-i-ka-uaua	Monk Seal										**E**	**E**
Mammals	M	*Orcinus orca*	Killer whale	none	Toothed Whales											
Mammals	M	*Peponocephala electra*	Melon-headed whale	none	Toothed Whales											
Mammals	M	*Physeter macrocephalus*	Sperm whale	none	Toothed Whales										**E**	**E**
Mammals	M	*Pseudorca crassidens*	False killer whale	none	False Killer Whale										**E**	**E**
Mammals	M	*Stenella attenuata*	Spotted dolphin	naiʻa	Spotted Dolphin											
Mammals	M	*Stenella coeruleoalba*	Striped dolphin	none	Toothed Whales											
Mammals	M	*Stenella longirostris*	Spinner dolphin	naiʻa	Spinner Dolphin											
Mammals	M	*Steno bredanensis*	Rough-toothed dolphin	naiʻa	Toothed Whales											
Mammals	M	*Tursiops truncatus*	Pacific bottlenose dolphin	naiʻa	Bottlenose Dolphin											
Mammals	M	*Ziphius cavirostris*	Cuvier's beaked whale	none	Toothed Whales											
Reptiles	M	*Caretta caretta*	Loggerhead sea turtle	none	Loggerhead turtle										**T**	**T**
Reptiles	M	*Chelonia mydas*	Green sea turtle	honu	Green sea turtle										**T**	**T**
Reptiles	M	*Dermochelys coriacea*	Leatherback sea turtle	none	Leatherback turtle										**E**	**E**
Reptiles	M	*Eretmochelys imbricata*	Hawksbill sea turtle	none	Hawksbill turtle										**E**	**E**
Reptiles	M	*Lepidochelys olivacea*	Olive Ridley Sea Turtle	none	Olive Ridley Turtle										**T**	**T**
Reptiles	M	*Pelamis platurus*	Yellow-bellied sea snake	none	Sea snake											
Sharks	M	*Carcharhinus longimanus*	Oceanic Witetip Shark	Manō	Oceanic Witetip Shark										**T**	**T**
Rays	M	*Manta birostris*	Oceanic Manta Ray	Hāhālua	Manta Rays										**T**	**T**
Rays	M	*Manta alfredi*	Manta Ray	Hāhālua	Manta Rays											
Fishes	M	*Acromycter alcocki*	none	none	Eels											
Fishes	M	*Ammodytoides pylei*	Pyle's sand lance	none	Active Reef Fishes											
Fishes	M	*Ammolabrus dicrus*	Sand wrasse	none	Sex Changers											
Fishes	M	*Anampses chrysocephalus*	Psychedelic wrasse	none	Sex Changers											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Fishes	M	*Antennarius commersoni*	Commerson's frogfish	none	Cryptic Reef Fishes											
Fishes	M	*Apogon maculiferus*	Spotted cardinalfish	'upāpalu	Cryptic Reef Fishes											
Fishes	M	*Apolemichthys arcuatus*	Bandit angelfish	none	Active Reef Fishes											
Fishes	M	*Araiophos gracilis*	none	none	Deep Fishes											
Fishes	M	*Argyripnus brocki*	none	none	Deep Fishes											
Fishes	M	*Aseraggodes borehami*	Boreham's sole	none	Flatfishes											
Fishes	M	*Aseraggodes holcomi*	none	none	Flatfishes											
Fishes	M	*Aseraggodes therese*	Therese's sole	none	Flatfishes											
Fishes	M	*Atherinomorus insularum*	Hawaiian silverside (FAO; Randall, 1996a), Togoro (DLNR)	'iao	Baitfishes											
Fishes	M	*Aulotrachichthys heptalepis*	none	none	Deep Fishes											
Fishes	M	*Bathycongrus aequorea*	none	none	Eels											
Fishes	M	*Bathygadus bowersi*	none	none	Deep Fishes											
Fishes	M	*Bothus thompsoni*	none	none	Flatfishes											
Fishes	M	*Cabillus caudimacula*	none	none	Cryptic Reef Fishes											
Fishes	M	*Caelorinchus doryssus*	none	none	Deep Fishes											
Fishes	M	*Caelorinchus gladius*	none	none	Deep Fishes											
Fishes	M	*Callechelys lutea*	Yellowspotted snake eel	pūhi	Eels											
Fishes	M	*Callionymus caeruleonotatus*	Bluespotted dragonet	none	Cryptic Reef Fishes											
Fishes	M	*Callionymus comptus*	Ornamented dragonet	none	Cryptic Reef Fishes											
Fishes	M	*Callionymus decoratus*	Decorated dragonet	none	Cryptic Reef Fishes											
Fishes	M	*Calotomus zonarchus*	Yellowbar parrotfish	uhu	Parrotfishes											
Fishes	M	*Cantherhines verecundus*	Shy filefish	'o'ili	Active Reef Fishes											
Fishes	M	*Caracanthus typicus*	Hawaiian orbicular velvetfish	none	Cryptic Reef Fishes											
Fishes	M	*Cataetyx hawaiiensis*	none	none	Deep Fishes											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Fishes	M	*Centropyge fisheri*	Orange angelfish (AFS), Fisher's angelfish (Hoover, 1993; Randall, 1996a)	none	Active Reef Fishes											
Fishes	M	*Centropyge loricula*	Hawaiian flame angelfish	none	Active Reef Fishes											
Fishes	M	*Chaetodon fremblii*	Bluestriped butterflyfish	kīkākapu	Active Reef Fishes											
Fishes	M	*Chaetodon tinkeri*	Tinker's butterflyfish	none	Active Reef Fishes											
Fishes	M	*Champsodon fimbriatus*	none	none	Deep Fishes											
Fishes	M	*Cheilodactylus vittatus*	Hawaiian morwong	kīkākapu	Active Reef Fishes											
Fishes	M	*Chlorurus perspicilatus*	Spectacled parrtofish	uhu	Parrotfishes											
Fishes	M	*Chromis hanui*	Chocolate-dip chromis	none	Active Reef Fishes											
Fishes	M	*Chromis ovalis*	Oval chromis	none	Active Reef Fishes											
Fishes	M	*Chromis struhsakeri*	Struhsaker's chromis	none	Active Reef Fishes											
Fishes	M	*Cirripectes obscurus*	Gargantuan blenny	pāo'o	Cryptic Reef Fishes											
Fishes	M	*Coris flavovittata*	Yellowstripe coris	hilu	Sex Changers											
Fishes	M	*Coris venusta*	Elegant coris	none	Sex Changers											
Fishes	M	*Cosmocampus balli*	Ball's pipefish	none	Syngnathiformes											
Fishes	M	*Cymolutes lecluse*	Slender razorfish, Hawaiian knifefish (Randall, 1996a; Hoover, 2003), Slender sand wrasse (Hoover, 1993, 2003)	none	Sex Changers											
Fishes	M	*Doryrhamphus baldwini*	Redstripe pipefish	none	Syngnathiformes											
Fishes	M	*Draculo pogognathus*	none	none	Cryptic Reef Fishes											
Fishes	M	*Elops hawaiensis*	Hawaiian ladyfish	awa 'aua	HI Ladyfish											
Fishes	M	*Enchelycore pardalis*	Dragon eel	pūhi-kauila	Eels											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Fishes	M	*Enchelyurus brunneolus*	none	none	Cryptic Reef Fishes											
Fishes	M	*Encrasicholina purpurea*	Hawaiian anchovy	nehu	Baitfishes											
Fishes	M	*Engyprosopon hawaiiensis*	none	none	Flatfishes											
Fishes	M	*Engyprosopon xenandrus*	none	none	Flatfishes											
Fishes	M	*Enneapterygius atriceps*	Hawaiian triplefin	none	Cryptic Reef Fishes											
Fishes	M	*Entomacrodus marmoratus*	Marbled blenny	pāo'o	Cryptic Reef Fishes											
Fishes	M	*Entomacrodus strasburgi*	Strasburg's blenny	none	Cryptic Reef Fishes											
Fishes	M	*Epigonus devaneyi*	none	none	Deep Fishes											
Fishes	M	*Epigonus glossodontus*	none	none	Deep Fishes											
Fishes	M	*Epinephelus quernus*	Hawaiian grouper	hāpu'u	Bottomfishes											
Fishes	M	*Etmopterus villosus*	Hawaiian lanternshark	none	Deep Fishes											
Fishes	M	*Eurypegasus papilio*	Hawaiian sea moth	none	Syngnathiformes											
Fishes	M	*Eustomias albibulbus*	none	none	Deep Fishes											
Fishes	M	*Eustomias bulbiramis*	none	none	Deep Fishes											
Fishes	M	*Eustomias magnificus*	none	none	Deep Fishes											
Fishes	M	*Eviota rubra*	none	none	Cryptic Reef Fishes											
Fishes	M	*Eviota susanae*	none	none	Cryptic Reef Fishes											
Fishes	M	*Gadella molokaiensis*	none	none	Deep Fishes											
Fishes	M	*Genicanthus personatus*	Masked angelfish	none	Active Reef Fishes											
Fishes	M	*Glossanodon struhsakeri*	none	none	Deep Fishes											
Fishes	M	*Gonorynchus moseleyi*	salmon (AFS), Beaked sandfish (FAO)	none	Deep Fishes											
Fishes	M	*Gorgasia hawaiiensis*	Hawaiian garden eel	pūhi	Eels											
Fishes	M	*Grammonus waikiki*	none	none	Deep Fishes											
Fishes	M	*Gymnothorax nuttingi*	Nutting's moray	none	Eels											
Fishes	M	*Gymnothorax polyspondylus*	Manyvertebrae moray	none	Eels											
Fishes	M	*Gymnothorax steindachneri*	Steindachner's moray	pūhi	Eels											
Fishes	M	*Halicampus edmondsoni*	Edmondson's pipefish	none	Syngnathiformes											
Fishes	M	*Halieutaea retifera*	none	none	Deep Fishes											
Fishes	M	*Hippocampus fisheri*	Fisher's seahorse	none	Syngnathiformes											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						*Island Distribution (Current (bold) and historic (unbold))*									**Status**	
Group	**Habitat***	**Scientific Name**	**Common Name**	**Hawaiian Name**	**Fact sheet**	***Kaua'i***	***Ni'ihau***	***O'ahu***	***Moloka'i***	***Lāna'i***	***Maui***	***Kaho'olawe***	***Hawai'i***	***NWHI***	****Federal***	****State***
Fishes	M	*Hippocampus histrix*	Spiny seahorse	none	Syngnathiformes											
Fishes	M	*Hippocampus kuda*	Yellow seahorse	none	Syngnathiformes											
Fishes	M	*Hymenocephalus antraeus*	none	none	Deep Fishes											
Fishes	M	*Hymenocephalus tenuis*	none	none	Deep Fishes											
Fishes	M	*Ichthyapus platyrhynchus*	none	none	Eels											
Fishes	M	*Ijimaia plicatellus*	none	none	Deep Fishes											
Fishes	M	*Iniistius umbrilatus*	Blackside razorfish (Hoover, 1993, 2003; Randall, 1996a), Nabeta (DLNR)	lae-nihi	Sex Changers											
Fishes	M	*Iso hawaiiensis*	Hawaiian surf sardine	none	Baitfishes											
Fishes	M	*Istiblennius zebra*	Zebra blenny	pāo'o	Cryptic Reef Fishes											
Fishes	M	*Kuhlia xenura*	Hawaiian flagtail (Hoover, 1993, 2003; Randall, 1996a), Mountain bass (DLNR)	āholehole	Flagtail											
Fishes	M	*Kumba hebetata*	none	none	Deep Fishes											
Fishes	M	*Lepidammodytes macrophthalmus*	none	none	Active Reef Fishes											
Fishes	M	*Linophryne escaramosa*	none	none	Deep Fishes											
Fishes	M	*Liopropoma aurora*	Sunset bass	none	Sex Changers											
Fishes	M	*Lophiodes bruchius*	none	none	Deep Fishes											
Fishes	M	*Luciobrotula lineata*	none	none	Deep Fishes											
Fishes	M	*Malacocephalus hawaiiensis*	Hawaiian softhead grenadier	none	Deep Fishes											
Fishes	M	*Microbrotula rubra*	none	none	Deep Fishes											
Fishes	M	*Nezumia ectenes*	none	none	Deep Fishes											
Fishes	M	*Nezumia holocentra*	none	none	Deep Fishes											
Fishes	M	*Ophichthus fowleri*	Fowler's snake eel	none	Eels											

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Fishes	M	*Ophichthus kunaloa*	none	none	Eels											
Fishes	M	*Osopsaron incisum*	none	none	Deep Fishes											
Fishes	M	*Ostracion whitleyi*	Whitley''s boxfish	none	Active Reef Fishes											
Fishes	M	*Oxyurichthys heisei*	Ribbon goby	none	Cryptic Reef Fishes											
Fishes	M	*Oxyurichthys lonchotus*	none	none	Cryptic Reef Fishes											
Fishes	M	*Parabothus chlorospilus*	none	none	Flatfishes											
Fishes	M	*Parupeneus porphyreus*	Whitesaddle goatfish, Red goat fish	kūmū	Kumu											
Fishes	M	*Physiculus sterops*	none	none	Deep Fishes											
Fishes	M	*Plagiotremus ewaensis*	Ewa blenny	none	Cryptic Reef Fishes											
Fishes	M	*Plagiotremus goslinei*	Scale-eating blenny	none	Cryptic Reef Fishes											
Fishes	M	*Plectroglyphidodon sindonis*	Hawaiian rock damselfish	none	Active Reef Fishes											
Fishes	M	*Pleurosicya larsonae*	none	none	Cryptic Reef Fishes											
Fishes	M	*Poecilopsetta hawaiiensis*	none	none	Flatfishes											
Fishes	M	*Priacanthus meeki*	Hawaiian bigeye	‘āweoweo	Active Reef Fishes											
Fishes	M	*Pseudanthias thompsoni*	Hawaiian anthias	none	Sex Changers											
Fishes	M	*Pseudogramma polyacanthum hawaiiensis*	Palespotted podge	none	Sex Changers											
Fishes	M	*Psilogobius mainlandi*	Mainland's goby	none	Cryptic Reef Fishes											
Fishes	M	*Pterois sphex*	Hawaiian turkeyfish, Hawaiian lionfish	nohu pinao	Cryptic Reef Fishes											
Fishes	M	*Pycnocraspedum armatum*	none	none	Deep Fishes											
Fishes	M	*Saccogaster hawaii*	none	none	Deep Fishes											
Fishes	M	*Samariscus corallinus*	Coralline-red flounder	none	Flatfishes											
Fishes	M	*Scolecenchelys puhioilo*	none	none	Eels											
Fishes	M	*Scorpaena pele*	none	none	Cryptic Reef Fishes											
Fishes	M	*Scorpaenopsis altirostris*	none	none	Cryptic Reef Fishes											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Fishes	M	*Scorpaenopsis brevifrons*	Bigmouth scorpionfish, Shortnose scorpionfish	none	Cryptic Reef Fishes											
Fishes	M	*Scorpaenopsis cacopsis*	Titan scorpionfish, Hogo	nohu	Cryptic Reef Fishes											
Fishes	M	*Scorpaenopsis pluralis*	none	none	Cryptic Reef Fishes											
Fishes	M	*Solocisquama erythrina*	none	none	Deep Fishes											
Fishes	M	*Sphagemacrurus gibber*	none	none	Deep Fishes											
Fishes	M	*Synagrops argyreus*	none	none	Deep Fishes											
Fishes	M	*Synchiropus hawaiiensis*	none	none	Cryptic Reef Fishes											
Fishes	M	*Synchiropus kinmeiensis*	none	none	Cryptic Reef Fishes											
Fishes	M	*Synodus falcatus*	none	none	Cryptic Reef Fishes											
Fishes	M	*Synodus janus*	none	none	Cryptic Reef Fishes											
Fishes	M	*Taeniopsetta radula*	none	none	Flatfishes											
Fishes	M	*Thamnaconus garretti*	None	none	Active Reef Fishes											
Fishes	M	*Torquigener randalli*	Randall's puffer	none	Active Reef Fishes											
Fishes	M	Undescribed *Anarchias* species	none	none	Eels											
Fishes	M	Undescribed *Bodianus* species	Hawaiian Pigfish	none	Sex Changers											
Fishes	M	Undescribed *Prognathodes* species	Orange-margin butterflyfish	none	Active Reef Fishes											
Fishes	M	*Ventrifossa ctenomelas*	Hawaiian grenadier	none	Deep Fishes											
Ascideans	M	*Aplidium crateriferum*	Cratered Aplidium	none	Misc Filter Feeders											
Ascideans	M	*Aplidium sp.*	Gold Ring Aplidium	none	Misc Filter Feeders											
Brachiopoda	M	*Lingula reevii*	Brachiopod	none	Misc Filter Feeders											
Bryozoa	M	*Parasmittina sp.*	none	none	Misc Filter Feeders											
Cephalopods	M	*Amphioctopus arenicola*	Short-Arm Sand Octopus	none	Cephalopods											
Cephalopods	M	*Euprymna scolopes*	Hawaiian Bobtail Squid	mūheʻe	Cephalopods											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Cephalopods	M	*Octopus hawaiiensis*	Hawaiian Octopus	he'e	Cephalopods											
Crustaceans	M	*Aethra edentata*	Flat elbow crab	none	Other Crustaceans											
Crustaceans	M	*Aniculus hopperae*	Hopper's hermit crab	unauna	Other Crustaceans											
Crustaceans	M	*Calcinus laurentae*	Laurent's hermit crab	unauna	Other Crustaceans											
Crustaceans	M	*Calcinus pictus*	Painted Hermit Crab	nonr	Other Crustaceans											
Crustaceans	M	*Carpilius maculatus*	7-11 or blood spot crab	'alakuma	Other Crustaceans											
Crustaceans	M	*Cinetorhynchus hawaiiensis*	Hawaiian hinge-beak shrimp	none	Other Crustaceans											
Crustaceans	M	*Cinetorhynchus hendersoni*	Henderson's hinge-beak shrimp	none	Other Crustaceans											
Crustaceans	M	*Hymenocera picta*	Harlequin shrimp	none	Other Crustaceans											
Crustaceans	M	*Levicaris mammilata*	Red Pencil urchin shrimp	none	Other Crustaceans											
Crustaceans	M	*Liomera supernodosa*	Knotted liomera	none	Other Crustaceans											
Crustaceans	M	*Lybia edmondsoni*	Hawaiian pom-pom crab	none	Other Crustaceans											
Crustaceans	M	*Metapenaeopsis sp.*	Bicolor sand shrimp	none	Other Crustaceans											
Crustaceans	M	*Panulirus marginatus*	black leg spiny lobster	ula poni, ula hiwa	Black Spiny Lobster											
Crustaceans	M	*Pseudopalicus oahuensis*	Button crab	none	Other Crustaceans											
Crustaceans	M	*Rhynchocinetes rathbunae*	Rathbun's hinge beaked shrimp	none	Other Crustaceans											
Crustaceans	M	*Stenopus earlei*	Earle's coral shrimp	none	Other Crustaceans											
Molluscs	M	*Acanthochiton viridis*	Green chiton	kuakulu	Chitons											
Molluscs	M	*Aldisa pikokai*	Pitted Nudibranch	none	Nudibranchs											
Molluscs	M	*Ardeadoris scottjohnsoni*	Scott Johnson's Nudibranch	none	Nudibranchs											
Molluscs	M	*Brachidontes crebristriarus*	Hawaiian mussel	nahawele li'ili'i	Bivalves											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kaua'i	Ni'ihau	O'ahu	Moloka'i	Lāna'i	Maui	Kaho'olawe	Hawai'i	NWHI	**Federal	**State
Molluscs	M	*Cellana exarata*	Black foot limpet	ʻopihi makaiauli	Limpets											
Molluscs	M	*Cellana melanostoma*	Green -foot opihi	none	Limpets											
Molluscs	M	*Cellana sandwicensis*	Yellow foot limpet	ʻopihi ʻālinalina	Limpets											
Molluscs	M	*Cellana talcosa*	Yellow foot limpet	ʻopihi kōʻele	Limpets											
Molluscs	M	*Charonia tritonis*	Triton's trumpet	pū	Snails											
Molluscs	M	*Chicoreus insularum*	Burnt murex	none	Snails											
Molluscs	M	*Chromodoris vibrata*	Trembling Nudibranch	none	Nudibranchs											
Molluscs	M	*Conus abbreviatus*	Abbreviated cone	pū pū ʻalā	Snails											
Molluscs	M	*Cypraea burgessi*	Burgess' cowry	none	Snails											
Molluscs	M	*Cypraea gaskoini*	Gaskoin's cowry	leho	Snails											
Molluscs	M	*Cypraea granulata*	Granulated cowry	leho	Snails											
Molluscs	M	*Cypraea mauiensis*	Maui cowry	leho	Snails											
Molluscs	M	*Cypraea ostergaardi*	none	leho	Snails											
Molluscs	M	*Cypraea rasleighana*	Rashleigh's cowry	leho	Snails											
Molluscs	M	*Cypraea semiplota*	"Half-swimmer" cowry	pū leholeho	Snails											
Molluscs	M	*Cypraea sulcidentata*	Groove-toothed cowry	leho	Snails											
Molluscs	M	*Cypraea tessallata*	Checkered cowry	leho	Snails											
Molluscs	M	*Cypraea tigris*	Tiger cowry	none	Snails											
Molluscs	M F	*Dendostrea sandvicensis*	Hawaiian Oyster	none	HI Oyster											
Molluscs	M	*Duplicaria gouldi*	Gould's Auger	pūpū loloa, ʻoiʻoi	Snails											
Molluscs	M	*Epitonium ulu*	Fungiid wentletrap	none	Snails											
Molluscs	M	*Glossodoris poliahu*	Snow-Goddess Nudibranch	none	Nudibranchs											
Molluscs	M	*Halgerda terramtuentis*	Gold Lace Nudibranch	none	Nudibranchs											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Molluscs	M	*Hypselodoris andersoni*	Anderson's Nudibranch	none	Nudibranchs											
Molluscs	M	*Stenoplax petaloides*	Flat chiton	pupu mo'o	Chitons											
Molluscs	M	*Isognomon californicum*	Black purse shells	nahawele	Bivalves											
Molluscs	M	*Melibe megaceras*	Dendronotid	none	Nudibranchs											
Molluscs	M	*Euprotomus hawaiiensis*	Hawaiian Stromb	none	Snails											
Molluscs	M	*Nerita picea*	Black Nerite	pipipi, pipipi kai	Snails											
Molluscs	M	*Nerita plicata*	none	none	Snails											
Molluscs	M	*Nerita polita*	Polished nerite	kūpe'e	Snails											
Molluscs	M	*Peltodoris fellowsi*	Fellow's nudibranch	none	Nudibranchs											
Molluscs	M	*Pinctada margaritifera*	Pearl oyster	pa	Bivalves											
Molluscs	M	*Pteria brunnea*	Winged pearl oyster	none	Bivalves											
Molluscs	M	*Sclerodoris paliensis*	Pali Nudibranch	none	Nudibranchs											
Molluscs	M	*Smaragdia bryannae*	HI sea grass snail	none	Snails											
Molluscs	M	*Turbo sandwicensis*	Hawaiian Turban	'ailea	Snails											
Sponge	M	*Spongia oceania*	none	none	Sponge											
Echinoderm	M	*Acanthocidaris hastigera*	Spear urnchin	none	Echinoderms											
Echinoderm	M	*Actinocidaris thomasi*	Thomas's sea urchin	none	Echinoderms											
Echinoderm	M	*Dactylosaster cylindricus pacificus*	Hawaiian cylindrical star	none	Echinoderms											
Echinoderm	M	*Holothuria cf. dofleinii*	Chocolate-chip sea cucumber	none	Echinoderms											
Echinoderm	M		Hawaiian lovenia	none	Echinoderms											
Echinoderm	M	*Lissodiadema purpureum*	Glass-spined urchin	none	Echinoderms											
Echinoderm	M	*Mithrodia fisheri*	Fisher's star	none	Echinoderms											
Echinoderm	M	*Prionocidaris hawaiiensis*	Hawaiian thorny urchin	none	Echinoderms											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Echinoderm	M	*Stichopus sp.1*	Hawaiian spiny sea cucumber	none	Echinoderms											
Echinoderm	M	*Stichopus sp.2*	Hawaiian yellow-tip sea cucumber	none	Echinoderms											
Flatworm	M	*Pericelis hymanae Poulter*	Hyman's flatworm	none	Worms											
Flatworm	M	*Pseudobiceros sp. 2*	Hawaiian spotted flatworm	none	Worms											
Annelida	M	*Vermiliopsis torquata*	none	none	Worms											
Nemertea	M	*Baseodiscus cingulatus*	Banded Ribbon Worm	ko'ekai	Worms											
Cnidaria	M	*Acropora cytherea*	Table coral	none	Stony Corals											
Cnidaria	M	*Acropora gemmifera*	none	none	Stony Corals											
Cnidaria	M	*Acropora humilis*	Finger staghorn coral	none	Stony Corals											
Cnidaria	M	*Acropora nasuta*	Branching staghorn coral	none	Stony Corals											
Cnidaria	M	*Acropora paniculata*	Fuzzy table coral	none	Stony Corals											
Cnidaria	M	*Acropora valida*	Bushy Staghorn coral	none	Stony Corals											
Cnidaria	M	*Anacropora sp.*	none	none	Stony Corals											
Cnidaria	M	*Anisopsammia ampheiliodes*	none	none	Stony Corals											
Cnidaria	M	*Anthemiphyllia pacifica*	none	none	Stony Corals											
Cnidaria	M	*Antipathes grandis*	Grand Black coral	'ekaha kū moana	Black Corals											
Cnidaria	M	*Antipathes griggi*	Hawaiian Black coral	none	Black Corals											
Cnidaria	M	*Balanophyllia desmophylloides*	none	none	Stony Corals											
Cnidaria	M	*Balanophyllia diomedeae*	none	none	Stony Corals											
Cnidaria	M	*Balanophyllia laysanensis*	none	none	Stony Corals											
Cnidaria	M	*Balanophyllia sp.*	Oval cup coral	none	Stony Corals											
Cnidaria	M	*Bathyactis hawaiiensis*	none	none	Stony Corals											
Cnidaria	M	*Caryophyllia alcocki*	none	none	Stony Corals											
Cnidaria	M	*Caryophyllia octopalli*	none	none	Stony Corals											
Cnidaria	M	*Ceratotrochus laxus*	none	none	Stony Corals											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Cnidaria	M	*Cirrhipathes anguina*	Common wire coral	none	Black Corals											
Cnidaria	M	*Cladactella manni*	Mann's Anemone	ʻokole, ʻokola	Other Anthozoans											
Cnidaria	M	*Cladopsammia eguchii*	none	none	Stony Corals											
Cnidaria	M	*Coscinaraea wellsi*	Wells coral	none	Stony Corals											
Cnidaria	M	*Cyathoceras diomedae*	none	none	Stony Corals											
Cnidaria	M	*Cycloseris fragilis*	Fragile mushroom coral	none	Stony Corals											
Cnidaria	M	*Cycloseris hexagonalis*	Humpback Coral	none	Stony Corals											
Cnidaria	M	*Cyphastrea agassizi*	none	ʻākoʻakoʻa	Stony Corals											
Cnidaria	M	*Cyphastrea ocellina*	Ocellated coral	ʻākoʻakoʻa	Stony Corals											
Cnidaria	M	*Deltocyathus andamanicus*	none	none	Stony Corals											
Cnidaria	M	*Dendrophyllia oahensis*	none	none	Stony Corals											
Cnidaria	M	*Desmophyllum cristagallis*	none	none	Stony Corals											
Cnidaria	M	*Diaseris distorta*	Distorted mushroom coral	none	Stony Corals											
Cnidaria	M	*Eguchipsammia serpentina*	Serpentine cup coral	none	Stony Corals											
Cnidaria	M	*Endopachys oahensis*	none	none	Stony Corals											
Cnidaria	M	*Flabellum deludens*	none	none	Stony Corals											
Cnidaria	M	*Flabellum pavoninum*	none	none	Stony Corals											
Cnidaria	M	*Fungia granulosa*	Granulated mushroom coral	none	Stony Corals											
Cnidaria	M	*Fungia scutaria*	Mushroom coral	ākoʻakoʻakohe	Stony Corals											
Cnidaria	M	*Fungia sp.*	none	none	Stony Corals											
Cnidaria	M	*Gardineria hawaiensis*	none	none	Stony Corals											
Cnidaria	M	*Gardineroseris planulata*	Honeycomb coral	none	Stony Corals											
Cnidaria	M	*Heteractis malu*	HI sand anemone	none	Other Anthozoans											
Cnidaria	M	*Leptastrea bewickensis*	Bewick coral	none	Stony Corals											
Cnidaria	M	*Leptastrea pruinosa*	Spotted coral	none	Stony Corals											
Cnidaria	M	*Leptastrea purpurea*	Crust coral	none	Stony Corals											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Cnidaria	M	*Leptastrea transversa*	Transverse coral	none	Stony Corals											
Cnidaria	M	*Leptoseris foliosa*	Foliose coral	none	Stony Corals											
Cnidaria	M	*Leptoseris hawaiiensis*	Hawaiian plate coral	none	Stony Corals											
Cnidaria	M	*Leptoseris incrustans*	Swelling coral	none	Stony Corals											
Cnidaria	M	*Leptoseris myctoseroides*	Ridge coral	none	Stony Corals											
Cnidaria	M	*Leptoseris papyracea*	Papyrus coral	none	Stony Corals											
Cnidaria	M	*Leptoseris scabra*	Rough plate coral	none	Stony Corals											
Cnidaria	M	*Leptoseris tubulifera*	Tube coral	none	Stony Corals											
Cnidaria	M	*Madracis kauaiensis*	none	none	Stony Corals											
Cnidaria	M	*Madracis pharensis*	Hidden orange coral	none	Stony Corals											
Cnidaria	M	*Madrepora kauaiensis*	none	none	Stony Corals											
Cnidaria	M	*Montipora capitata*	Rice Coral	none	Stony Corals											
Cnidaria	M	*Montipora dilatata*	Irregular rice coral	none	Stony Corals											
Cnidaria	M	*Montipora flabellata*	Blue Rice Coral	none	Stony Corals											
Cnidaria	M	*Montipora patula*	Spreading Coral	none	Stony Corals											
Cnidaria	M	*Montipora studeri*	Branching rice coral	none	Stony Corals											
Cnidaria	M	*Montipora tuberculosa*	none	none	Stony Corals											
Cnidaria	M	*Montipora turgescens*	Lumpy rice coral	none	Stony Corals											
Cnidaria	M	*Montipora verrilli*	none	none	Stony Corals											
Cnidaria	M	*Melithaea bicolor*	Bicolor Gorgonian	none	Other Anthozoans											
Cnidaria	M	*Palythoa mutuki*	White Stripe Zoanthid	none	Other Anthozoans											
Cnidaria	M	*Palythoa heliodiscus*	Sunray Zoanthid	none	Other Anthozoans											
Cnidaria	M	*Paracyathus gardineri*	none	none	Stony Corals											
Cnidaria	M	*Paracyathus mauiensis*	none	none	Stony Corals											
Cnidaria	M	*Paracyathus molokensis*	none	none	Stony Corals											
Cnidaria	M	*Paracyathus tenuicalyz*	none	none	Stony Corals											
Cnidaria	M	*Palythoa tuberculosa*	Rubbery or Pillow Zoanthid	none	Other Anthozoans											
Cnidaria	M	*Pavona duerdeni*	Flat lobe coral	none	Stony Corals											
Cnidaria	M	*Pavona maldivensis*	none	none	Stony Corals											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						Island Distribution (Current (bold) and historic (unbold))									Status	
Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	*Kaua'i*	*Ni'ihau*	*O'ahu*	*Moloka'i*	*Lāna'i*	*Maui*	*Kaho'olawe*	*Hawai'i*	*NWHI*	**Federal	**State
Cnidaria	M	*Pavona varians*	Corrugated coral	‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Placotrochus fuscus*	none	none	Stony Corals											
Cnidaria	M	*Pocillopora damicornis*	Lace coral	‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Pocillopora grandis*	Antler coral	none	Stony Corals											
Cnidaria	M	*Pocillopora ligulata*	Thin cauliflower coral	none	Stony Corals											
Cnidaria	M	*Pocillopora meandrina*	Cauliflower coral	none	Stony Corals											
Cnidaria	M	*Pocillopora molokensis*	Molokai cauliflower coral	none	Stony Corals											
Cnidaria	M	*Porites annae*	Nodule coral	none	Stony Corals											
Cnidaria	M	*Porites bernardi*	False lichen coral	none	Stony Corals											
Cnidaria	M	*Porites brighami*	Brighams coral	none	Stony Corals											
Cnidaria	M	*Porites compressa*	Finger coral	pō haku puna, ‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Porites duerdeni*	Thick finger coral	none	Stony Corals											
Cnidaria	M	*Porites evermanni*	Evermann’s coral	pō haku puna, ‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Porites hawaiiensis*	Hawaain Porite	none	Stony Corals											
Cnidaria	M	*Porites lichen*	Lichen coral	none	Stony Corals											
Cnidaria	M	*Porites lobata*	Lobe coral	pō haku puna, ‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Porites monticulosa*	Plate and knob coral	none	Stony Corals											
Cnidaria	M	*Porites pukoensis*	none	none	Stony Corals											
Cnidaria	M	*Porites rus*	Plate and Pillar Coral	none	Stony Corals											
Cnidaria	M	*Porites solida*	Solid coral	none	Stony Corals											
Cnidaria	M	*Porites studeri*	Deep lobe coral	none	Stony Corals											
Cnidaria	M	*Psammocora explanulata*	Flat coral	none	Stony Corals											
Cnidaria	M	*Psammocora haimeana*	Haime's lump coral	none	Stony Corals											
Cnidaria	M	*Psammocora nierstraszi*	Nierstrasz''s coral	none	Stony Corals											
Cnidaria	M	*Psammocora profundacella*	Cat's paw coral	none	Stony Corals											
Cnidaria	M	*Psammocora stellata*	Stellar coral	‘ākoʻakoʻa	Stony Corals											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

APPENDIX A: WILDLIFE (FAUNA) SPECIES OF GREATEST CONSERVATION NEED

Species						*Island Distribution (Current (bold) and historic (unbold))*									**Status**	
Group	**Habitat***	**Scientific Name**	**Common Name**	**Hawaiian Name**	**Fact sheet**	***Kaua'i***	***Ni'ihau***	***O'ahu***	***Moloka'i***	***Lāna'i***	***Maui***	***Kaho'olawe***	***Hawai'i***	***NWHI***	****Federal***	****State***
Cnidaria	M	*Psammocora verrilli*	Verril's lump coral	none	Stony Corals											
Cnidaria	M	*Rhizopsammia verrilli*	Verrill's lump coral	none	Stony Corals											
Cnidaria	M	*Sarcothelia edmondsoni*	Blue soft coral	'okole	Other Anthozoans											
Cnidaria	M	*Sinularia molokaiensis*	Hawaiian Leather Coral	none	Other Anthozoans											
Cnidaria	M	*Stephanophyllia formosissima*	none	none	Stony Corals											
Cnidaria	M	*Tethocyathus minor*	Tiny cup coral	none	Stony Corals											
Cnidaria	M	*Trochocyathus oahensis*	none	none	Stony Corals											
Cnidaria	M	*Tubastraea coccinea*	Colonial cup coral	none	Stony Corals											
Cnidaria	M	*Tubastraea diaphana*	Black cup coral	none	Stony Corals											
Cnidaria	M	*Zoanthus kealakekuaensis*	Green mat Zoanthid	none	Other Anthozoans											
Crustaceans	M	*Tumidodromia dromia*	Sleepy Sponge Crab	none	Other Crustaceans											

*T=terrestrial, F=freshwater, A=anchialine, M=marine

**Status: E = Endangered; T = Threatened; C = Candidate

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Abutilon	eremitopetalum				E		X	
Abutilon	incanum							X
Abutilon	menziesii			ko`oloa`ula	E			
Abutilon	sandwicense				E			
Acacia	koa			koa				X
Acacia	koaia			koaia; koa oha				X
Acaena	exigua			liliwai, nani wai‘ale‘ale	E		X	
Achyranthes	mutica				E			
Achyranthes	splendens	var.	rotundata		E			
Achyranthes	splendens	var.	splendens					X
Adenophorus	periens				E		X	
Alectryon	macrococcus	var.	auwahiensis	mahoe	E	Alectryon macrococcus	X	
Alectryon	macrococcus	var.	macrococcus	mahoe	E	Alectryon macrococcus	X	
Alphitonia	ponderosa			kauila				X
Alyxia	stellata			maile				X
Amaranthus	brownii				E			
Antidesma	platyphyllum	var.	platyphyllum	hame				X
Antidesma	pulvinatum							X
Argemone	glauca	var.	glauca					X
Argyroxiphium	kauense				E			
Argyroxiphium	sandwicense	subsp.	macrocephalum	‘ahinahina	T			X
Argyroxiphium	sandwicense	subsp.	sandwicense	‘ahinahina	E		X	X
Argyroxiphium	virescens						X	
Asplenium	dielerectum			palapalai lau li‘i	E		X	
Asplenium	dielfalcatum				E			
Asplenium	diellaciniatum				E		X	
Asplenium	dielmannii				E		X	
Asplenium	dielpallidum				E		X	
Asplenium	peruvianum	var.	insulare		E			
Asplenium	unisorum				E			
Astelia	menziesiana			pa‘iniu				X
Astelia	waialealae			pa‘iniu	E		X	
Athyrium	microphyllum			‘akolea				X
Bacopa	monnieri							X
Bidens	amplectens			ko‘oko‘olau	E			
Bidens	campylotheca	subsp.	pentamera	ko‘oko‘olau	E			
Bidens	campylotheca	subsp.	waihoiensis	ko‘oko‘olau	E			
Bidens	conjucta			ko‘oko‘olau	E			
Bidens	hillebrandiana	subsp.	hillebrandiana	ko‘oko‘olau	E		X	
Bidens	micrantha	subsp.	ctenophylla	ko‘oko‘olau	E			
Bidens	micrantha	subsp.	kalealaha	ko‘oko‘olau	E			
Bidens	spp.			ko‘oko‘olau				X
Bidens	wiebkei			ko‘oko‘olau	E			
Bobea	brevipes			ahakea				X
Bobea	elatior			ahakea				X
Boehmeria	grandis							X
Bolboschoenus	maritimus							X
Bonamia	menziesii				E			
Brighamia	insignis			‘olulu	E		X	

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Brighamia	rockii				E		X	
Calamagrostis	hillebrandii			Hillegrand's reedgrass	E			
Canavalia	hawaiiensis							X
Canavalia	molokaiensis			ʻāwikiwiki	E		X	
Canavalia	napaliensis			ʻāwikiwiki	E			
Canavalia	pubescens			ʻāwikiwiki	E			
Capparis	sandwichiana			maiapilo				X
Carex	alligata							X
Carex	meyenii							X
Carex	wahuensis	subsp.	herbstii					X
Carex	wahuensis	subsp.	wahuensis					X
Cenchrus	agrimonioides	var.	agrimonioides	kāmonomono	E	Cenchrus agrimonioides		
Cenchrus	agrimonioides	var.	laysanensis	kāmonomono	E	Cenchrus agrimonioides		
Ceodes	brunoniana			papala kepau				X
Ceodes	umbellifera			papala kepau				X
Charpentiera	densiflora			pāpala	E			
Charpentiera	obovata			pāpala				X
Charpentiera	ovata	var.	niuensis	pāpala			X	
Charpentiera	spp.			pāpala				X
Cheirodendron	platyphyllum			lapalapa				X
Cheirodendron	trigynum			ʻolapa				X
Chenopodium	oahuense			ʻaweoweo				X
Cibotium	chamissoi			hapuʻu				X
Cibotium	glaucum			hapuʻu				X
Cibotium	menziesii			hapuʻu				X
Cibotium	nealiae			hapuʻu				X
Cladium	jamaicense			ʻuki				X
Claoxylon	sandwicense			pooloa				X
Clermontia	clermontioides			ohawai				X
Clermontia	drepanomorpha				E			
Clermontia	fauriei			hahaʻaiakamanu				X
Clermontia	grandiflora	subsp.	maxima				X	
Clermontia	lindseyana				E			
Clermontia	oblongifolia	subsp.	brevipes	ʻoha wai	E			
Clermontia	oblongifolia	subsp.	mauiensis	ʻoha wai	E		X	
Clermontia	peleana	subsp.	peleana	ʻoha wai	E	Clermontia peleana	X	
Clermontia	peleana	subsp.	singuliflora	ʻoha wai	E	Clermontia peleana	X	
Clermontia	pyrularia			ʻoha wai	E		X	
Clermontia	samuelii	subsp.	hanaensis		E	Clermontia samuelii		
Clermontia	samuelii	subsp.	samuelii		E	Clermontia samuelii	X	
Clermontia	spp.			oha, ʻoha wai, haha, oha kepau				X
Coleus	australis							X
Colubrina	oppositifolia			kauila	E			
Coprosma	elliptica			pilo				X
Coprosma	ernodeoides			kukainene				X
Coprosma	foliosa			pilo				X
Coprosma	kauensis			pilo				X
Coprosma	kawaikiniensis			pilo			X	
Coprosma	menziesii			pilo				X

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Coprosma	montana			pilo				X
Coprosma	ochracea			pilo				X
Coprosma	pubens			pilo				X
Coprosma	rhynchocarpa			pilo				X
Coprosma	spp.			pilo				X
Cordia	subcordata							X
Cryptocarya	mannii			holio				X
Cryptocarya	oahuensis			holio			X	
Ctenitis	squamigera			pauoa	E			
Cyanea	acuminata			haha	E			
Cyanea	asarifolia			haha	E			
Cyanea	asplenifolia			haha	E			
Cyanea	calycina			haha	E			
Cyanea	cf. fernaldii				E	Cyanea platyphylla	X	
Cyanea	copelandii	subsp.	copelandii	haha	E			
Cyanea	copelandii	subsp.	haleakalaensis	haha	E			
Cyanea	crispa			haha	E		X	
Cyanea	dolichopoda			haha	E		X	
Cyanea	dunbariae			haha	E		X	
Cyanea	duvalliorum			haha	E		X	
Cyanea	eleeleensis			haha	E		X	
Cyanea	gibsonii				E		X	
Cyanea	glabra			haha	E			
Cyanea	grimesiana	subsp.	grimesiana	haha	E		X	
Cyanea	grimesiana	subsp.	obatae	haha	E		X	
Cyanea	hamatiflora	subsp.	carlsonii	haha	E		X	
Cyanea	hamatiflora	subsp.	hamatiflora		E			
Cyanea	hardyi						X	
Cyanea	heluensis						X	
Cyanea	horrida			haha	E			
Cyanea	humboldtiana				E		X	
Cyanea	kauaulaensis				E			
Cyanea	kolekoleensis				E		X	
Cyanea	konahuanuiensis						X	
Cyanea	koolauensis				E			
Cyanea	kuhihewa			haha	E		X	
Cyanea	kunthiana			haha	E			
Cyanea	lanceolata			haha	E		X	
Cyanea	lobata	subsp.	baldwinii		E	Cyanea lobata	X	
Cyanea	lobata	subsp.	lobata	haha	E	Cyanea lobata	X	
Cyanea	longiflora				E			
Cyanea	magnicalyx			haha	E		X	
Cyanea	mannii				E			
Cyanea	maritae				E		X	
Cyanea	marksii			haha	E		X	
Cyanea	mauiensis				E			
Cyanea	mceldowneyi				E			
Cyanea	munroi			haha	E		X	
Cyanea	obtusa			haha	E		X	

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Cyanea	pinnatifida			haha	E		X	
Cyanea	platyphylla			‘aku‘aku	E		X	
Cyanea	procera			haha	E		X	
Cyanea	profuga			haha	E		X	
Cyanea	purpurellifolia			haha	E		X	
Cyanea	recta				T			
Cyanea	remyi				E		X	
Cyanea	rivularis				E		X	
Cyanea	sessilifolia				E			
Cyanea	shipmanii			haha	E		X	
Cyanea	solanacea			popolo, haha nui	E		X	
Cyanea	spp.							X
Cyanea	stictophylla			haha	E		X	
Cyanea	st-johnii			haha	E	Cyanea st.-johnii	X	
Cyanea	superba	subsp.	regina	haha	E	Cyanea superba		
Cyanea	superba	subsp.	superba	haha	E	Cyanea superba	X	
Cyanea	tritomantha			aku	E			X
Cyanea	truncata			haha	E		X	
Cyanea	undulata			haha	E		X	
Cyclosorus	interruptus			neke fern				X
Cyperus	fauriei				E			
Cyperus	laevigatus			makaloa				X
Cyperus	neokunthianus				E		X	
Cyperus	pennatiformis	subsp.	bryanii		E	Cyperus pennatiformis		
Cyperus	pennatiformis	subsp.	pennatiformis		E	Cyperus pennatiformis		
Cyperus	polystachyos							X
Cyperus	prescottianus						X	
Cyperus	trachysanthos			pu`uka`a	E			
Cyrtandra	crenata			ha‘iwale	E			
Cyrtandra	cyaneoides			Mapele	E			
Cyrtandra	dentata			ha‘iwale	E			
Cyrtandra	ferripilosa			ha‘iwale	E		X	
Cyrtandra	filipes			ha‘iwale	E			
Cyrtandra	giffardii			ha‘iwale	E			
Cyrtandra	gracilis			ha‘iwale	E		X	
Cyrtandra	halawensis			ha‘iwale				X
Cyrtandra	hematos			ha‘iwale	E		X	
Cyrtandra	kaulantha			ha‘iwale	E		X	
Cyrtandra	kealiae	subsp.	kealiae	ha‘iwale	T	Cyrtandra limahuliensis		
Cyrtandra	kohalae						X	
Cyrtandra	munroi			ha‘iwale	E			
Cyrtandra	nanawaleensis			ha‘iwale	E			
Cyrtandra	oenobarba			ha‘iwale	E			
Cyrtandra	oxybapha			ha‘iwale	E			
Cyrtandra	paliku			ha‘iwale	E		X	
Cyrtandra	polyantha			ha‘iwale	E		X	
Cyrtandra	sessilis			ha‘iwale	E		X	
Cyrtandra	spp.			ha‘iwale				X
Cyrtandra	subumbellata			ha‘iwale	E		X	

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Cyrtandra	tintinnabula			haʻiwale	E			
Cyrtandra	viridiflora			haʻiwale	E		X	
Cyrtandra	wagneri			haʻiwale	E		X	
Cyrtandra	waiolani			haʻiwale	E		X	
Delissea	argutidentata				E	Delissea undulata	X	
Delissea	kauaiensis				E	Delissea undulata	X	
Delissea	niihauensis				E	Delissea undulata		
Delissea	rhytidosperma				E		X	
Delissea	subcordata	subsp.	obtusifolia	oha	E	Delissea subcordata		
Delissea	subcordata	subsp.	subcordata	oha	E	Delissea subcordata		
Delissea	takeuchii				E	Delissea subcordata		
Delissea	undulata				E			X
Delissea	waianaeensis				E	Delissea subcordata	X	
Deparia	kaalaana				E		X	
Deschampsia	nubigena							X
Dianella	sandwicensis			uki				X
Dicranopteris	linearis			ʻuluhe				X
Diospyros	hillebrandii							X
Diospyros	sandwicensis			lama				X
Diplazium	molokaiense				E		X	
Diplazium	sanwichiananum			hoʻiʻo				X
Dodonaea	viscosa			ʻaʻaliʻi				X
Doryopteris	angelica				E			
Doryopteris	takeuchii				E			
Dracaena	aurea			halapepe				X
Dracaena	fernaldii			hala pepe	E	Dracaena fernaldii		
Dracaena	forbesii			hala pepe	E	Dracaena forbesii		
Dracaena	konaensis			hala pepe	E	Dracaena konaensis		
Dryopteris	crinalis	var.	podosorus		E		X	
Dryopteris	glabra	var.	pusilla	kīlau	E			
Dryopteris	spp.							X
Dryopteris	tetrapinnata							X
Dubautia	arborea			naʻenaʻe				X
Dubautia	herbstobatae			naʻenaʻe	E			
Dubautia	imbricata		imbricata	naʻenaʻe	E			
Dubautia	kalalauensis			naʻenaʻe	E		X	
Dubautia	kenwoodii			naʻenaʻe	E		X	
Dubautia	latifolia				E			
Dubautia	paleata			naʻenaʻe pua kea				X
Dubautia	pauciflorula			naʻenaʻe	E		X	
Dubautia	plantaginea	subsp.	humilis		E		X	
Dubautia	plantaginea	subsp.	magnifolia		E			X
Dubautia	raillardioides			naʻenaʻe ʻula				X
Dubautia	spp.			naʻenaʻe				X
Dubautia	waialealae			naʻenaʻe	E			
Elaeocarpus	bifidus			kalia				X
Elaphoglossum	spp.			ekaha; laukahi nunui				X
Eragrostis	fosbergii				E		X	
Eragrostis	grandis							X

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Eragrostis	monticola							X
Eragrostis	variabilis			kawelu				X
Erythrina	sandwicensis			wiliwili				X
Eugenia	koolauensis			nioi	E		X	
Euphorbia	arnottiana						X	
Euphorbia	celastroides	var.	kaenana	‘akoko	E			X
Euphorbia	deppeana			‘akoko	E		X	
Euphorbia	eleanoriae			‘akoko	E			
Euphorbia	haeleeleana				E			
Euphorbia	halemanui			‘akoko	E			
Euphorbia	herbstii			‘akoko	E		X	
Euphorbia	kuwaleana			‘akoko	E			
Euphorbia	olowaluana			‘akoko				X
Euphorbia	remyi	var.	hanaleiensis				X	
Euphorbia	remyi	var.	kauaiensis	‘akoko	E			
Euphorbia	remyi	var.	remyi	‘akoko	E			
Euphorbia	rockii				E			
Euphorbia	skottsbergii	var.	skottsbergii		E			
Euphorbia	spp.			koko or akoko				X
Exocarpos	luteolus				E			
Exocarpos	menziesii			Menzies ballart	E			
Festuca	hawaiiensis				E			
Festuca	molokaiensis				E		X	
Flueggea	neowawraea			mehamehame	E		X	
Freycinetia	arborea			ieie				X
Gahnia	lanaiensis							
Gardenia	brighamii			nanu	E		X	
Gardenia	mannii				E		X	
Gardenia	remyi			nanu	E		X	
Geranium	arboreum			hinahina	E		X	X
Geranium	hanaense			nohoanu	E			
Geranium	hillebrandii			nohoanu	E			
Geranium	kauaiense				E		X	
Geranium	multiflorum				E			
Geranium	tridens			hinahina				X
Gossypium	tomentosum			ma‘o				X
Gouania	hillebrandii				E			
Gouania	meyenii				E		X	
Gouania	vitifolia				E		X	
Greeneochloa	expansa			Maui reedgrass	E	Calamagrostis expansa		
Haplostachys	haplostachya				E			
Heliotropium	anomalum	var.	argenteum	hina hina				X
Heliotropium	curassavicum			kipukai				X
Hesperomannia	arborescens				E		X	
Hesperomannia	lydgatei				E		X	
Hesperomannia	oahuensis				E	Hesperomannia arbuscula	X	
Hesperomannia	sweezyi				E	Hesperomannia arborescens		
Heteropogon	contortus			pili grass				X
Hibiscadelphus	distans			hau kuahiwi	E			

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Hibiscadelphus	giffardianus			hau kuahiwi	E		X	
Hibiscadelphus	hualalaiensis			hau kuahiwi	E		X	
Hibiscadelphus	stellatus			hau kuahiwi			X	
Hibiscadelphus	woodii			hau kuahiwi	E		X	
Hibiscus	arnottianus	subsp.	arnottianus	hauhele, hau				X
Hibiscus	arnottianus	subsp.	immaculatus	hauhele, hau	E			X
Hibiscus	brackenridgei	subsp.	brackenridgei	ma‘o hau hele	E	Hibiscus brackenridgei	X	
Hibiscus	brackenridgei	subsp.	mokuleianus	ma‘o hau hele	E	Hibiscus brackenridgei		
Hibiscus	brackenridgei	subsp.	molokaiana	ma‘o hau hele	E	Hibiscus brackenridgei		
Hibiscus	clayi			koki‘o ‘ula ‘ula; aloalo	E			
Hibiscus	kokio	subsp.	kokio					X
Hibiscus	kokio	subsp.	saintjohnianus					X
Hibiscus	tiliaceus			hau				X
Hibiscus	waimeae	subsp.	hannerae		E			
Hydrangea	arguta			kanawao				X
Hypolepis	hawaiiensis	var.	mauiensis	olua	E		X	
Ilex	anomala			kawa‘u				X
Ipomoea	indica							X
Isachne	distichophylla			ohe				X
Ischaemum	byrone				E			
Isodendrion	hosakae				E		X	
Isodendrion	laurifolium				E			
Isodendrion	longifolium				T			
Isodendrion	pyrifolium			aupaka; wahine noho kula	E		X	
Jacquemontia	sandwicensis							X
Joinvillea	ascendens	subsp.	ascendens	ohe	E			X
Kadua	affinis			manono				X
Kadua	cookiana			‘awiwi	E			
Kadua	cordata	subsp.	remyi		E		X	
Kadua	coriacea			kio‘ele	E			
Kadua	degeneri	var.	coprosmifolia		E	Kadua degeneri		
Kadua	degeneri	var.	degeneri		E	Kadua degeneri		
Kadua	fluviatilis				E			
Kadua	haupuensis				E		X	
Kadua	laxiflora				E		X	
Kadua	parvula				E			
Kadua	st-johnii				E	Kadua st.-johnii	X	
Kanaloa	kahoolawensis			kohe malama malama o kanaloa	E		X	
Keysseria	erici				E			
Keysseria	helena				E			
Kokia	cookei			koki‘o	E		X	
Kokia	drynarioides			hau hele ‘ula; koki‘o	E		X	
Kokia	kauaiensis			koki‘o	E		X	
Korthalsella	degeneri			hulumoa	E			
Labordia	cyrtandrae			kāmakahala	E		X	
Labordia	helleri			kāmakahala	E			
Labordia	lorenciana			kāmakahala	E		X	
Labordia	lydgatei			kāmakahala	E			
Labordia	pumila			kāmakahala	E			

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Labordia	tinifolia	var.	lanaiensis	kāmakahala	E		X	
Labordia	tinifolia	var.	wahiawaensis	kāmakahala	E		X	
Labordia	triflora			kāmakahala	E		X	
Labordia	waialaeale			kāmakahala lau li‘I				X
Lepidium	arbuscula			anaunau	E		X	
Lepidium	orbiculare				E			
Leptecophylla	tameiameiae			pukiawe				X
Lepturus	repens							X
Lipochaeta	lobata	var.	leptophylla	nehe	E			
Lipochaeta	populifolia						X	
Lipochaeta	spp.							X
Lobelia	dunbariae	subsp.	dunbariae				X	
Lobelia	koolauensis				E			
Lobelia	monostachya				E		X	
Lobelia	niihauensis				E			
Lobelia	oahuensis				E		X	
Lobelia	spp.							X
Lysimachia	daphnoides			lehua makanoe	E			
Lysimachia	filifolia				E			
Lysimachia	iniki				E		X	
Lysimachia	lydgatei				E		X	
Lysimachia	maxima				E		X	
Lysimachia	ovoidea						X	
Lysimachia	pendens				E		X	
Lysimachia	scopulensis				E			
Lysimachia	sp. nov. (Pohakea, Kauai)						X	
Lysimachia	sp. nov. (Wainiha, Kauai)						X	
Lysimachia	spp.							X
Lysimachia	venosa				E			
Machaerina	angustifolia			‘uki				X
Marsilea	villosa			‘ihi‘ihi	E			X
Melicope	adscendens			alani	E		X	
Melicope	anisata			mokihana				X
Melicope	balloui			alani	E			
Melicope	christophersenii			alani	E			
Melicope	clusiifolia			kukaemoa				X
Melicope	cornuta	var	cornuta		E		X	
Melicope	cornuta	var	decurrens		E			
Melicope	cruciata			pilo ‘ula				X
Melicope	degeneri			alani	E			
Melicope	haupuensis			alani	E		X	
Melicope	hiiakae			alani	E		X	
Melicope	knudsenii			alani	E		X	
Melicope	lydgatei			alani	E		X	
Melicope	macropus							X
Melicope	makahae			alani	E		X	
Melicope	mucronulata			alani	E		X	
Melicope	munroi			alani	E		X	
Melicope	nealae						X	

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Melicope	oppenheimeri			alani			X	
Melicope	ovalis			alani	E			
Melicope	pallida			alani	E			
Melicope	paniculata			alani	E			
Melicope	puberula			alani	E			
Melicope	quadrangularis			alani	E		X	
Melicope	reflexa			alani	E			
Melicope	remyi				E		X	
Melicope	rostrata			pilo kea lau li‘i	E			
Melicope	saint-johnii			alani	E		X	
Melicope	spp.			alani				X
Melicope	stoneii						X	
Melicope	wailauensis						X	
Melicope	zahlbruckneri			alani	E		X	
Menisciopsis	boyidiae			Boyd's maidenfern	E			
Metrosideros	macropus			‘ōhi‘a				X
Metrosideros	polymorpha			‘ōhi‘a				X
Metrosideros	rugosa			lehua papa				X
Metrosideros	tremuloides			Lehua ‘āhihi				X
Metrosideros	waialealae			‘ōhi‘a				X
Mezoneuron	kavaiense			uhiuhi	E		X	X
Microlepia	strigosa	var.	mauiensis		E	Microlepia strigosa var. mauiensis		
Mucuna	persericea				E			
Myoporum	degeneri			naio			X	X
Myoporum	sandwicense	subsp.	lanaiense	naio				X
Myoporum	sandwicense	subsp.	sandwicense	naio				X
Myoporum	stellatum			naio				X
Myrsine	fosbergii				E			
Myrsine	juddii				E			
Myrsine	knudsenii			kolea	E			
Myrsine	lessertiana			kolea				X
Myrsine	linearifolia			kolea	T			
Myrsine	mezii			kolea	E		X	
Myrsine	sandwicensis			kolea lauli‘i				X
Myrsine	sp. nov. (Kauai)						X	
Myrsine	spp.			kolea				X
Myrsine	vacciniodes			kolea	E			
Nama	sandwicensis							X
Neraudia	angulata	var.	angulata		E	Neraudia angulata		
Neraudia	angulata	var.	dentata		E	Neraudia angulata	X	
Neraudia	kauaiensis						X	
Neraudia	ovata				E		X	
Neraudia	sericea				E		X	
Notelaea	sandwicensis			olopua				X
Nothocestrum	breviflorum			‘aiea	E		X	X
Nothocestrum	latifolium			‘aiea	E			X
Nothocestrum	longifolium			‘aiea				X
Nothocestrum	peltatum			‘aiea	E		X	
Nothocestrum	spp.							X

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Nototrichium	humile				E			
Nototrichium	sandwicense							X
Ochrosia	haleakalae			holei	E			
Ochrosia	kilaueaensis			holei	E			
Oreobolus	furcatus							X
Osteomeles	anthyllidifolia			ʻūlei				X
Pandanus	tectorius			hala				X
Panicum	fauriei	var.	carteri		E			
Panicum	niihauense			lauʻehu	E		X	
Panicum	spp.							X
Paratrophis	pendulina			aʻiaʻi				X
Peperomia	degeneri						X	
Peperomia	subpetiolata			ʻala ʻala wai nui	E		X	
Perrottetia	sandwicensis			olomea				X
Peucedanum	sandwicense			makoe	T			
Phlegmariurus	mannii				E			
Phlegmariurus	nutans			wawaeʻiole	E		X	
Phlegmariurus	stemmermanniae			wawaeʻiole	E		X	
Phyllostegia	bracteata				E		X	
Phyllostegia	brevidens				E		X	
Phyllostegia	electra						X	
Phyllostegia	floribunda				E		X	
Phyllostegia	glabra	var.	glabra				X	
Phyllostegia	glabra	var.	lanaiensis		E			
Phyllostegia	haliakalae				E		X	
Phyllostegia	helleri				E		X	
Phyllostegia	hirsuta				E		X	
Phyllostegia	hispida				E		X	
Phyllostegia	kaalaensis				E		X	
Phyllostegia	knudsenii				E		X	
Phyllostegia	macrophylla						X	
Phyllostegia	mannii				E		X	
Phyllostegia	mollis				E		X	
Phyllostegia	parviflora	var.	glabriuscula		E	Phyllostegia parviflora		
Phyllostegia	parviflora	var.	lydgatei		E	Phyllostegia parviflora	X	
Phyllostegia	parviflora	var.	parviflora		E	Phyllostegia parviflora	X	
Phyllostegia	pilosa				E		X	
Phyllostegia	racemosa			kiponapona	E		X	
Phyllostegia	renovans				E			
Phyllostegia	stachyoides				E		X	
Phyllostegia	velutina				E		X	
Phyllostegia	waimeae				E		X	
Phyllostegia	warshaueri				E		X	
Phyllostegia	wawrana				E		X	
Pipturus	albidus			mamaki				X
Pittosporum	halophilum			hōʻawa	E		X	
Pittosporum	hawaiiense			hōʻawa	E			X
Pittosporum	hosmeri			hōʻawa				X
Pittosporum	napaliense			hōʻawa	E			

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Pittosporum	spp.			hōʻawa				X
Pittosporum	terminalioides			hōʻawa				X
Planchonella	spathulata							X
Plantago	hawaiensis			kuahiwi laukahi	E		X	
Plantago	princeps	var.	anomala	kuahiwi laukahi	E	Plantago princeps	X	
Plantago	princeps	var.	laxifolia	kuahiwi laukahi	E	Plantago princeps	X	
Plantago	princeps	var.	longibracteata	kuahiwi laukahi	E	Plantago princeps		
Plantago	princeps	var.	princeps	kuahiwi laukahi	E	Plantago princeps		
Platanthera	holochila				E		X	
Plumbago	zeylanica							X
Poa	mannii				E			
Poa	sandvicensis				E			
Poa	siphonoglossa				E			
Polyscias	bisattenuata			ʻohe mauka	E		X	
Polyscias	flynnii			ʻoheʻohe	E		X	
Polyscias	gymnocarpa			ʻoheʻohe	E			
Polyscias	hawaiensis			ʻoheʻohe				X
Polyscias	racemosa				E			
Polyscias	sandwicensis			ohe, ohe makai				X
Polyscias	spp.			ohe				X
Polyscias	lydgatei				E		X	
Polysicas	sp. nov. (Koiae, Kauai)						X	
Portulaca	molokiniensis			ihi			X	
Portulaca	sclerocarpa			poʻe	E			
Portulaca	villosa			ihi	E			
Pritchardia	bakeri			loʻulu	E		X	
Pritchardia	beccarriana			loʻulu				X
Pritchardia	gordonii			loʻulu			X	
Pritchardia	hardyi			loʻulu	E			
Pritchardia	kaalae			loʻulu	E			
Pritchardia	lanigera			loʻulu	E			
Pritchardia	maideniana			loʻulu	E		X	
Pritchardia	munroi			loʻulu	E		X	
Pritchardia	napaliensis			loʻulu	E			
Pritchardia	remota			loʻulu	E			
Pritchardia	schattaueri			loʻulu	E		X	
Pritchardia	viscosa			loʻulu	E		X	
Pseudognaphalium	sandwicensium	var.	molokaiense	enaʻena	E			
Psychotria	grandiflora			kōpiko	E		X	
Psychotria	hexandra	var.	oahuensis	kōpiko	E		X	
Psychotria	hobdyi			kōpiko	E			
Psychotria	spp.			kōpiko				X
Psydrax	odorata			alaheʻe				X
Pteralyxia	kauaiensis			kaulu	E			
Pteralyxia	macrocarpa			kaulu	E			X
Pteris	lidgatei				E		X	
Pyschotria	hawaiiensis			kopiko				X
Racomitrium	lanuginosum							X
Ranunculus	hawaiensis			makou	E		X	

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Ranunculus	mauiensis			makou	E			
Rauvolfia	sandwicensis			hao				X
Remya	kauaiensis				E			
Remya	mauiensis				E			
Remya	montgomeryi				E		X	
Rhynchospora	chinensis	subsp.	spiciformis	kuolohia				X
Rockia	sandwicensis			āulu				X
Rubus	hawaiensis			ʻākala				X
Rumex	giganteus							X
Sadleria	cyatheoides			amaumau				X
Sanicula	mariversa				E			
Sanicula	purpurea				E			
Sanicula	sandwicensis				E			
Santalum	ellipticum			ʻiliahialoʻe				X
Santalum	freycinetianum			ʻiliahi				X
Santalum	haleakalae	var.	lanaiense	Lānaʻi sandalwood, ʻiliahi	E			
Santalum	involutum				E			
Sapindus	oahuensis			kaulu				X
Sapindus	saponaria			aʻe				X
Scaevola	coriacea			dwarf naupaka	E		X	
Scaevola	glabra			ʻohe naupaka				X
Scaevola	hobdyi						X	
Scaevola	procera			naupaka kuahiwi				X
Scaevola	spp.			naupaka				X
Scaevola	taccada			naupaka kahakai				X
Schenkia	sebaeoides			awiwi	E			
Schiedea	adamantis			maʻoliʻoli	E		X	
Schiedea	apokremnos			maʻoliʻoli	E			
Schiedea	attenuata			maʻoliʻoli	E		X	
Schiedea	diffusa	subsp.	diffusa		E		X	
Schiedea	diffusa	subsp.	macraei		E		X	
Schiedea	haakoaensis						X	
Schiedea	haleakalensis			maʻoliʻoli	E		X	
Schiedea	hawaiiensis			maʻoliʻoli	E		X	
Schiedea	helleri			maʻoliʻoli	E		X	
Schiedea	hookeri			maʻoliʻoli	E			
Schiedea	jacobii			maʻoliʻoli	E		X	
Schiedea	kaalae			maʻoliʻoli	E		X	
Schiedea	kauaiensis			maʻoliʻoli	E		X	
Schiedea	kealiae			maʻoliʻoli	E			
Schiedea	laui				E		X	
Schiedea	lychnoides			kuawawaenohu	E			
Schiedea	lydgatei				E			
Schiedea	membranacea				E			
Schiedea	nuttallii				E		X	
Schiedea	obovata				E		X	
Schiedea	pentandra						X	
Schiedea	perlmanii				E		X	
Schiedea	pubescens				E		X	

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Schiedea	salicaria				E			
Schiedea	sarmentosa				E			
Schiedea	spergulina				E	Schiedea spergulina var. spergulina		
Schiedea	stellarioides				E			
Schiedea	trinervis				E			
Schiedea	verticillata				E			
Schiedea	viscosa				E			
Schoenoplectus	tabernaemontani			ʻakaʻakai				X
Senna	gaudichaudiana							X
Sesbania	tomentosa			ʻohai	E			X
Sesuvium	portulacastrum			ʻakulikuli				X
Sicyos	albus			ānunu	E		X	
Sicyos	hillebrandii						X	
Sicyos	lanceoloideus			ānunu	E		X	
Sicyos	macrophyllus			ānunu	E			
Sida	fallax			ʻilima				X
Sideroxylon	polynesicum			keahi				X
Silene	alexandri				E		X	
Silene	hawaiiensis				T			
Silene	lanceolata				E			
Silene	perlmanii				E		X	
Smilax	melastomifolia			piʻoi				X
Solanum	americanum			popolo				X
Solanum	incompletum			popolo ku mai	E		X	
Solanum	sandwicense			popolo ʻaiakeakua	E		X	
Solanum	nelsonii			popolo	E			X
Sophora	chrysophylla			mamane				X
Spermolepis	hawaiiensis				E			
Sporobolus	virginicus			ʻakiʻaki				X
Stenogyne	angustifolia				E	Stenogyne angustifolia var. angustifolia		
Stenogyne	bifida				E		X	
Stenogyne	calycosa						X	
Stenogyne	campanulata				E		X	
Stenogyne	cranwelliae				E		X	
Stenogyne	kaalae	subsp.	kaalae				X	
Stenogyne	kaalae	subsp.	sherffii		E		X	
Stenogyne	kanehoana				E		X	
Stenogyne	kauaulaensis				E		X	
Stenogyne	kealiae				E		X	
Stenogyne	macrantha			maʻohiohi				X
Stenogyne	purpurea							X
Stenogyne	rugosa			maʻohiohi				X
Stenogyne	scrophularioides			maʻohiohi				X
Syzygium	sandwicensis			ʻohiʻa ha				X
Tetramolopium	arenarium	subsp.	arenarium		E	Tetramolopium arenarium		
Tetramolopium	arenarium	subsp.	laxum		E	Tetramolopium arenarium		
Tetramolopium	capillare			pamakani	E		X	
Tetramolopium	filiforme	var.	filiforme		E	Tetramolopium filiforme		
Tetramolopium	filiforme	var.	polyphyllum		E	Tetramolopium filiforme		

E = Endangered, T = Threatened

PEPP= than 50 individuals in the wild

Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Tetramolopium	lepidotum	subsp.	lepidotum		E		X	
Tetramolopium	remyi				E		X	
Tetramolopium	rockii	var.	calcisabulorum		T	Tetramolopium rockii		
Tetramolopium	rockii	var.	rockii		T	Tetramolopium rockii		
Tetramolopium	sp. nov. 2 (Mauna Kahalawai)						X	
Tetramolopium	stemmermanniae						X	
Touchardia	latifolia			olona				X
Touchardia	sandwicensis			opuhe				X
Trematolobelia	singularis				E			
Urera	kaalae			opuhe	E		X	
Vaccinium	calycinum			‘ohelo; ‘ohelo kau la‘au				X
Vaccinium	dentatum			‘ohelo				X
Vaccinium	reticulatum			‘ohelo				X
Vicia	menziesii				E		X	
Vigna	marina							X
Vigna	owahuensis				E	Vigna o-wahuensis		
Viola	chamissoniana	subsp.	chamissoniana	pamakani	E			
Viola	helenae				E		X	
Viola	kauaensis	var.	hosakae				X	
Viola	kauaensis	var.	wahiawaensis	nani wai‘ale‘ale	E		X	
Viola	lanaiensis				E			
Viola	oahuensis				E			
Vitex	rotundifolia							X
Waltheria	indica							X
Wikstroemia	monticola			‘akia				X
Wikstroemia	oahuensis			‘akia				X
Wikstroemia	oahuensis			‘akia				X
Wikstroemia	phillyreifolia			‘akia				X
Wikstroemia	sanwicensis			‘akia				X
Wikstroemia	skottsbergiana			‘akia	E		X	
Wikstroemia	villosa				E		X	
Wilkesia	gymnoxiphium			iliau				X
Wilkesia	hobdyi			iliau	E			X
Wollastonia	fauriei				E	Lipochaeta fauriei		
Wollastonia	kamolensis				E	Melanthera kamolensis	X	
Wollastonia	micrantha	subsp.	exigua	nehe	E	Lipochaeta micrantha		
Wollastonia	micrantha	subsp.	micrantha	nehe	E	Lipochaeta micrantha	X	
Wollastonia	tenuifolia			nehe	E	Melanthera tenuifolia		
Wollastonia	venosa			nehe	E	Lipochaeta venosa		
Wollastonia	waimeaensis			nehe	E	Lipochaeta waimeaensis	X	
Xylosma	crenata				E	Xylosma crenatum	X	
Xylosma	hawaiiense			maua				X
Zanthoxylum	dipetalum	var.	tomentosum	kawa‘u	E		X	
Zanthoxylum	hawaiiense				E			
Zanthoxylum	kauaense			a‘e or hea‘e				X
Zanthoxylum	oahuense				E		X	
Aquatic Plants								
Halophila	hawaiiana			seagrass				X

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Ruppia	maritima			widgeon grass				X
Endemic Terrestrial Algae								
Bjornbergiella	hawaiiensis							X
Diprora	haenaensis							X
Navicula	contenta							X
Navicula	hawaiiensis							X
Navicula	thurstonensis							X
Scytonema	javanicum	var.	hawaiiense					X
Scytonema	pulvinatum							X
Endemic Freshwater Algae								
Batrachospermum	spermatiophorum							X
Cladophora	longiarticulata	var.	valida					X
Conferva	sandvicensis							X
Cosmarium	depauperatum							X
Eunotia	abbottiae							X
Eunotia	smithiae							X
Frustulia	creuzburgensis							X
Haematococcus	thermalis							X
Lophopodium	sandvicense							X
Lyngbya	cladophorae							X
Micrasterias	adscendens							X
Navicula	genustriata							X
Navicula	oahuensis							X
Navicula	testata							X
Pithophora	affinis							X
Pithophora	macrospora							X
Staurastrum	monticulosum	var.	duplex					X
Staurastrum	subtile							X
Stauroneus	maunakeäensis							X
Stigonema	aerugineum							X
Tolypothrix	musicola	var.	havaiensis					X
Trentepohlia	cucculata	var.	sandvicensis					X
Trentepohlia	diffracta	var.	sandvicensis					X
Xanthidium	octocorne	var.	majus f. havaiensis					X
Endemic Marine Algae								
Acrochaetium	dotyi							X
Alsidium	cymatophilum							X
Antithamnion	erucacladellum							X
Boodleopsis	hawaiiensis							X
Callidictyon	abyssorum							X
Callithamniella	pacifica							X
Centroceras	corallophilloides							X
Ceramium	cingulum							X
Ceramium	dumosertum							X
Ceramium	hanaense							X
Ceramium	tranquillum							X

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Ceramium	womersleyi							X
Chrysymenia	glebosa							X
Codium	cicatrix							X
Codium	extricatum							X
Corallophila	ptilocladioides							X
Crouania	sp.							X
Dasya	iridescens							X
Dasya	kriseniae							X
Dasya	muurayana							X
Ditria	reptans							X
Dotyella	hawaiiensis							X
Dotyella	irregularis							X
Dotyophycus	pacificum							X
Dudresnaya	littleri							X
Euptilocladia	magruderi							X
Fernandosiphonia	ecorticata							X
Gelidiella	womersleyana							X
Gelidium	pluma							X
Gelidium	reediae							X
Gracilaria	abbottiana							X
Gracilaria	coronopifolia							X
Gracilaria	dawsonii							X
Gracilaria	dotyi							X
Gracilaria	epihippisora							X
Grateloupia	hawaiiana							X
Halymenia	chiangiana							X
Halymenia	cromwellii							X
Halymenia	stipitata							X
Hawaiia	trichia							X
Helminthocladia	rhizoidea							X
Helminthocladia	simplex							X
Herposiphonia	dubia							X
Hypoglossum	wynnei							X
Endemic Marine Algae								
Janczewskia	hawaiiana							X
Laurencia	mcdermidae							X
Liagora	perennis							X
Lophocladia	kipukaia							X
Micropeuce	setosus							X
Naccaria	hawaiiana							X
Padina	melemele							X
Padina	thivyae							X
Palisada	crustiformans							X
Peleophycus	multiprocarpium							X
Phaeocolax	kajimurai							X
Platoma	ardreanum							X
Pleonosporium	intricatum							X
Plocamium	sp.							X

E = Endangered, T = Threatened
PEPP= than 50 individuals in the wild
Important Interaction= wildlife habitat or dominant plant in community

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, Flowering Plants, and Algae

Genus	Species	Variatey	Subspecies	Common/Hawaiian Name	Federal Status	Federal Listing Name (if diff	PEPP	Important Interaction
Polyopes	hakalauensis							X
Polysiphonia	profunda							X
Polysiphonia	rubrorhiza							X
Polysiphonia	tuberosa							X
Prionitis	corymbifera							X
Pseudochlorodesmis	hawaiiensis							X
Pterocladiella	bulbosa							X
Reticulocaulis	mucosissimus							X
Sargassum	echinocarpum							X
Sargassum	obtusifolium							X
Sargassum	polyphyllum							X
Scinaia	furcata							X
Scinaia	hormoides							X
Spirocladia	hodgsoniae							X
Sporochnus	dotyi							X
Trichogloeopsis	hawaiiana							X
Ululania	stellata							X
Valonia	trabeculata							X
Womersleyella	pacifica							X
Wrangelia	elegantissima							X

APPENDIX C: OVERVIEW OF MANAGEMENT PROGRAMS AND EXISTING REGULATIONS

A variety of land and water management programs and existing regulations protect Hawai‘i’s native species and their habitats. This appendix provides an overview of these protections, first outlining the land and water management by federal, state, county, and private entities, then describing existing regulations in order from international, federal, state, and local protections.

LAND AND WATER MANAGEMENT PROGRAMS

National Parks

The National Park system, operated by the National Park Service of the U.S. Department of Interior, was established to preserve natural areas (including scenery, natural and historic features, and wildlife) in the United States so that they can be enjoyed by current generations and preserved for future generations. The protection, management, and administration of these areas are to be conducted in light of the high public value and integrity of the National Park System. There are nine national park units in Hawai‘i: Haleakalā National Park (Maui); Kalaupapa National Historical Park (Moloka‘i); Hawai‘i Volcanoes National Park (Hawai‘i); Kaloko-Honokōhau National Historical Park (Hawai‘i); Pu‘uhonua O Hōnaunau National Historical Park (Hawai‘i); Ala Kahakai National Historic Trail (Hawai‘i); Pu‘ukoholā Heiau National Historic Site (Hawai‘i), the U.S.S. Arizona Memorial (O‘ahu); and the most recent addition, Honouliuli National Monument (O‘ahu).

National Wildlife Refuges

Over 500 National Wildlife Refuges (NWRs) across the United States form a system of habitats managed by the U.S. Fish and Wildlife Service (USFWS) of the U.S. Department of Interior. Hawai‘i’s Refuges were established to protect the Islands’ unique native plants and animals and their habitats. There are eleven wildlife refuges in Hawai‘i: Hawaiian Islands NWR (Northwestern Hawaiian Islands, including marine waters), Hanalei NWR (Kaua‘i), Hulē‘ia NWR (Kaua‘i), Kīlauea Point NWR (Kaua‘i), O‘ahu Forest NWR (O‘ahu), James Campbell NWR (O‘ahu), Pearl Harbor NWR (O‘ahu), Keālia Pond NWR (Maui), Kakahai‘a NWR (Moloka‘i), Hakalau Forest NWR (Hawai‘i), and Midway Atoll NWR (an unincorporated territory of the United States administered as a National Wildlife Refuge).

U.S. Military Installations – Integrated Natural Resources Management Plans

The Sikes Act Improvements Act of 1997 required every military installation containing land and water suitable for the conservation and management of natural resources to complete an Integrated Natural Resources Management Plan (INRMP). The purpose of these INRMPs is to integrate the mission of the military installation with stewardship of the natural resources found there. There are several INRMPs covering military installations in Hawai‘i, including:

- Oahu INRMP (covers U.S. Army installations at Dillingham Military

Reservation, Kahuku Training Area, Kawailoa Training Area, Mākua MilitaryReservation, Schofield Barracks East Range, Schofield Barracks Military Reservation);
- Pōhakuloa Training Area INRMP (covers U.S. Army installation at Pōhakuloa Training Area, Hawai‘i);
- Marine Corps Base Hawai‘i INRMP (covers Marine Corps installations on O‘ahu, including Mōkapu Peninsula (Kāne‘ohe Marine Base), Waikāne Valley, and Marine Corps Training Area – Bellows);
- Pearl Harbor Naval Complex INRMP (covers U.S. Navy installations at Pearl Harbor, O‘ahu);
- Naval Magazine Pearl Harbor INRMP (covers U.S. Navy installation at Lualualei, O‘ahu);
- Naval Computer and Telecommunications Area Master Station Pacific INRMP (covers U.S. Navy installation at Wahiawā and Lualualei, O‘ahu); and
- Pacific Missile Range Facility INRMP (covers U.S. Navy installation at Barking Sands, Kaua‘i).

National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) is responsible for managing fisheries in federal waters and protecting species under the Endangered Species Act (ESA), the Marine Mammal Protection Act, and other federal legislation.

Western Pacific Fisheries Management Council

The Western Pacific Fisheries Management Council (WPFMC) is responsible for recommending fisheries management actions in federal waters in the region, including Hawai‘i, and works in concert with NMFS. WPFMC develops Fisheries Management Plans under the Magnuson-Stevens Fishery Conservation and Management Act for commercially harvested species. These plans must identify Essential Fish Habitat that is necessary for “spawning, breeding, feeding, or growth to maturity” and enact actions to minimize threats to and conserve Essential Fish Habitat. These plans also identify more limited Habitat Areas of Particular Concern that are key habitats for managed species. The Fisheries Management Plans are developed for bottomfishes, coral reef ecosystems, crustaceans, pelagic fishes, and precious corals.

Papahānaumokuākea Marine National Monument

Papahānaumokuākea Marine National Monument is the single largest fully protected conservation area in the United States, and one of the largest marine conservation areas in the world. It encompasses 582,578 square miles (1,508,870 square kilometers) of the Pacific Ocean—an area larger than all the country’s national parks combined. The Papahānaumokuākea Marine National Monument was established in 2006, Act and expanded in 2016 by Presidential Proclamations under the authority of the Antiquities Act. It was expressly created to protect an exceptional array of natural and cultural resources. No commercial fishing is allowed, and recreational activities are limited to the

Midway Atoll Special Management Area (SMA). Native Hawaiian practices may be authorized within the monument through Native Hawaiian practices permit.

Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve
The Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve was established in 2000 by Executive Order. On August 26, 2016, President Barack Obama signed a proclamation expanding PMNM to 582,578 square miles (1,508,870 km2). The reserve protects the species in the marine waters and submerged lands of the Northwestern Hawaiian Islands, as well as the Hawaiian Islands NWR outside of state waters. It is managed by the National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA-NOS). Only limited fishing that occurred before the Executive Order is allowed, and then only in areas not designated for complete protection from fishing and other consumptive uses.

Hawaiian Islands Humpback Whale National Marine Sanctuary
Jointly managed by NOAA-NOS and Hawai‘i Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR), to protect humpback whales (koholā) in federal and state waters. The sanctuary's mission is to protect Hawai‘i humpback whales and their principal breeding and calving wintering habitat around the Hawaiian Islands through closely aligned education, research, and resource protection efforts. The Sanctuary includes waters around portions of all the Main Hawaiian Islands, centering on the key habitat of Maui County. Protections for the whales include increased fines for violations of the ESA and Marine Mammal Protection Act and 91-meter (100-yard) approach rule to limit harassment of whales in the water.

State Natural Area Reserves
The State Natural Area Reserve (NAR) system was established to preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawai‘i (Hawai‘i Revised Statutes [HRS] Chapter 195). The NARS are managed by the State DLNR, Division of Forestry and Wildlife (DOFAW). Each Natural Area Reserve was established based on the concept of protecting ecosystems rather than individual species, with the goal of preserving and protecting representative samples of Hawaiian biological ecosystems and geological formations. There are 21 NARs in Hawai‘i covering more than 50,000 hectares (123,000 acres): Hono o Na Pali (Kaua‘i), Ku‘ia (Kaua‘i), Ka‘ena Point (O‘ahu), Kaluanui (O‘ahu), Pahole (O‘ahu), Mt. Ka‘ala (O‘ahu), West Maui (Maui), Hanawī (Maui), ‘Āhihi-Kīna‘u (Maui) (contains both terrestrial and marine acreage), Kanaio (Maui), Nakula (Maui), Oloku‘i (Moloka‘i), Pu‘u Ali‘i (Moloka‘i), Manukā (Hawai‘i), Kīpāhoehoe (Hawai‘i), Mauna Kea Ice Age (Hawai‘i), Waiākea 1942 Flow (Hawai‘i), Kahauale‘a (Hawai‘i), Pu‘u Maka‘ala (Hawai‘i), Laupāhoehoe (Hawai‘i), and Pu‘u o ‘Umi (Hawai‘i).

State Forest Reserves
The State Forest Reserves were first established in Hawai‘i over a century ago to protect the water supply that was being threatened due to the destruction of the forest

by cattle (HRS Chapter 183). The Forest Reserves are managed by DOFAW. Limited collecting for personal use (e.g., ti leaves and bamboo) and limited (no more than $3,000 value per year) commercial harvesting of timber, seedlings, greenery, and tree ferns is allowed by permit. There are 55 forest reserves on the five major islands (Kauaʻi, Oʻahu, Maui, Molokaʻi, and Hawaiʻi), totaling over 273,500 hectares (676,000 acres); most of the state land in the Conservation District is within a forest reserve.

State Restricted Watersheds
The purpose of a State Restricted Watershed is to regulate human use in areas where water supplies are vulnerable to contamination by public access (Hawaiʻi Administrative Rules (HAR) §§ 13-105-1 et seq.). Six restricted watersheds on Oʻahu (three) and Hawaiʻi (three) have been established and are managed by DOFAW.

State Wilderness Preserves
The purpose of a State Wilderness Preserve is to preserve and protect "all manner of flora and fauna" (HAR §§ 13-3-1 et seq.). The only wilderness preserve in the state is the Alakaʻi Wilderness Preserve on Kauaʻi, covering just over 3,600 hectares (9,000 acres) on the summit plateau of Mt. Waiʻaleʻale, and is managed by DOFAW.

State Wildlife Sanctuaries
Wildlife Sanctuaries are established by the State to conserve, manage, and protect indigenous wildlife (HAR §§ 13-126-1 et seq.). The Wildlife Sanctuaries are managed by DOFAW. There are eight wildlife sanctuaries in the state: Paikō Lagoon Wildlife Sanctuary (Oʻahu), Pouhala Marsh (Oʻahu), Hamakua Marsh (Oʻahu), Kawainui Marsh (Oʻahu), Kanahā Pond Wildlife Sanctuary (Maui), Kīpuka ʻĀinahou Nēnē Sanctuary (Hawaiʻi), Puu Waawaa Forest Bird Sanctuary (Hawaiʻi), and the Hawaiʻi State Seabird Sanctuary (multiple islands offshore of the Main Hawaiian Islands and two islands of Kure Atoll in the Northwestern Hawaiian Islands).

State Parks
There are 52 state parks encompassing nearly 10,000 hectares (25,000 acres) on all the Main Hawaiian Islands. These parks are managed for outdoor recreation and heritage opportunities and range from landscaped grounds with developed facilities to wildland areas with trails and primitive facilities (HRS Chapter 183).

Leased and Unencumbered Lands
The DLNR Division of Land Management manages state lands not set aside to agencies or otherwise encumbered or designated for a specific land use. Some of these lands are leased by auction to private landowners, while lands that are not under lease are called "unencumbered lands." Unencumbered lands are often beach or coastal areas in the Conservation District (see below under State Land Use Districting) but do not include parks, harbors, or forest reserves.

Hawaiian Home Lands

The Department of Hawaiian Home Lands manages approximately 82,000 hectares (203,000 acres) in trust for Native Hawaiians. The mission of the Department of Hawaiian Home Lands is to manage the Hawaiian Home Lands trust effectively and to develop and deliver land to Native Hawaiians. The Department will partner with others towards developing self-sufficient and healthy communities.

Commission on Water Resources Management

The Commission on Water Resources Management within the DLNR is mandated by Chapter 174C of the Hawai‘i Revised Statutes to set policies, protect resources, defines uses, establish priorities while assuring rights and uses, and establish regulatory procedures for inland surface water and ground water resources. The Commission designates and manages water management areas and is responsible for protecting instream uses of water, including maintaining the biological integrity of aquatic wildlife.

State Waters

DAR manages marine and freshwater areas throughout the state under general management authority from Hawai‘i Revised Statutes Chapters 188 and 190. These areas include 10 Marine Life Conservation Districts (MLCDs), 22 Fishery Management Areas (FMAs), four freshwater Public Fishing Areas (PFAs), the Paiko Lagoon Wildlife Sanctuary, the Coconut Island Marine Laboratory Refuge, the South Kona ‘Ōpelu Fishing Area, and the ‘Ewa Limu Managment Area.

Marine Life Conservation Districts (MLCDs)

MLCDs were introduced to Hawai‘i in the fall of 1967 with Hanauma Bay on O‘ahu. The resulting increase in fish populations was phenomenal, and the bay has become world famous. At the present time there are eleven MLCDs statewide, and other sites are being considered as well. Eight MLCDs include areas that are set aside as No Take Marine Protected Areas to protect sensitive species and habitats and other areas that allow a variety of forms of take but were set up to manage user conflicts or address other management issues. Some limitations on access (e.g., boats) also occur. Note one MLCD, Wai‘ōpae on Hawai‘i Island, was covered by the 2018 lava flow.

Marine Fishery Management Areas (FMAs)

FMAs are areas where specific regulations are implemented to conserve fish stocks, protect habitat, manage key species and, in some cases, incorporate traditional resource management approaches to sustain local subsistence fishing practices. They have restrictions on gear, size of fish, access, season, etc., that differ from general fishing regulations. The Waikiki-Diamond Head Shoreline FMA is closed to fishing on odd numbered years and open to fishing on even numbered years. Many FMAs are in harbors, bays, or canals.

Public Fishing Areas (PFA)

PFAs are freshwater managed areas with regulations to protect introduced gamefish and other fishes. Access, take, size, gear, and season limits are used. There is one PFA located on Hawai‘i island, two on Kaua‘i and one on O‘ahu.

Statutorily Designated Regulated Areas

Statutorily designated regulated areas are specific regions that are defined and regulated by law for the purpose of conservation, management, or other forms of oversight. These areas are managed to protect natural resources, wildlife, or cultural heritage. The designation of these areas helps maintain sustainable use, preserve ecosystems, and provide guidelines for human activities within them. There are five statutorily designated regulated areas on Oʻahu, and one on Kauaʻi.

Bottomfish Restricted Fishing Areas
Bottomfish Restricted Fishing Areas (BRFAs) are managed by DAR and were established in 1998 after encouragement by the Western Pacific Fisheries Management Council and consultation with an ad hoc committee and extensive public comment. There are 12 BRFAs. Their goal is to protect stocks of bottomfish in the Main Hawaiian Islands. No fishing for state-defined bottomfish species was allowed from 2007 – 2019, after which the BLNR approved reopening of four, and in 2022, all BRFAs.

Fish Replenishment Areas
Fish Replenishment Areas (FRAs) are managed by DAR and were established in 2000 in order to replenish and protect the stocks of marine aquarium fishes on the island of Hawaiʻi. The goal of FRAs is to address declining fish populations, habitat degradation and overfishing pressures, especially among commercial aquarium fishers and other resource users. No commercial or recreational aquarium fish collecting or fish feeding is allowed. There are nine FRAs in within the West Hawaiʻi Regional Fishery Managment Area.

Kahoʻolawe Island Reserve
In late 1990, the U.S. Department of Defense stopped using Kahoʻolawe for bombing and target practice and shortly thereafter began a Congressionally-funded clean-up of the island. In 1993, the Hawaiʻi State Legislature established the Kahoʻolawe Island Reserve to protect the entire island and surrounding coastal waters extending two miles seaward and established the Kahoʻolawe Island Reserve Commission (KIRC) to manage the island. The U.S. Navy clean-up resulted in approximately ten percent subsurface clearance of the island and 69 percent surface clearance of unexploded ordnance from the island. In 2003, management and ownership of the island was officially transferred from the U.S. Navy to KIRC, a state agency administratively attached to DLNR. Kahoʻolawe Island Reserve is to be used solely and exclusively, in perpetuity, for: (1) the preservation and practice of all rights customarily and traditionally exercised by Native Hawaiians for cultural, spiritual, and subsistence purposes; (2) the preservation and protection of the Reserve's archaeological, historical, and environmental resources; (3) rehabilitation, revegetation, habitat restoration, and preservation; and (4) education. Commercial uses are strictly prohibited in the Reserve (HRS Chapter 6K). Marine take is restricted to non-commercial catch for Kahoʻolawe visitors and open trolling for the general public in restricted areas and dates.

Division of Boating and Ocean Recreation

The aim of the DLNR Division of Boating and Ocean Recreation (DOBOR) is to preserve Hawai‘i’s natural and cultural resources while ensuring public access to State waters and enhancing the ocean experience. DOBOR manages 21 small boat harbors, 54 launching ramps, 13 offshore mooring areas, 10 designated ocean water areas, and 108 designated ocean recreation management areas. DOBOR regulates commercial operations, events, placement of sinking vessels, pollution, anchoring, and user conflicts, all of which can affect wildlife conservation efforts.

Office of Conservation and Coastal Lands
The DLNR Office of Conservation and Coastal Lands (OCCL) has a mission to protect and conserve Conservation District lands and beaches within the State of Hawai‘i (including submerged lands) for the benefit of present and future generations, pursuant to Article XI, Section 1, of the Hawai‘i State Constitution. OCCL plays an important role in determining shoreline boundaries for public access, shoreline encroachments, administers application for ocean aquaculture, and enacts beach restoration projects.

State Department of Agriculture
The State Department of Agriculture, Agricultural Resource Management Division, operates the state’s Agricultural Park program. This program makes land available to small farmers at reasonable cost with long-term tenure and provides irrigation water. There are ten agricultural parks: four on Hawai‘i, four on O‘ahu, one on Kaua‘i, and one on Moloka‘i. The lessees are all engaged in diversified agricultural crops or aquaculture and are small farming enterprises (under 8 hectares or 20 acres). The Division also manages five irrigation systems (two on O‘ahu, two on Hawai‘i, and one on Moloka‘i) and six reservoirs (four on Hawai‘i, one on Moloka‘i, and one on O‘ahu).

Board of Water Supply
The Boards of Water Supply in each county own and manage land in their island watersheds, typically in mountainous areas, in order to protect the county’s supply of water.

CONSERVATION EFFORTS

Invasive species committees
Over the past decade, partnerships and groups have organized to address gaps in Hawai‘i’s biosecurity system. These include the Hawai‘i Invasive Species Council (HISC), to provide cabinet-level leadership, the Coordinating Group on Alien Pest Species (CGAPS), for interagency and non-governmental organization communications and collaborative projects, and the Invasive Species Committees (ISCs) for island-based rapid response.

HISC was created in 2003 to advise the Governor on issues regarding invasive species, create and implement an invasive species plan, review state agency mandates and commercial interests, and suggest appropriate legislation to improve the State’s administration of invasive species programs and policies. HISC, under the co-leadership

of the State Department of Agriculture and DLNR, comprises the leaders of the University of Hawai‘i, the State Department of Business, Economic Development and Tourism, State Department of Health, and State Department of Transportation, with an invitation to participate issued to the Hawai‘i State Legislature, county mayors, State Department of Defense, State Department of Commerce and Consumer Affairs, State Department of Hawaiian Home Lands, federal agency representatives, and non-profit agency representatives. Hawai‘i is the sixth state in the nation to create this type of council.

CGAPS was formed in 1995 and is composed of primarily management-level participants from every major agency and organization involved in invasive species work including federal, state, county, and private entities. Members meet quarterly to discuss how to influence policy and funding decisions, improve communications, increase collaborations, and promote public awareness.

The first ISC was formed on Maui in 1997 in response to the need for an early detection and rapid on-the-ground response to an array of incipient invasive species, and one is now on every major Hawaiian island (Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i). The ISCs are voluntary partnerships of private, government, non-profit organizations, and individuals working together to address invasive species issues particular to the island. The overall goal of the ISCs is to prevent, eradicate, or control priority incipient plant and animal species that threaten Hawai‘i’s most intact federal, state, and private conservation lands.

> In addition, there are working groups specific to high-priority potential invasive species. Examples include the West Nile Virus Prevention Group, the Brown Tree Snake Rapid Response Team, and the Axis Deer (*Axis axis*) Rapid Response Team. The West Nile Virus Prevention Group is composed of a broad coalition of government agencies and non-governmental organizations, including the State Department of Agriculture, DLNR, the Department of Health, the federal Department of Agriculture, USFWS, the U.S. Geological Survey Biological Resources Division, the U.S. Postal Service, the University of Hawai‘i, the Hawaiian Humane Society, the Honolulu Zoo, Ducks Unlimited, and The Nature Conservancy (TNC) of Hawai‘i. The West Nile Virus Prevention Group has developed a plan to respond to, track, and limit the spread of West Nile virus in Hawai‘i. A multi-agency Brown Tree Snake Rapid Response Team has been formed to address potential brown tree snake sightings in Hawai‘i. Members travel to Guam for regular training in how to search for and capture brown tree snakes, as one method to prevent the establishment of this animal. The Axis Deer Rapid Response Team was funded by DLNR and HISC in 2011 to eliminate this new pest. Four deer were shot in 2012-2013 and no deer sightings have been confirmed since.

Watershed partnerships

The first watershed partnership was established in East Maui in 1991 by the State DLNR, the National Park Service, the county of Maui, the East Maui Irrigation Company, TNC,

Keola Hana Maui, and Haleakalā Ranch Company in recognition that active management was needed to sustain a healthy forested watershed and that effective management is best achieved through coordinated actions of all major landowners in the watershed. Since that time, watershed partnerships have now been established on five islands: Kauaʻi Watershed Alliance (Kauaʻi, 2003), Koʻolau Mountains Watershed Partnership (Oʻahu, 1999), Waiʻanae Mountains Watershed Partnership (Oʻahu, 2010), West Maui Mountains Watershed Partnership (Maui, 1998), East Maui Watershed Partnership (Maui, 1991), Leeward Haleakalā Watershed Restoration Partnership (Maui, 2003), East Molokaʻi Watershed Partnership (Molokaʻi, 1999), Three Mountain Alliance (Hawaiʻi, 2007), the Kohala Mountains Watershed Partnership (Hawaiʻi, 2004), and the Mauna Kea Watershed Alliance (Hawaiʻi, 2010). Overall, these partnerships cover over 890,000 hectares (2.2 million acres) of forested watershed, involving more than 71 public and private partners. The amount of land under active management varies between partnerships. In 2003, the individual watershed partnerships jointly formed the Hawaiʻi Association of Watershed Partnerships, to support the statewide needs of watershed partnerships.

Endangered forest bird conservation

The State has established a partnership of non-profit conservation organizations, private landowners, and government agencies including DLNR and USFWS to work cooperatively for the conservation of endangered birds. The Maui Forest Bird Recovery Project and the Kauaʻi Endangered Bird Recovery Team are two ongoing efforts. The goal of these cooperative efforts is to recover native Hawaiian ecosystems at the landscape level and to establish self-sustaining bird populations in the wild, using management programs that include captive propagation and reintroduction. Their efforts employ an integrated conservation strategy of research, habitat management, and public education, with a focus on ecosystem health and protection as a prerequisite to reintroduction. On Maui, the focus of the program is on conservation efforts for the most critically endangered of the surviving Maui honeycreepers, the Maui parrotbill (*Pseudonestor xanthophrys*) and the ʻakohekohe (*Palmeria dolei* [crested honeycreeper]). On Kauaʻi, the focus is primarily on three federally listed endangered species: the puaiohi (*Myadestes palmeri*), ʻakikiki (*Oreomystis bairdi*), and ʻakekeʻe (*Loxops caeruleirostris*), with the goal of facilitating recovery of their populations in the Alakaʻi Swamp.

Endangered seabird conservation

The State has formed a partnership with USFWS and University of Hawaiʻi to conserve the endangered seabirds on Kauaʻi. The project focuses on the three endangered seabirds found on the island of Kauaʻi: ʻaʻo (*Puffinus newelli* [Newell's shearwater]), ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), and ʻakēʻakē (*Oceanodroma castro* [band-rumped storm petrel]).Project staff work involves identifying the breeding distribution of these rare and enigmatic seabirds, monitoring their breeding colonies, undertaking research projects to better understand their life histories and the various

threats they face, and working with partner projects and organizations to ensure their long-term conservation.

Offshore Island Restoration Committee
The Offshore Island Restoration Committee (OIRC) is a cooperative effort made up of USFWS, DOFAW, Bishop Museum, the University of Hawai‘i at Mānoa, TNC, and the National Park Service to inventory and restore high-priority offshore islands and islets throughout the Main Hawaiian Islands. OIRC conducted an initial round of inventorying, identifying, and prioritizing offshore islands and islets for restoration, management, and conservation activities. The O‘ahu Offshore Islet Seabird Management project, a cooperative project between DOFAW and the Center for Conservation Research and Training, University of Hawai‘i, has begun eliminating alien predators and removing non-native plants on priority islets.

Hawai‘i and Pacific Plants Recovery Coordinating Committee
The Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC) was established by USFWS in 1993 to provide the agency with information and advice on the biology, current status, and management needs to recover the many listed endangered or threatened Hawaiian plant taxa. Current members of the HPPRCC include representatives from USFWS, DOFAW, TNC, U.S. Geological Survey, U.S. Army, Hawai‘i Biodiversity and Mapping program, University of Hawai‘i, and the Hawai‘i Silversword Foundation. HPPRCC has developed strategies for rare plant conservation and standards for viable population sizes in mitigation projects, and has identified “Genetic Safety Net” plants—plants for which there are fewer than 50 known individuals in the wild—to be included in the Plant Extinction Prevention (PEP) program. The goal is to coordinate and integrate existing plant conservation efforts.

Plant Extinction Prevention Program
The Hawaii Plant Extinction Prevention Program (PEPP) is a statewide initiative focused on safeguarding the rarest native plants in Hawaii by actively monitoring, collecting, propagating, and reintroducing endangered species, primarily targeting those with fewer than 50 individuals remaining in the wild; it operates as a project under the University of Hawaii at Manoa and collaborates with various partners to protect Hawaii's unique flora from extinction.

Invertebrate Conservation Strategy Initiative
The Invertebrate Conservation Strategy Initiative is supported by a variety of state, federal, academic, and non-profit organizations dedicated to the conservation of native invertebrate fauna. Participants include the University of Hawai‘i, the Hawai‘i Department of Agriculture, USFWS, the U.S. Forest Service, the National Park Service, the U.S. Geological Survey Biological Resources Division, the U.S. Department of Agriculture, the U.S. Army Garrison Hawai‘i Natural Resources Management, Bishop Museum, HISC, the Hawai‘i Alliance of Watershed Partnerships, the Hawai‘i Wildlife Fund, the University of California Berkeley, and Cornell University. The objective of the initiative is to develop long-term strategies for the assessment, management,

and conservation of invertebrate species and the habitats in which they occur. The initiative partners are also focusing on immediate tasks to:

1. Identify and prioritize invertebrate conservation needs for species and habitats of greatest concern across the state;
2. Analyze existing expertise, and research completed to date, to understand gaps in our knowledge base,
3. Identify and prioritize future research needs;
4. Develop a standard method of classifying threats to, or status of, a given species;
5. Identify and prioritize management strategies that address or mitigate current threats to invertebrate conservation;
6. Develop a means of measuring conservation successes; and
7. Examine current and future funding available to pursue action on items-

Natural Area Partnership Preserves

Under the Natural Area Partnership (NAP) program, the State provides two-thirds of the management costs for private landowners who agree to permanently protect intact native ecosystems, essential habitat for threatened and endangered species, or areas with other significant biological resources (HRS Chapter 195). The NAP program can support a full range of management activities to protect, restore, or enhance significant native resources or geological features. There are nine NAP-funded preserves in Hawai‘i: Pu‘u Kukui (Maui), Kapunakea (Maui), Waikamoi (Maui), Waikamoi (East Maui Irrigation) (Maui), Mo‘omomi (Moloka‘i), Kamakou (Moloka‘i), Pelekunu (Moloka‘i), Kanepu‘u (Lāna‘i), and Ka‘ū (Hawai‘i).

The Nature Conservancy Preserves

TNC Hawai‘i is a private, non-profit affiliate of the national organization, with a goal to bring active, protective management to representative, viable, native ecological systems and species of the Hawaiian Archipelago, and to thereby sustain the greatest possible complement of native Hawaiian biodiversity into the future. In addition to managing seven of the nine NAP preserves, TNC manages other protected areas: ‘Ihi‘ihilauakea Preserve (O‘ahu), Wainiha Preserve (Kaua‘i), and Kona Hema Preserve (Hawai‘i). Additional conservation management is conducted through cooperation with private landowners.

National Tropical Botanical Gardens

The National Tropical Botanical Garden (NTBG) is dedicated to the conservation of tropical plant diversity, particularly rare and endangered species. The NTBG, which is supported by private contributions, operates three gardens on Kaua‘i: Limahuli Garden and Preserve (400+ hectares or 1,000+ acres), McBryde Garden (102 hectares or 252 acres), and Allerton Garden (40+ hectares or 100+ acres).

Land Trusts

The state has several private non-profit organizations whose mission is to acquire lands for long-term protection and preservation for the enjoyment of current and future generations. Examples include the Trust for Public Land, the Hawaiian Islands Land

Trust, and the Molokaʻi Land Trust. The Hawaiian Islands Land Trust is currently managing the Waiheʻe Coastal Dunes and Wetlands Reserve on Maui.

General Conservation Management on Private Land

Unlike the continental United States, most of the private land in Hawaiʻi is owned by a few major landowners. Though nearly half of Hawaiʻi's lands are owned by either state or federal agencies, the participation and involvement of private landowners, many of whose lands are adjacent to government managed areas, is critical for the conservation of native species and habitats. Hawaiʻi has several programs that provide financial and technical support for assisting private landowners interested in conservation on their lands. Examples include federal programs offered through USFWS and the Natural Resources Conservation Service (in the U.S. Department of Agriculture), state programs through DOFAW (e.g., Landowner Incentive Program, Forest Stewardship program), and county tax incentives (e.g., island of Hawaiʻi native forest tax exemption).

Management of Game Wildlife Species

One of the mandates of DLNR is to preserve, protect, and promote public hunting in the State of Hawaiʻi. This program involves the management of 15 species of game birds and six species of game mammals that are considered a valued source of food and subsistence in many communities in Hawaiʻi. DOFAW manages game resources under the federal Wildlife Restoration Program (Pittman-Robertson, or PR, Program). This program supports and facilitates hunting on public and private lands by providing a structured program that promotes and encourages participation. The program aims to direct hunting toward less ecologically sensitive areas, while at the same providing structured hunter access to more remote/pristine sites where recreational hunting can help to control game mammal populations. The program includes projects for monitoring hunter activities, monitoring game species population status, leasing land to provide additional areas for public hunting, improving game habitat, controlling alien predators to enhance game populations in suitable habitats, developing facilities and infrastructure, and gathering and analyzing data. The game species hunted in Hawaiʻi are not native, and game mammal species in particular may have negative impacts on sensitive native species and ecosystems. Managing game in balance with conserving native wildlife involves managing game populations to control or eliminate them in habitat and places necessary to sustain and conserve native wildlife and managing to support game in areas that are not essential for native wildlife.

EXISTING REGULATIONS

Convention on International Trade in Endangered Species

The Convention on International Trade in Endangered Species (CITES) establishes import and export restrictions and regulations to protect living and dead animals and plants and their parts from excessive extractive use and international trade.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act is the domestic law that implements the United States' commitment to four international conventions (with Canada, Japan, Mexico, and Russia)

for the protection of migratory birds. Each of the conventions protect selected species of birds that are common to the U.S. and the other country (i.e., they occur in both countries at some point during their annual life cycle).

Federal Endangered Species Act

The ESA was passed in 1973, to prevent the extinction of species. The current purpose of the ESA is to conserve the ecosystems on which threatened and endangered species depend and to conserve and recover listed species. A species may be listed as threatened if it is likely to become endangered within the foreseeable future, and a species may be listed as endangered if it is in danger of extinction throughout all or a significant portion of its range. In addition, listed species receive regulatory protection, as taking (which includes injuring or killing) a listed species is prohibited under the ESA. In addition, the ESA requires federal agencies to consult with USFWS or NMFS in order to ensure that activities they fund, authorize, permit, or carry out are not likely to jeopardize the continued existence of the species or result in destruction or adverse modification of critical habitat. The ESA allows USFWS (terrestrial and some aquatic species) or NMFS (marine species) to allow takes that would otherwise be prohibited, provided that such taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity ("incidental take"), by permit and an accompanying habitat conservation plan (USFWS only). In addition to the protection offered by listing, many species in Hawai‘i have designated critical habitat, including most of the listed plants, the Blackburn's sphinx moth (*Manduca blackburni*), the palila (*Loxioides bailleui*), Hawaiian monk seal (*Monachus schauinslandi*), and the O‘ahu ‘elepaio (*Chasiempis ibidis*). Subspecies and other populations may be listed separately if they are sufficiently distinct from their conspecific relatives. In Hawai‘i, such protections extend to bats, some birds, and many plants. Candidate species are those species which are under consideration for listing as threatened or endangered by the USFWS. NMFS calls these "species of concern" when there is not enough information available to decide on a listing or they are not actively being considered. A number of species are candidates or species of concern in Hawai‘i. The ESA also authorizes federal implementation of CITES.

Marine Mammal Protection Act

The Marine Mammal Protection Act of 1972 protects marine mammals by prohibiting the take, harassment, and importation of marine mammals in the United States and by prohibiting the take of marine mammals by U.S. citizens anywhere in the world. Exceptions can be granted for scientific research, education, native subsistence, and take incidental to commercial fisheries. The Act also requires establishing stock assessments and research. Species which fall below their "optimal sustainable population" size are listed as "depleted". Depleted populations must have a conservation plan to guide research and management actions to restore the health of the species.

The Clean Water Act

The Clean Water Act of 1977 established the basic structure for regulating discharges of pollutants into the waters of the United States. Its goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The Clean Water Act gives the Environmental Protection Agency the authority to implement pollution control

programs such as setting wastewater standards for industry. The Clean Water Act also contains requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants and recognized the need for planning to address the critical problems posed by non-point source pollution.

National Environmental Policy Act
The National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet this requirement, federal agencies prepare a detailed statement known as an Environmental Impact Statement (EIS). The Environmental Protection Agency reviews and comments on EISs prepared by other federal agencies, maintains a national filing system for all EISs, and assures that its own actions comply with NEPA.

State Species Protection
The State has established various laws and administrative rules to protect indigenous wildlife and plants. HRS § 195-1 recognize that "[a]ll indigenous species of aquatic life, wildlife, and land plants are integral parts of Hawai'i's native ecosystems and comprise the living heritage of Hawai'i, for they represent a natural resource of scientific, cultural, educational, environmental, and economic value to future generations of Hawai'i's people" and that "it is necessary that the State take positive actions to enhance their prospects for survival." Administrative rules designed to conserve, manage, protect, and enhance indigenous wildlife, endangered and threatened wildlife, and introduced wild birds contain a long list of prohibited activities, with additional protections afforded threatened and endangered species (HAR Chapter 13-124). Similarly, administrative rules designed to conserve, manage, protect, and enhance native threatened and endangered plants contain a list of prohibited activities, including a ban on the take of threatened or endangered plants (HAR Chapter 13-107). The state list of threatened and endangered species includes by reference species on the federal list, as well as a few additional species, such as the 'i'iwi (*Vestiaria coccinea*) on O'ahu. "Incidental takes" of threatened or endangered species (plant and animals) are allowed subject to approved habitat conservation plans and Safe Harbor Agreements (HRS Chapter 195D).

State Protection for Caves
In 2002, special laws were enacted to protect the irreplaceable resources of cultural, spiritual, aesthetic, and scientific value contained in Hawai'i's network of underground caves (HRS Chapter 6D). A cave is defined as any naturally occurring void, cavity, recess, or system of interconnected passages large enough for human entry beneath the surface of the earth. Hawai'i State law prohibits destruction of a cave or any part of the interior of a cave without the owner's written consent, prohibits removing, killing, or harming any native organisms within a cave, prohibits burning any material within a cave that may produce smoke that is harmful to naturally occurring organisms, and prohibits storage or disposal of garbage, dead animals, sewage, litter, or other toxic substances in any cave. However, state law does not prohibit these activities if they occur during

permitted construction activities, provided that cave protection mitigation measures disclosed through the environmental review process and land-use permitting processes are adhered to. In addition, state law does not prohibit or constrain surface activities on the land above a cave.

State Land Use Districting

All lands in Hawai‘i are allocated by the State into one of four districts: Conservation, Agricultural, Urban, or Rural. The State, through its DLNR and the Board of Land and Natural Resources (the Board), has primary land-management responsibility for activities and development in the Conservation District, while the counties have primary responsibility in the Urban, Rural, and Agricultural Districts. The purpose of the Conservation District is to conserve, protect, and preserve the state's important natural resources through appropriate management in order to promote the long-term sustainability of these natural resources, and to promote public health, safety, and welfare (HRS Chapter 183C). To this end, only limited development is allowed in the Conservation District. "Important natural resources" include the watersheds that supply potable water and water for agriculture; natural ecosystems and sanctuaries of native flora and fauna, particularly those which are endangered; forest areas; scenic areas; significant historical, cultural, archaeological, geological, mineral, and volcanological features and sites; and other designated unique areas. Permits are required for most activities in the Conservation District (HAR § 13-5-1 et seq.). As an additional measure of protection, all land in the Conservation District has been assigned to one of five subzones that reflect a hierarchy of uses from the most restrictive to the most permissive. These subzones are the Protective Subzone (the most restrictive), Limited, Resource, General, and Special. Except for the Special Subzone, all uses and activities allowed in a more restrictive subzone in the hierarchy are allowed in the less restrictive subzones.

Introduction of Non-native Species

The Hawai‘i Department of Agriculture is primarily responsible for regulating the introduction of non-native species. The Department's Plant Industry Division is responsible for protecting Hawai‘i's agricultural industries, natural resources, and the public from the entry and establishment of detrimental plants, animals, insects, weeds, and other pests and to assure the safe and efficient use of pesticides in Hawai‘i (HRS Chapters 150A, 152, and 149A; HAR Title 4, Subtitle 6). The Department's Division of Animal Industry is responsible for controlling and preventing the entry and spread of pests and disease that may affect the poultry and livestock industries, operating the rabies quarantine program and the airport holding facility, conducting investigations into violations of animal quarantine/importations statutes, and providing veterinary laboratory support for diagnosing animal diseases (HRS Chapter 142).

State Water Quality

The State Department of Health is responsible for administering the Clean Water Act in Hawai‘i. The Department administers the National Pollutant Discharge Elimination System (NPDES) permit program, issues Clean Water Act Section 401 Water Quality Certifications for federal permits for construction in nearshore and inland waters, and partners to develop best management practices for non-point source pollution control.

The Department promotes community-based watershed management through education and voluntary compliance with environmental management standards.

State Environmental Review Requirements
Hawai‘i State law establishes a system of environmental review to ensure that environmental concerns are given appropriate consideration in decision-making (HRS Chapter 343). Similar to NEPA, Hawai‘i law requires environmental assessments or environmental impact statements (depending on the impacts of the project) to be prepared for any project occurring in the Conservation District, as well as any project using state or county lands or funds. There are six other triggers for environmental review that more rarely operate to benefit native species (e.g., construction within the Waikīkī Special District).

Enforcement of Conservation Regulations
The DLNR Division of Conservation and Resource Enforcement (DOCARE), the U.S. Coast Guard, the NOAA Office of Law Enforcement, the U.S. Navy, the U.S. Marine Corps Base Hawai‘i, and the county police departments all play a role in enforcing the conservation regulations of the state.

Coastal Zone Management
The federal Coastal Zone Management (CZM) Program was created through passage of the Coastal Zone Management Act of 1972. The program for Hawai‘i was approved in 1977 (HRS Chapter 205A), and is administered through the Department of Business, Economic Development and Tourism Coastal Zone Management Program (CZM Hawai‘i). Within a framework of cooperation among federal, state, and local levels, CZM Hawai‘i employs a wide variety of regulatory and non-regulatory techniques to address coastal issues and uphold environmental law. Among them are stewardship, planning, permitting, education and outreach, technical assistance to local governments and permit applicants, policy development and implementation, and identification of emerging issues and exploration of solutions. CZM Hawai‘i is leading the preparation of a framework for updating the Ocean Resources Management Plan. CZM Hawai‘i is mandated to develop and implement a Coastal Nonpoint Pollution Control Program which is to be approved by NOAA and the Environmental Protection Agency.

Special Management Areas
As mandated by the Hawai‘i Coastal Zone Management program, counties are responsible for administering permits for development in SMAs located along the shoreline. The intent of this permitting process is to avoid the permanent loss of valuable resources and to ensure adequate access to beaches, recreation areas, and natural reserves (HRS Chapter 205A). Although SMAs are defined to include all lands extending no fewer than 91 meters (100 yards) inland from the shoreline, counties can amend their boundaries to achieve certain Coastal Zone Management objectives. Amendments removing areas from an SMA are subject to state review for compliance with the coastal law.

County Zoning

Counties are responsible for reviewing development in the Agricultural, Rural, and Urban Districts. The Agricultural District includes both “good” farm land and “junk” land that is unsuitable for farming or ranching. “Junk” land includes gulches, steep hillsides, rocky land, and on Maui and the Big Island, even relatively recent lava flows having little or no topsoil. Crops, livestock, and grazing are permitted in the Agricultural District, as are accessory structures and farmhouses. Although land in the Agricultural District is not meant to be urbanized, it has, in practice, been used for large-lot subdivisions. These subdivisions can be designed for “residential” development (i.e., housing units targeted at Hawai‘i residents) or high-end “resort/residential” development (i.e., housing units targeted at non-Hawai‘i residents and associated with resorts). The Urban and Rural Districts in each county are subject to county land use and development (commercial, industrial, residential, etc.) regulations, including county community plans, zoning, and building code regulations.

APPENDIX D. SUMMARY OF PUBLIC COMMENTS ADDRESSED

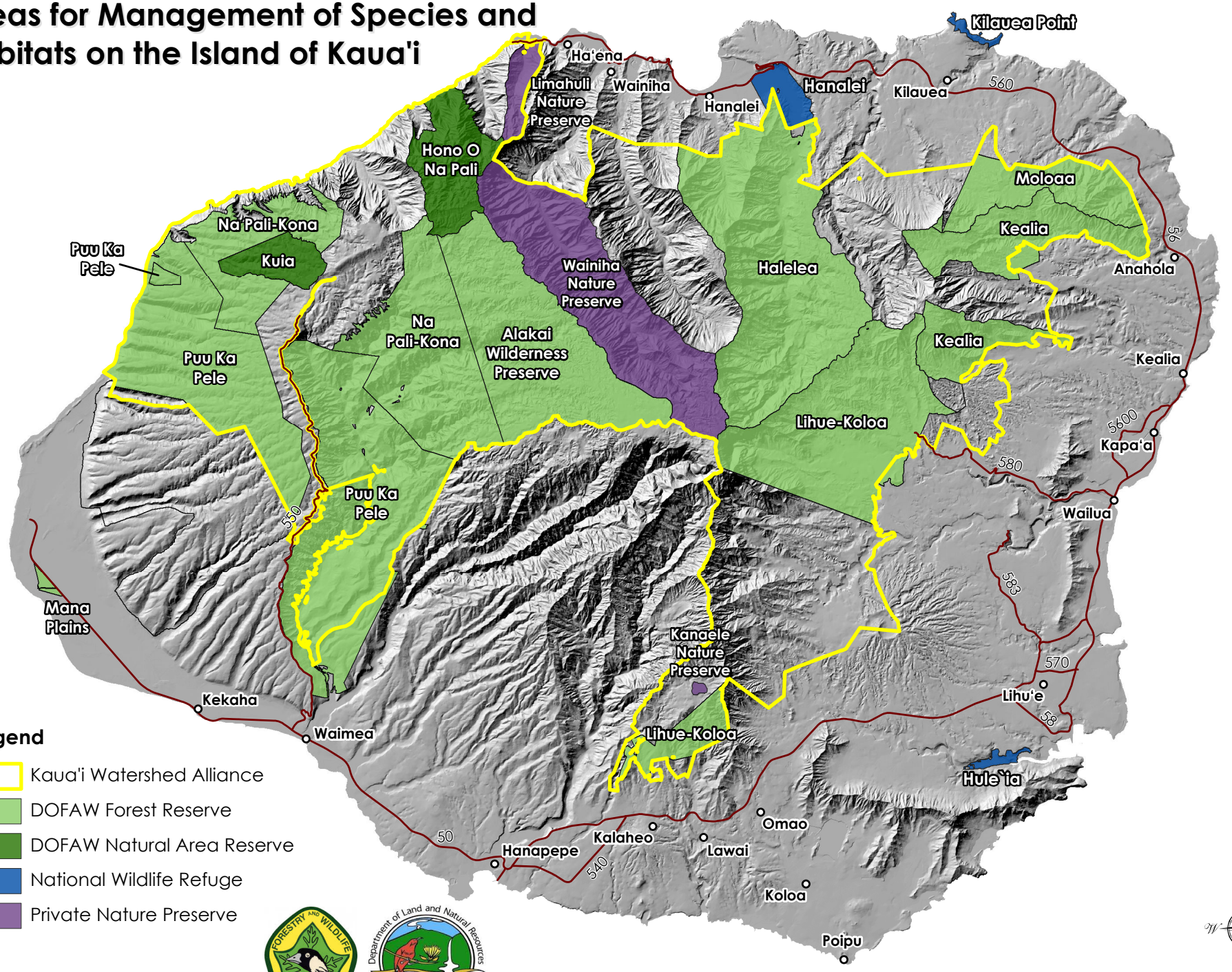
This appendix summarizes the public comments received during development of the 2025 State Wildlife Action Plan (SWAP) and how the issue was addressed in the plan. It does not include specific biological information (such as new data on a species' distribution or abundance). Further, the public comments have been summarized and aggregated for better understanding and explanation of the issues and topics identified and how they were addressed in the plan.

Theme	Public Feedback Summary	SWAP Revision
Public Engagement, Education, and Accessibility	There is a pervasive desire for more accessible, user-friendly information about conservation efforts and the state of Hawai‘i's wildlife and habitats. The public wants to understand complex issues, know how they can contribute to conservation, and have more meaningful avenues for feedback and community involvement, especially for youth.	The Division of Aquatic Resources (DAR) and the Division of Forestry and Wildlife (DOFAW) have enhanced accessibility to the 2015 State Wildlife Action Plan (SWAP) by developing a user-friendly StoryMap and a publicly available dashboard interface.
Data, Monitoring, and Research Gaps	The public is keen to understand the specifics of how data is collected, what the current status of species and habitats is, and where knowledge gaps exist. There's particular interest in less-studied groups (invertebrates, amphibians), historical data, and the interconnectedness of ecosystems.	DAR and DOFAW have integrated this information throughout the 2025 SWAP, with particular emphasis in Chapter 7: Species Fact Sheets.
Conservation Strategies, Effectiveness, and Adaptive Management	The public questions the effectiveness of current conservation strategies and seeks clear information on how threats are being addressed. There is a strong call for adaptive management to respond to new challenges, an emphasis on preventative measures, and a desire to see success stories.	This information is distributed throughout the 2025 SWAP by DAR and DOFAW, appearing in various sections of the document.
Species-Specific and	Feedback highlights concerns and questions about the status of iconic	DAR and DOFAW have incorporated this

Habitat-Specific Concerns	Hawaiian species (e.g., ʻiʻiwi, honeycreepers, specific marine life) and the urgent need to protect unique Hawaiian habitats. There is also a plea to not overlook lesser-known native species.	information across the SWAP, with detailed content presented in Chapter 7: Species Fact Sheets.
Mosquito Control Strategies and Associated Risks	This theme is highly polarized. While some see mosquito control as crucial for avian conservation, others express strong opposition to specific methods (e.g., Wolbachia-infected, GMO mosquitoes, gene drives) due to perceived risks to human health, other native species, watersheds, and ethical concerns about "playing God" or inadequate testing. There is a demand for more due diligence, transparency, and consideration of long-term impacts.	Expanded information on mosquito control methods is presented by DAR and DOFAW in Chapters 3 and 4 of the 2025 SWAP.
Climate Change Impacts and Resilience	Climate change is recognized as a significant and escalating threat to Hawaiʻi's wildlife and habitats. Feedback specifically calls for its deep integration into the SWAP 2025, particularly concerning its impacts on native forest birds (habitat shifts, disease vectors moving to higher elevations) and marine ecosystems (coral reefs). There's a need for foresight and adaptive measures.	The 2025 SWAP reflects a strong emphasis by DAR and DOFAW on the impacts and implications of climate change across multiple chapters.
Cultural Values and Indigenous Knowledge Integration	Highlights the insufficient and often superficial integration of Hawaiian cultural perspectives and indigenous knowledge within conservation processes, such as SGCN selection and management strategies. It emphasizes the need to move beyond historical mentions to actively incorporate both ancient	In Chapter 5, DAR and DOFAW have delineated their approach to integrating, and their ongoing commitment to further incorporating, local indigenous knowledge and Hawaiian cultural practices into all phases of

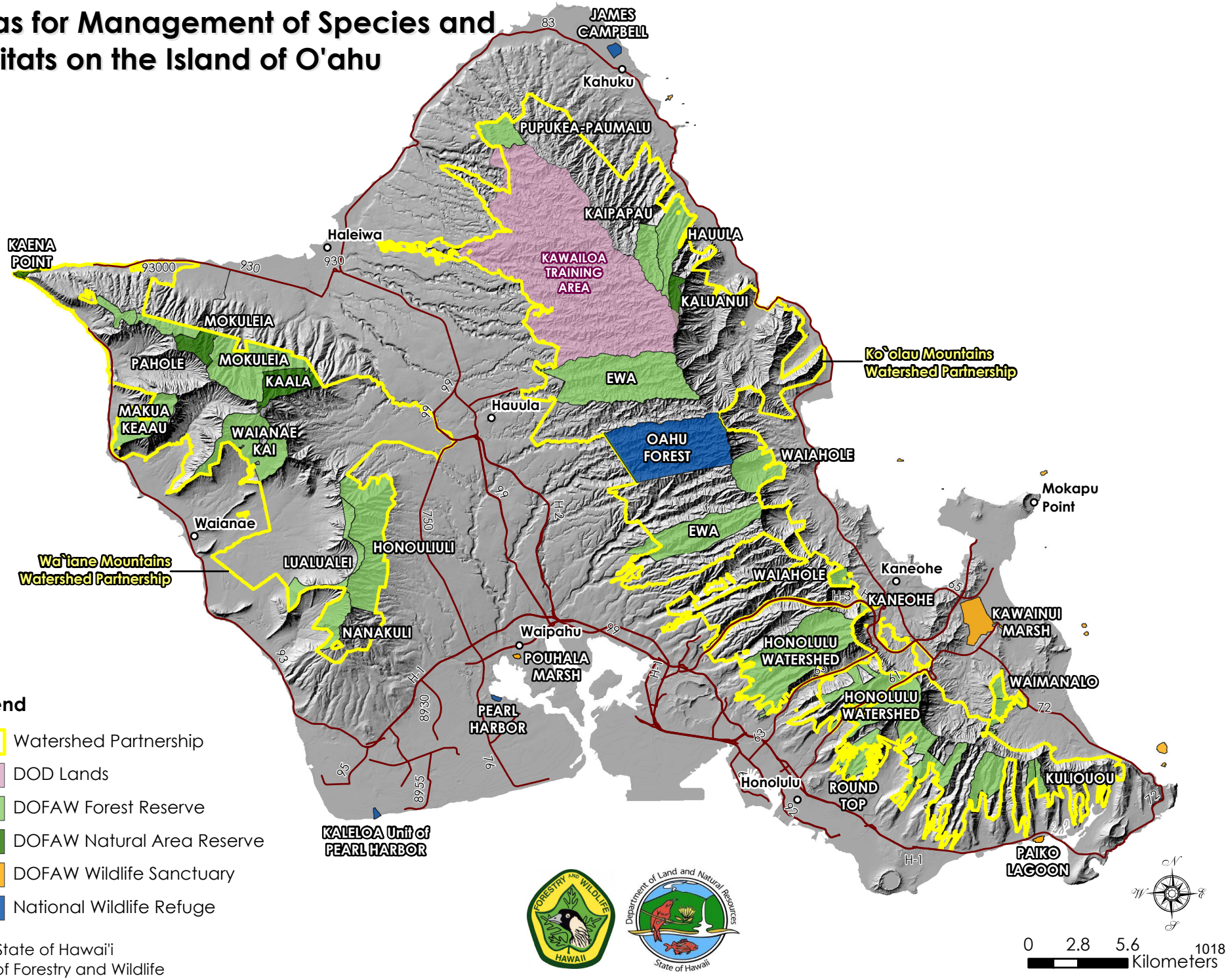
	and evolved Hawaiian methodologies into contemporary conservation, acknowledging and rectifying historical disenfranchisement of indigenous populations.	conservation planning, implementation, and monitoring.
Policy, Regulation, and Enforcement	Some feedback implicitly or explicitly points to the need for stronger regulatory frameworks and enforcement to prevent new threats and ensure accountability in conservation actions. This includes concerns about the introduction of non-native species and the approval processes for new interventions.	DAR and DOFAW address policy, regulatory frameworks, and enforcement measures in depth throughout the 2025 SWAP

Areas for Management of Species and Habitats on the Island of Kaua'i



Source: State of Hawai'i
Division of Forestry and Wildlife

Areas for Management of Species and Habitats on the Island of O'ahu

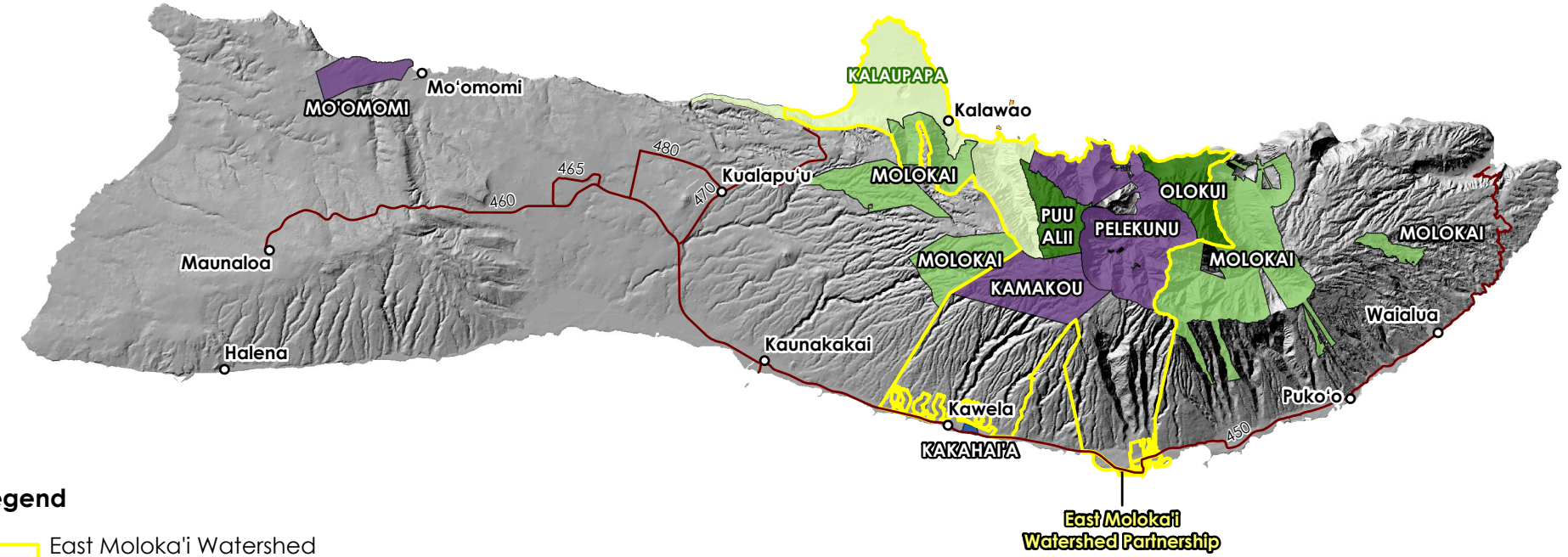


Legend

- Watershed Partnership
- DOD Lands
- DOFAW Forest Reserve
- DOFAW Natural Area Reserve
- DOFAW Wildlife Sanctuary
- National Wildlife Refuge

Source: State of Hawai'i
Division of Forestry and Wildlife

Areas for Management of Species and Habitats on the Island of Moloka'i



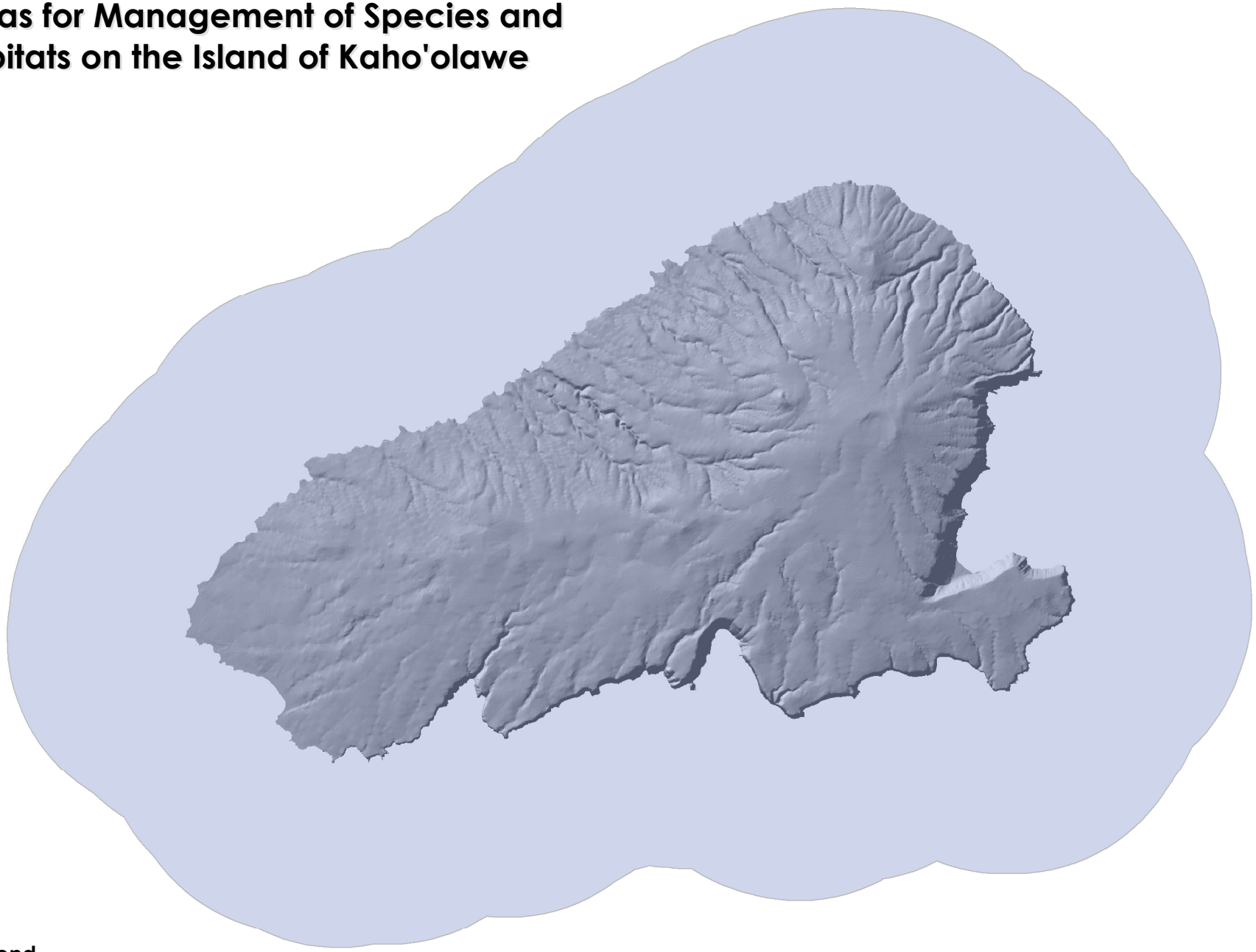
Legend

- East Moloka'i Watershed Partnership
- National Park
- DOFAW Forest Reserve
- DOFAW Natural Area Reserve
- DOFAW Wildlife Sanctuary
- Private Nature Preserve
- National Wildlife Refuge

Source: State of Hawai'i
Division of Forestry and Wildlife

0 2.6 5.2 1019
Kilometers

Areas for Management of Species and Habitats on the Island of Kaho'olawe



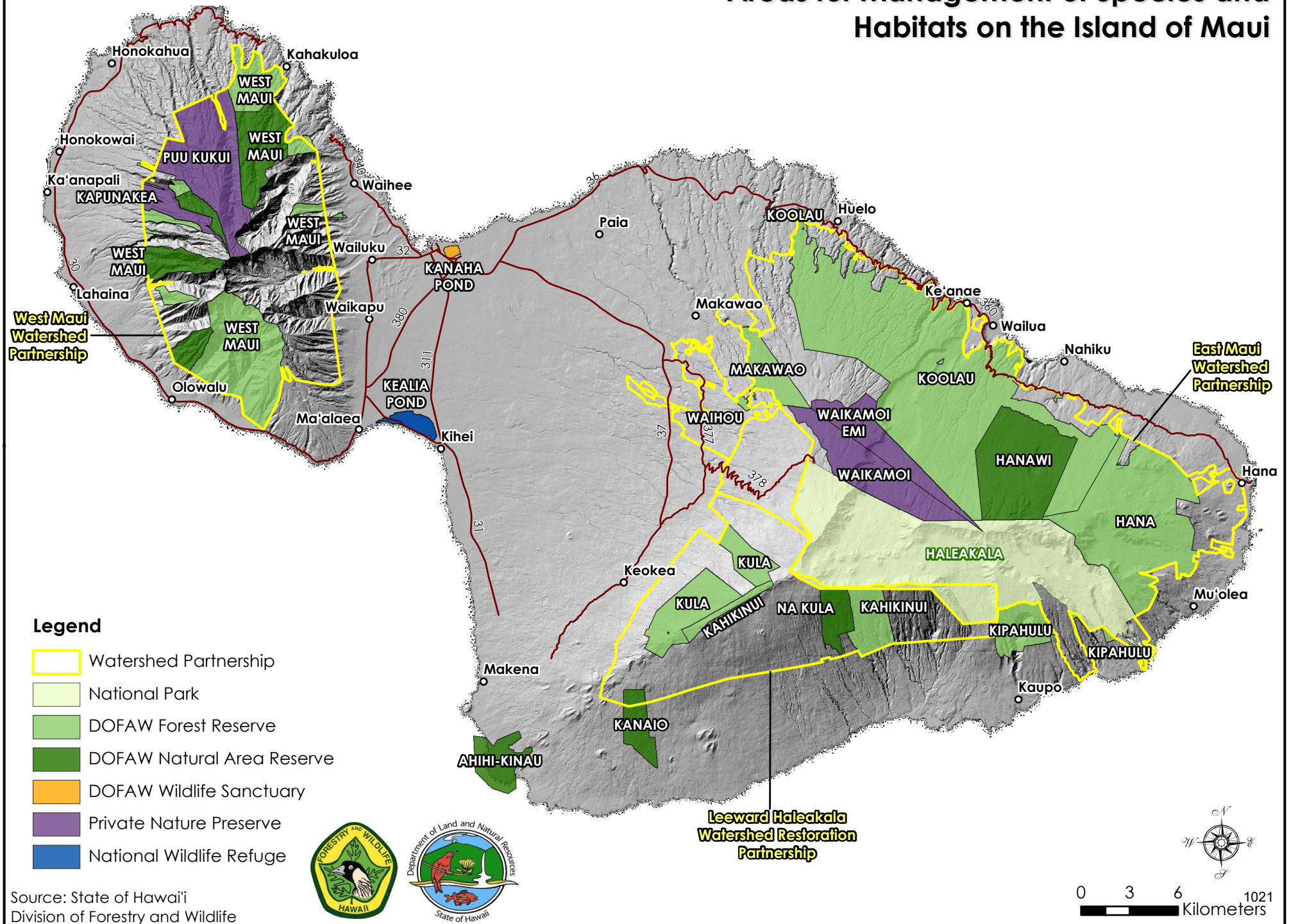
Legend

Kaho`olawe Island Reserve

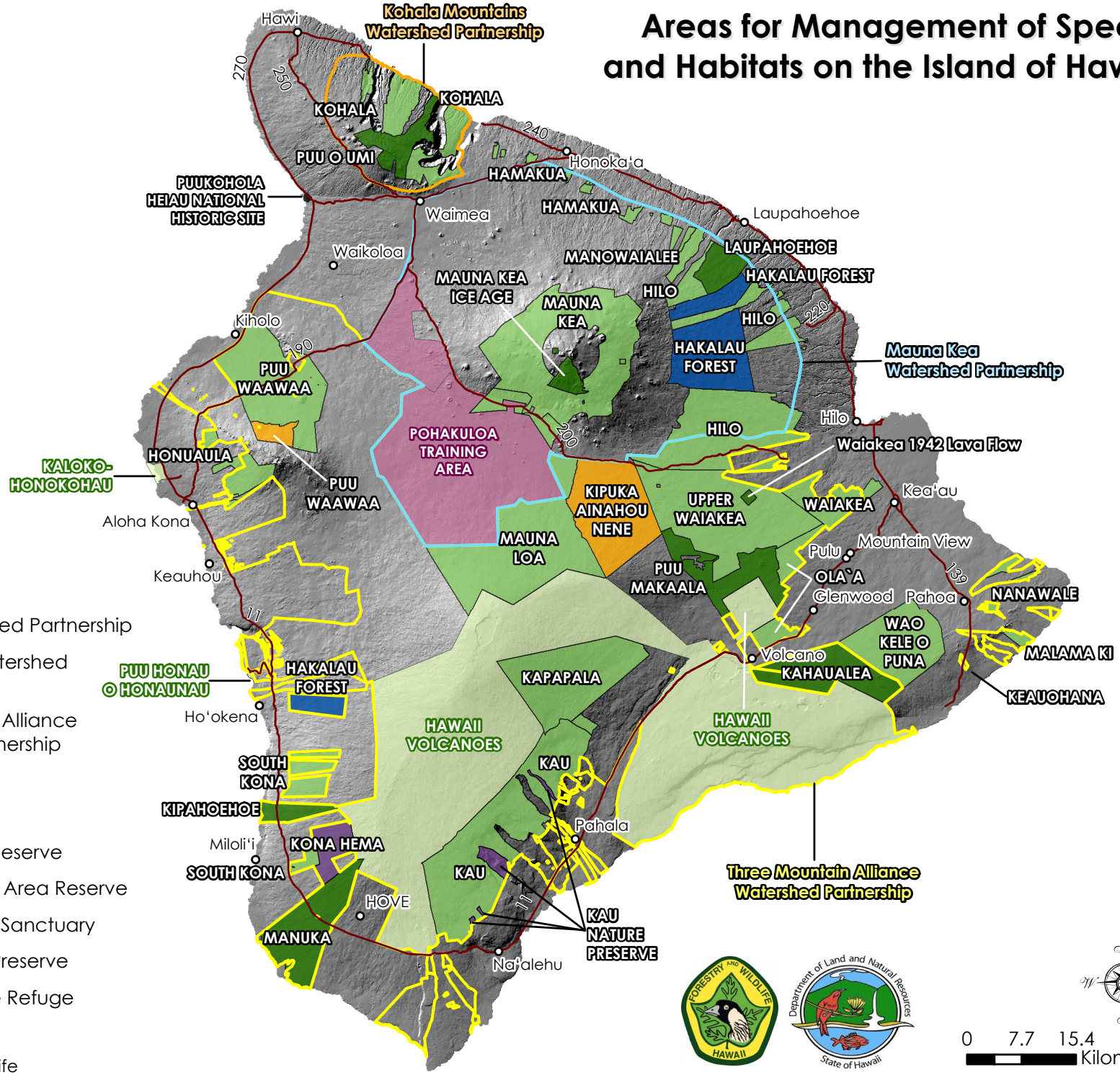
Source: State of Hawai'i
Division of Forestry and Wildlife

0 1.1 2.2 1020
Kilometers

Areas for Management of Species and Habitats on the Island of Maui



Areas for Management of Species and Habitats on the Island of Hawai'i



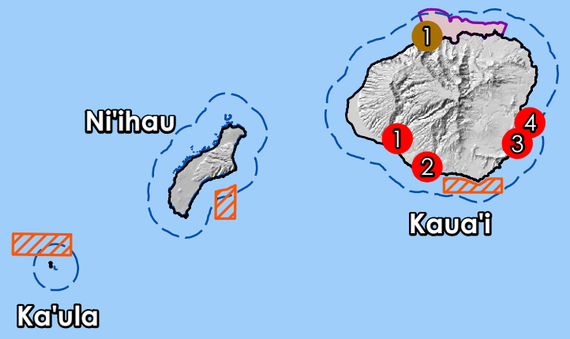
Legend

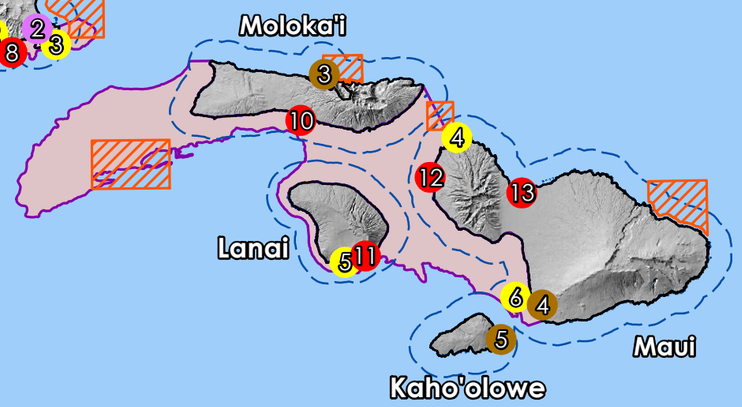
- Kohala Watershed Partnership
- Mauna Kea Watershed Partnership
- Three Mountain Alliance Watershed Partnership
- DOD Lands
- National Park
- DOFAW Forest Reserve
- DOFAW Natural Area Reserve
- DOFAW Wildlife Sanctuary
- Private Nature Preserve
- National Wildlife Refuge

Source: State of Hawai'i
Division of Forestry and Wildlife

0 7.7 15.4 1022 Kilometers

Marine Managed Areas
Main Hawaiian Islands





Legend

- State Managed Waters 0-3 Nautical Miles
- HIHWNMS (Sanctuary Boundary Areas in MHI)
- Bottomfish Restricted Fishing Areas

Marine Life Conservation Districts (MLCD)

1. Pupukea*
2. Waikīkī*
3. Hanauma Bay*
4. Honolua-Mokuleia Bay*
5. Manele-Hulopoe
6. Molokini Shoal*
7. Lapakahi*
8. Waialea Bay
9. Old Kona Airport
10. Kealakekua Bay*
11. Waiopae*

Fishery Replenishment Areas (FRA)

1. North Kohala
2. Puako-Anaehoomalu
3. Kaupulehu
4. Kaloko-Honokohau
5. Kailua-Keauhou
6. Red Hill
7. Napoopoo-Honaunau
8. Hookena
9. Milolii

Fishery Management Areas (FMA)

1. Waimea Bay
2. Port Allen
3. Nawiliwili Harbor
4. Hanamaulu Bay
5. Waialua Bay (Haleiwa Harbor)
6. Pokai Bay
7. Honolulu Harbor
8. Waikīkī-Diamond Head Shoreline*
9. Heeia Kea Wharf
10. Kaunakakai Harbor
11. Manele Harbor
12. Kahekili Herbivore FMA
13. Kahului Harbor
14. Kawaihae Harbor
15. Puako Bay and Puako Reef
16. Kiholo Bay
17. Kona Coast
18. Kailua Bay
19. Keauhou Bay
20. Hilo Harbor

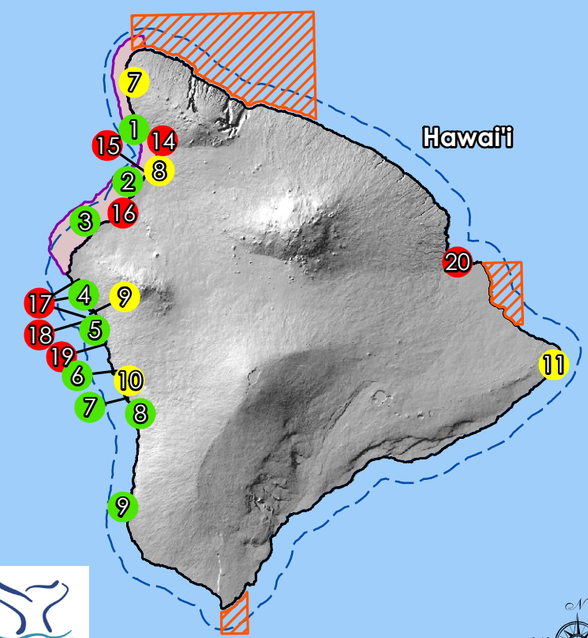
Wildlife Sanctuaries

1. Coconut Island-Hawai'i Marine Laboratory Refuge*
2. Paiko Lagoon Wildlife Sanctuary*

Other Managed Areas

1. Haena Community-Based Subsistence Fishing Area
2. Ewa Beach Limu Management Area
3. Kalaupapa National Historic Park*
4. Ahihi-Kinau Natural Area Reserve*
5. Kaho'olawe Island Reserve*

* These areas contain provisions for "no take" (no fishing) zones or years. All others allow fishing with certain restrictions.



Department of Land and Natural Resources, State of Hawaii
Hawai'i DAR Division of Aquatic Resources
National Marine Sanctuaries
Hawaiian Islands Humpback Whale

1023

0 16 32 Kilometers

Papahānaumokuākea Marine National Monument
Northwestern Hawaiian Islands

Kure Atoll (State of Hawai'i Wildlife Sanctuary)

Midway Atoll

Pearl and Hermes Atoll

Lisianski Island

Laysan Island

Maro Reef

Gardner Pinnacles

French Frigate Shoals

Mokumanamana

Nihoa

Kaua'i

Ni'ihau

O'ahu

Legend

- Ship Reporting Area
- Papahānaumokuākea Marine National Monument Boundary
- Papahānaumokuākea Marine National Monument Management Zones

0 55 110 Kilometers

1024