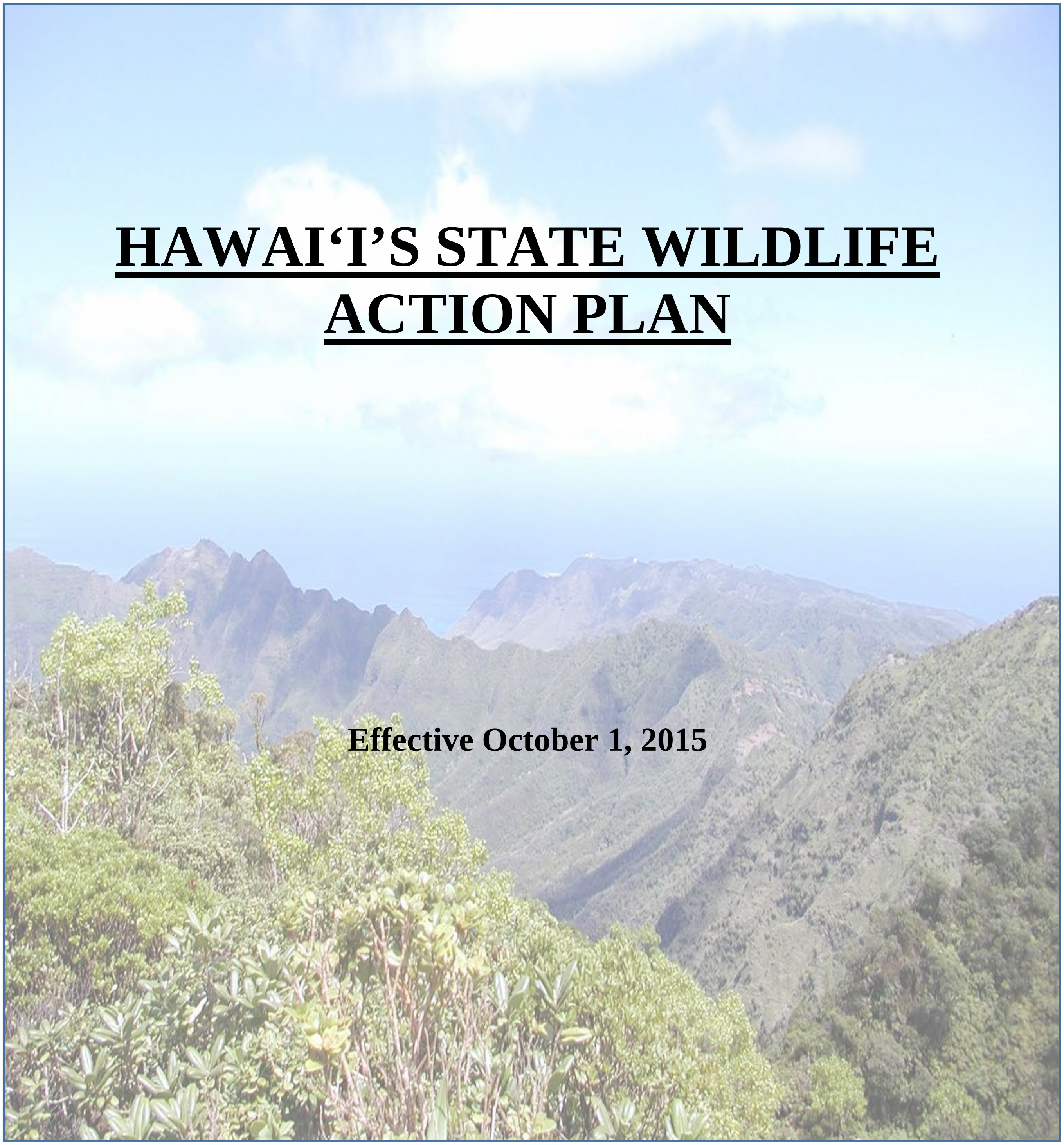
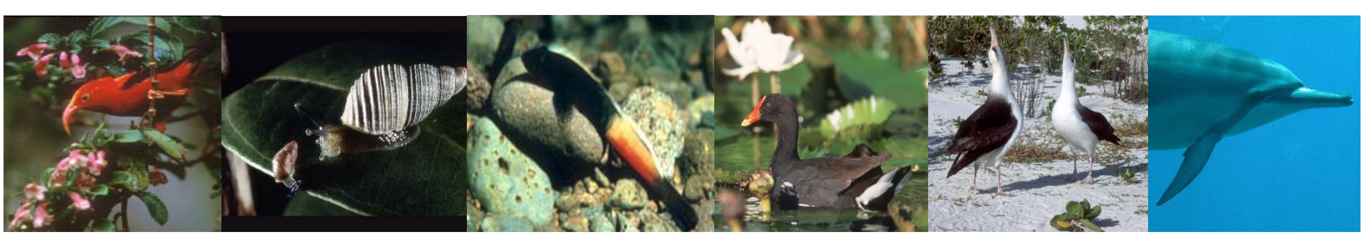
HAWAI‘I’S STATE WILDLIFE ACTION PLAN



Effective October 1, 2015



HAWAI'I'S STATE WILDLIFE ACTION PLAN

As Approved by the US Fish and Wildlife Service
November 1, 2016

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

HAWAI‘I’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 Hawai‘i Comprehensive Wildlife Conservation Strategy

Prepared by

H. T. Harvey & Associates, Ecological Consultants

List of Preparers

Paul Conry, Senior Associate Ecologist
Gregory Spencer, Senior Ecologist
Shahin Ansari, Senior Ecologist
David Ainley, Senior Ecologist
Christine Hamilton, Ecologist
Karl Magnacca, Ecologist

With assistance from:
John Vetter, Division of Forestry and Wildlife, Department of Land and Natural Resources, and
Michael Fujimoto, Division of Aquatic Resources, Department of Land and Natural Resources.

Recommended Citation

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.

Copies of this publication may be downloaded from http://www.state.hi.us/dlnr/dofaw/swap/.

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)

FOREWORD

Aloha! I am pleased to present the 2015 edition of Hawaiʻi's State Wildlife Action Plan (SWAP), detailing the strategy and plans of the Department of Land and Natural Resources and its partners to address the conservation needs of over 10,000 species native to Hawaiʻi. This is an update of the 2005 plan that was used successfully over the past ten years to make significant progress in the conservation of our native wildlife. In keeping with the original plan, this SWAP comprehensively outlines a statewide strategy for conserving native wildlife species, encompassing species found from the mountains to the seas, and from the Northwestern Hawaiian Islands to the Main Hawaiian Islands.

This update is timely, and can be used to begin a new phase of cooperation, coordination, and renewed effort to conserve Hawaiʻi's native wildlife. Although progress is being made, the stark reality is that these species and their habitats, many of which are found nowhere else on earth, face tremendous challenges because of habitat loss, the introduction of non-native invasive species, and the adverse effects of a changing climate. More than half of native habitats have been lost, and the introduction of non-native plants, animals, and diseases, like miconia, coqui frog, and West Nile virus, constitutes an ongoing threat to native animals and the very existence of entire species. Hawaiʻi's SWAP calls for working together to turn the tide on the decline of native wildlife and habitats. By building on and incorporating lessons from the conservation and research efforts that have been made thus far, and by applying the best available science, this SWAP establishes statewide objectives and strategies that address the challenges facing our native wildlife and habitats.

This plan is the result of the hard work of many people—I offer a sincere mahalo to all who participated in its update. I invite everyone to join in partnership with the Department, our sister management agencies, community groups, businesses, landowners, and citizens to help implement the vision expressed in this plan. Together, we can ensure that Hawaiʻi's unique and rare species continue to exist for future generations.

Suzanne Case
Chairperson
Department of Land and Natural Resources

TABLE OF CONTENTS

Appendices:

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	Hawaiʻi Gap Analysis Project
HISC	Hawaiʻi Invasive Species Council
HRS	Hawaiʻi Revised Statutes
IUCN	International Union for the Conservation of Nature and Natural Resources
KIRC	Kahoʻolawe 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
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service

ACRONYM	MEANING
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 Hawaiʻi
UH	University of Hawaiʻi
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 2015 edition of the State Wildlife Action Plan (SWAP) is a continuation of a historic initiative begun in 2005 with the first edition of this plan, then called the Comprehensive Wildlife Conservation Strategy (CWCS). This plan comprehensively reviews the status of the full range of the state’s native terrestrial and aquatic species, over 10,000 of which are found nowhere else on earth, and builds on the foundation developed in 2005. Hawai‘i’s SWAP presents strategies for long-term conservation of these species and their habitats. The SWAP continues the approach established by the CWCS, which leveraged Hawai‘i’s strong history of conservation and prescribed collaboration among resource managers, biologists, and concerned individuals statewide. The 2015 SWAP builds on the cooperation and successes that came out of the 2005 CWCS and the broad level of support it received. It 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 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, 2015, 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 Hawaiʻi DLNR has worked with conservation partners to update the 2015 SWAP and thus continue to guide conservation efforts across the state for the next ten years. The 2015 plan 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. Their 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 meetings with staff and technical experts, public information meetings, an interactive website, press releases, and email were used to invite and expand participation in the update process. Chapter 2 of this document outlines the methods and approaches used to update Hawaiʻi's 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. Under each objective, strategies of highest priority are labeled; however, because conservation needs in Hawaiʻi far exceed the resources available, implementation of any of the identified strategies will benefit native wildlife and habitats. 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 monitoring is critical to the overall success of the SWAP, Chapter 8 discusses existing and needed monitoring programs for species and habitats, as well as implementation and monitoring of Hawaiʻi's SWAP, including the ten-year revision.

HAWAIʻI'S STATE WILDLIFE ACTION PLAN

Hawaiʻi's Species of Greatest Conservation Need (SGCN) include all native terrestrial animals, all endemic aquatic animals, additional indigenous aquatic animals identified as in need of conservation attention, a range of native plants identified as in need of conservation attention, and all identified endemic algae. The SGCN include terrestrial mammal (1), birds (78), terrestrial invertebrates (~5,000), freshwater fishes (5), freshwater invertebrates (12), anchialine pond-associated fauna (20), marine mammals (26), marine reptiles (6), marine fishes (151), marine invertebrates (197), and flora (over

756). The 2015 plan includes 122 new or updated fact sheets, with much greater coverage of native invertebrates (55 new fact sheets and five updates) addressing the status of, threats to, 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 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, alteration of hydrology, wildfire, invasive species, recreational overuse, and natural disaster;
- Invasive species (e.g., habitat modifiers, including weeds, ungulates, algae and corals, predators, 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 were 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.

To address these threats, the SWAP identifies multiple strategies to implement the following seven priority conservation objectives for the state:

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 Hawaiʻi;*
6) *Support policy changes aimed at improving and protecting native species and habitats; and*
7) *Enhance funding opportunities to implement needed conservation actions.*

Remarkable progress has been made in conservation and in implementing the strategies and actions called for in the SWAP over the past ten years. The largest conservation area in the country, Papahānaumokuākea Marine National Monument, encompassing 363,000 square kilometers (140,000 square miles) of land and marine waters around the Northwest Hawaiian Islands, was established. The amount of land being managed for conservation purposes in watershed partnerships has increased from 344,000 hectares to 890,000 hectares (850,000 acres to 2.2 million acres). At risk species such as the endangered Kaua‘i ‘akikiki (*Oreomystis bairdi*) and ‘akeke‘e (*Loxops caeruleirostris*), and O‘ahu tree snails have had captive propagation programs begun or expanded and the Nihoa millerbird (*Acrocephalus familiaris kingi*) and Laysan duck (*Anas laysanensis*) have been translocated to create populations on other islands in the NWHI. A project to relocate nēnē (*Branta sandvicensis*) from a hazardous location near the Kaua‘i Airport to safe locations on other islands is in progress and reducing risk to both the flying public and the birds. Predator proof fences to protect populations of seabirds, nēnē and O‘ahu tree snails have been built and operated. Increased survey and monitoring of status and threats to seabirds, forestbirds and native invertebrates are ongoing and being expanded. Conservation initiatives such as the Plant Extinction Prevention Program, Snail Extinction Prevention Program, Kaua‘i Endangered Seabird Recovery Program, and community-based marine managed areas, to name just a few, have begun, based largely on partnerships, agency cooperation, and community involvement to address conservation needs.

Further implementation of the 2015 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 herein 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* Hawaii's State Wildlife Action Plan *is to guide conservation efforts across the state to ensure protection of Hawaiʻi's wide range of native wildlife and the diverse habitats that support them.*

PURPOSE OF HAWAII'S STATE WILDLIFE ACTION PLAN

The purpose of updating *Hawaii's State Wildlife Action Plan* (SWAP) is to 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 Hawaiʻi's unique native wildlife. The original plan, Hawaiʻi's 2005 *Comprehensive Wildlife Conservation Strategy* (CWCS), was comprehensive in scope and went beyond the legislative mandate to fully recognize the interconnectedness of Hawaiʻi's diverse flora and fauna to create an integrated, strategic blueprint for the protection and recovery of Hawaiʻi's biodiversity. Ten 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 Hawaiʻi'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 2015, Congress provided $45,994,981 to the States and territories under the SWG program. 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 Hawaiʻi Department of Land and Natural Resources (DLNR) holds the constitutional and statutory authority to protect wildlife resources and administers the use of these funds. Hawaiʻi's share of that funding has varied between $450,000 - $500,000 per year over the past several years, and in 2015 was $459,950.

As a condition for participation in these federal aid programs, Congress required states to develop CWCSs to be eligible for SWG funding. Hawaiʻi's CWCS was developed and approved in 2005 to meet this requirement. Congress also requires that each state update its plan at least every ten years. The current update effort will meet this requirement. Then and now, 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, 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 10 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.

HAWAI‘I'S UNIQUE WILDLIFE RESOURCES AND THEIR VALUES

The SWAP is especially important to Hawai‘i, the United States, and even the world, because of the unique biology, cultural importance, and economic value of native Hawaiian species. 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, colonists rapidly adapted to their novel environments. For many such colonists, unique adaptations occurred simultaneously among populations that were isolated from one another on an island and between islands. Hawai‘i provides a text-book example of adaptive radiation, the process by which many new species evolved from a single common ancestor in a relatively short time span.

Although Charles Darwin never visited the Hawaiian Islands, he was aware of their unique biology. If he had visited the islands, he would have discovered that Hawai‘i surpasses the Galapagos Islands in the number and variety of species that evolved from a small set of original colonizing ancestors. Scientists now recognize that the world's premier showcase of adaptive radiation is the Hawaiian archipelago. 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 – 90 percent for terrestrial species and 15 to 20 percent for marine species.

The arrival of Polynesians approximately 1,600 years ago, and increasingly with the arrival of Westerners in 1778, contributed to the destruction of native habitats and introduced many novel threats to which the island'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 humans to the islands, within what is a blink of an eye in geological time, 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 434 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, 2015).

Despite this, in present day Hawaiʻi, the link between Native Hawaiian culture and native species has not been lost and continues to be practiced in belief systems as well as traditional practices such as gathering of native plants and animals for hula, traditional medicines, carving, weaving, tool making, jewelry, and ceremonies. The special role and relationship Native Hawaiians have with the native species and ecosystems in the islands is perhaps most reflected in their increasing role in natural resource management in places such as the island of Kahoʻolawe; Limahuli and Lumahaʻi valleys on Kauaʻi; Moʻomomi, Molokaʻi; and Keauhou, Hawaiʻi where traditional management practices such as *kapu* (taboo) and *ahupuaʻa* (watershed)-scale thinking predominate.

Native wildlife is also important to all of Hawaiʻi's residents. Based on a 2004 "Wildlife Values in the West" survey, a large majority of Hawaiʻi's residents (71%) strongly agree that it is important to take steps to prevent the extinction of endangered species (Dayer et al. 2006). Economically, wildlife viewing opportunities are worth hundreds of millions of dollars to the State's $10-billion-a-year tourism industry. Hawaiʻi's native wildlife and their habitats also provide hundreds of millions of dollars in important goods and services to residents. A recent University of Hawaiʻi study of the economic valuation of water quality, in-stream uses, species habitat, hunting, commercial harvest, ecotourism, and climate control estimated the value of services to be between $7.4 to $14 billion in the Koʻolau Mountains of Oʻahu alone. Other examples of ecological services provided by native habitats include coral reefs that protect beaches, homes, and businesses from erosion, storms, and tsunami waves, and wetland habitats that filter the water supply. Finally, actions preventing the introduction of invasive species benefit people as well as native wildlife: invasive weeds increase the likelihood of wildfires that threaten homes and native habitats; introduced ungulates (hooved animals) denude native forest, causing soil erosion and sedimentation of streams and nearshore reefs and impacting fishing opportunities; plants such as *Miconia calvescens* provide much less erosion control than native trees, threatening billions of gallons of water provided by our watersheds; the coqui frog (*Eleutherodactylus coqui*) poses quality of life issues for residents while eating native invertebrates; the West Nile Virus and the brown tree snake (*Boiga irregularis*) raise public health and safety concerns; and ʻōhiʻa wilt (*Ceratocystis fimbriata*), a newly arrived fungal disease, threatens to decimate ʻōhiʻa forests.

ORGANIZATION AND FORMAT OF HAWAI‘I’S SWAP

Hawai‘i’s SWAP retains the organization and format of the 2005 CWCS, and addresses the required eight elements at multiple scales, from the statewide perspective to island-specific and taxa-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 Hawai‘i 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 contain information for one taxa, 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, Glossary,** and **Bibliography** are included to provide additional detail.

Bibliography:

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.

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).

CHAPTER 2: APPROACH AND METHODS

APPROACH

The State of Hawaiʻi developed the first edition of its state wildlife action plan in 2005; at that time, it was called *Hawaiʻi's Comprehensive Wildlife Conservation Strategy* (CWCS). Now, ten years later, 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 this major revision of the Hawaiʻi SWAP. The deadline for completion of the revision and submittal to USFWS is October 1, 2015.

As was the case in 2005, the critical status of native ecosystems in Hawaiʻi 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 communities 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 2015 is to build on and synthesize information from the 2005 plan, nurture and expand on conservation partnerships and cooperative efforts implemented thus far, and incorporate new information learned over the past ten years. The successful partnerships and their efforts in Hawaiʻi over the past ten years are highlighted with the goal of enhancing and expanding existing partnerships and creating new partnerships that increase support for, and the effectiveness of, Hawaiʻi's SWAP.

The Hawaiʻi Department of Land and Natural Resources (DLNR) leads the development and renewal of Hawaiʻi'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 current 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.

Because so much of the 2005 plan remained a relevant and sound foundation on which to continue conservation efforts, the structure and content of that document was retained as much as possible. The content of the 2005 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 drafted revisions to the plan and provided a public review draft to DOFAW and DAR to review and approve for distribution to the public. The draft update was released to the public for a 1-month review period, and a series of public information meetings was held on each of the Main Hawaiian Islands to present the plan and gather input from the public. The draft was also presented to the Board of Land and Natural Resources at a board meeting to brief the board on updated plan content, process, and public input. Comments from the public meetings, comments from the board, and any written comments submitted were addressed in the final version of plan, as 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.

OUTREACH

Public Participation

A variety of methods and opportunities was used to reach out to the public regarding the SWAP update. The SWAP website, www.state.hi.us/dlnr/dofaw/cwcs/index.html, has been active and on the DLNR website since the development of the first edition of the plan in 2005. The website presented the 2005 edition in user-friendly sections, and encouraged the public and partners involved in the first edition to stay involved, assist with implementation, and continue to develop conservation strategies. Through the website, members of the public were urged to take the opportunity to help shape the direction of current and future wildlife conservation efforts, and were reminded that their experience, expertise, and ideas were critical to the process. They were invited to provide information on Hawai‘i SGCN and identify opportunities and resources for conservation action. As the SWAP update was taking shape, the website announced the start of the process and again urged the public to get involved and provide input to improve the plan.

During the update process, the website was updated to make new announcements, advertise public meetings, and make products available for review. The public was invited to share information by email or mail. Interested persons and entities were added to a contact list, which was used to keep people updated and engaged in the process.

DLNR also issued press releases announcing the update of the plan and encouraging public participation via the website. A press release was issued to announce the availability of the draft public review document and to advertise the schedule of information meetings to be held on each island. The draft SWAP was made available for a 30-day review period from August 1st to August 31st, 2015. In mid-August, a series of seven public meetings were held on six islands (two meetings on Hawaiʻi Island) to engage the public in updating the draft SWAP. A total of 68 participants attended the public meetings, as private citizens, representatives of conservation organizations, state or federal agencies, or interested stakeholders. Following these meetings, the public was encouraged to provide comments via the website, email, and mail up through the close of the public review period. The draft also was presented to the Board of Land and Natural Resources as an informational briefing at a regular board meeting that was open to the public, and at which the public and board could ask questions, and provide testimony and comments.

Resource Management Agency and Technical Expert Participation

Conservation and management of natural resources in Hawaiʻi traditionally have involved strong collaborative efforts. Hawaiʻi'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 update.

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. Emails and phone calls were made to a wide range of local, state, and federal agencies, non-governmental organizations, and researchers to engage them in the process. The SWAP team also identified existing partners and individually contacted them to solicit input and invite their participation. Members of the SWAP team attended several professional conferences and meetings to network and invite participation in the update process. Agencies and individuals were encouraged to provide comments on additional SGCN, new information on threats and challenges, conservation strategies and management approaches, and information on species vulnerability assessments to incorporate into the update. Input received was incorporated into the draft plan. Those who provided input were sent a copy of the public review draft and invited to participate in the public information meetings on their island.

Participants in the revision included a wide range of agencies and organizations that have been integral in implementing the 2005 plan and in conducting research on, and management of, wildlife resources. Major contributors included Bishop Museum, The Nature Conservancy of Hawaiʻi (TNC), the Hawaiʻi Invasive Species Council (HISC), Hawaiʻi Watershed Partnerships, the University of Hawaiʻi, the Hawaiʻi Institute of Marine Biology, 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 the website, and public meetings were used to develop updates for the following components of Hawaiʻi's SWAP.

Identifying Species of Greatest Conservation Need and Their Habitats

The Hawaiian Islands are biologically diverse, with fauna characterized by high levels of endemism. Many migratory species spend key parts of their life cycles (e.g., breeding or wintering) in Hawaiʻi. The 2005 CWCS recognized the global rarity of these species or the importance of Hawaiʻi to these species, and developed a broad list of Hawaiʻi's SGCN. The 2005 list included species meeting the following criteria: 1) all terrestrial indigenous animals as identified by the Hawaiʻi list of indigenous species (Hawaiʻi 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 Hawaiʻi. 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 in the Plant Extinction Prevention program (PEP) (2005 genetic safety-net plants; i.e., plants with fewer than 50 individuals extant); 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 Hawaiʻi* 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 Hawaiʻi's SGCN. The focus of the SWAP is on habitats essential to these species, threats to these important habitats, and management strategies needed to preserve and expand these habitats. 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 of species of greatest conservation need by individual species or taxa. The conservation of habitat is approached at an ecosystem and landscape level to benefit multiple species.
To develop the 2015 update, the 2005 SGCN list was reviewed by DLNR agency staff, partner agencies, and species experts, was posted on DLNR website 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. Perhaps reflecting the degraded and threatened status of most native habitats, no recommendations were made to remove species from 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, 2015," whereas accounts that were not revised retain the 2005 date.

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, implementation of any of the identified strategies will benefit native wildlife and habitats. 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. Reviewers were informed that all updated sections of the SWAP are identified by a footer with the date “October 1, 2015,” whereas the Fact Sheets which were not revised contained the note “Last Updated October 2005.”

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, 2015 deadline.

Plan Style

The writing style, document structure, and relevant content of the 2005 plan was retained as much as possible in drafting the 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. Lastly, some species accounts in Chapter 7 did not require updates; therefore, all updated sections of the SWAP are identified by a footer with the date “October 1, 2015,” whereas unrevised sections are noted to have been “Last updated October 2005.”

Bibliography:

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 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 Hawaiʻi 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 Hawaiʻi'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, alteration of hydrology, wildfire, recreational overuse, natural disaster, and other factors;
- Invasive species (e.g., habitat-modifiers, including weeds, ungulates, algae and corals, predators, competitors, disease carriers, and disease);
- 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 Hawaiʻi's native bird species and are suspected to continue playing an important role in the decline of native invertebrate populations and loss of species diversity. 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 Hawaiʻi's native habitats. At low elevations where development pressures are highest, less than ten percent of native vegetation remains. 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. As the most oil-dependent state, we have millions of seabirds and shorebirds in our archipelago 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 Hawaiʻi, 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 are threatened by residential 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, hotels and resorts, and residential landscaping. The 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 as well in areas formerly considered "remote," such as Kaʻū or north shore of Kauaʻi. 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, 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. Many times, wildlife and people can coexist, such as at urban wetlands like Hamakua Marsh on Oʻahu, 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 Līhu'e 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. 2014), 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 landscape and habitat areas and displace native plant species.

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 directly harm 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 some negative effects related to non-native species. Non-native species almost always outcompete native species or may directly harm native species through predation or infection. Non-native species may also threaten native species through interbreeding and hybridization, leading to loss or genetic alteration 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 affecting 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 Hawaiʻi has averaged more than 40 species per year. It is estimated that over 10,000 plants have been introduced into Hawaiʻi and about 1,215 (roughly equal to the number of native vascular plant species in the state) have established wild population. While some plant introductions do not pose a threat to native habitats, approximately ten percent of the established non-native species are highly invasive and aggressive and/or pose significant threats to Hawaiʻi's ecosystems and economy.

In addition to those introduced species that are already established in Hawaiʻi, numerous species are considered high-risk species that are known to represent a dangerous threat to island ecosystems. Over a nine-month period in 2002, a pest risk assessment conducted at Kahului Airport by the State Department of Agriculture discovered over 100 alien species entering Maui as cargo. Because this risk is so acute for Hawaiʻi, screening and search protocols are in place to monitor and intercept dangerous wildlife originating outside of Hawaiʻi. 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, red-imported fire ant (*Solenopsis invicta*), Africanized honey bee (*Apis mellifera* hybrid), biting flies, and marine organisms all present 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 Hawaiʻi's native species and forests is the uncontrolled spread of many non-native invasive plants. These plants displace Hawaiʻi'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 Hawaiʻi, 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 Hawaiʻi.

Uncontrolled ungulates (hooved animals) are another major threat to native habitat. Ungulates in Hawaiʻi 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 in the best remaining habitats and areas where they still remain, managing ungulate populations to control or eliminate them in habitat and 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. DLNR is authorized to use its authorities 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.

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) and are linked to the spread of mosquito-borne avian disease (i.e., pig wallows create mosquito breeding habitat).

Because Hawaiʻi 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 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 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. 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 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

Hawai‘i’s terrestrial animals evolved in the complete absence of mammalian predators and are extremely vulnerable to depredation by rats, feral cats (*Felis silvestris*), 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 populations that occurred in the early 1900s. Rats are ubiquitous throughout the state, preying on seabirds, waterbirds, and forest birds. They readily climb trees to prey upon canopy-nesting 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 Hawai‘i, 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*), frogs, 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 Hawai‘i would have equally devastating consequences. The introduced Jackson’s chameleon (*Chamaeleo jacksonii*) preys on native snails and is an identified problem for endangered O‘ahu 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 has been identified as an invasive species that has been intentionally introduced or escaped to streams, lakes and ponds and consumes native fish and invertebrates. Introduced frogs such as the coqui prey on aquatic and terrestrial invertebrates, and bullfrogs (*Rana catesbeiana*) prey on native freshwater fishes, invertebrates, and even waterbirds. Anchialine ponds are threatened by introduced fishes and shrimps that prey on native shrimp and amphipods and alter the habitat structure.

Over the last 200 years, introductions of invertebrates, including ants, snails, and wasps, have occurred extensively throughout the archipelago. Many of these species prey on or parasitize native invertebrates. Biologists have long suspected that these introductions caused declines in native insects and snails and had indirect community-level effects.

Scientists in the last century, for example, noted extensive declines in native moths after introductions of predatory arthropods. These declines were followed by subsequent declines in native birds that preyed on the native moths. More recently, studies have documented the effects of introduced ants and vespid wasps on native arthropod fauna and on nesting birds; for example, introduced ants have been documented killing nestlings and are a problem for ground-nesting seabirds. Rats and the introduced carnivorous snail (*Euglandina rosea*) and flatworm (*Platydemus manokwari*) prey on native tree snails and have decimated populations of endangered Oʻahu tree snails.

Disease Carriers, Disease, and Pathogens

The introduction of mosquitoes (*Culex quinquefasciatus*) to the Hawaiian Islands in 1826 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*), mosquitoes effectively spread these diseases throughout lowland areas. Many species of introduced birds now present in Hawaiʻi may provide effective reservoirs for these diseases, 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. Over the next 150 years, many bird species became extinct. Today, most of the remaining native forest birds persist at elevations above 1,600 meters (5,000 feet), where few mosquitoes can survive.

In recent years, a few species have begun to recolonize lower elevations where avian malaria and poxvirus are common, indicating that at least some species may have developed resistance to these diseases. However, global warming could enable transmission of poxvirus and malaria to reach higher elevations, threatening remaining populations of endangered birds. New vectors of such diseases are also of concern. On the island of Hawaiʻi, the recent establishment of *Aedes japonicus*, the state's first truly temperate mosquito, may extend the range of mosquito-borne disease into currently mosquito-free high elevation forests.

Other diseases impact native wildlife; for example, avian botulism is the most prevalent disease in Hawaiʻi 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 introduction of West Nile virus or avian influenza (HPAI) could have even more devastating impacts. Knemidokoptic mange has been diagnosed in Hawaiʻi ʻamakihi (*Hemignathus virens* [Hawaiian honeycreeper]) on Hawaiʻi island and toxoplasmosis, an easily transmitted pathogen, is considered a significant threat to nēnē and other wildlife such as the Hawaiian monk seal.

Disease threat is not limited to terrestrial fauna, however. Recent work has shown that many species of corals are susceptible to diseases and that diseases affecting coral are on the increase in Hawaiʻi. 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, and is believed to be associated with climate change. Many bacterial, fungal, and protozoan diseases are known to affect stony corals in

Hawaiʻi; these include cyanobacterium, black band disease, yellow band disease, and acute Montipora white syndrome. These diseases are occurring with more frequency and showing up in widespread portions of the MHI, with severe recent outbreaks on Kauaʻi and Maui and in Kāneʻohe Bay. Green sea turtles, or hōnu (*Chelonia mydas* [green sea turtles]) in most areas suffer from fibropappiloma, which may also be caused by an introduced disease. With little natural resistance to disease, Hawaiʻi'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. The fungus *Ceratocystis fimbriata* infects the vascular system of the native ʻōhiʻa trees, causing them to die within a few weeks. This disease, aptly referred to as the "rapid ʻōhiʻa death," or "ʻōhiʻa wilt" is known to occur only in the Hilo and Puna districts on the island of Hawaiʻi, but it has the potential to affect ʻōhiʻa on all Hawaiian Islands. The disease can spread fast across the landscape. In 2012, it killed about 1,000 hectares (2,470 acres) of ʻōhiʻa on Hawaiʻi island, and by summer 2014 the disease had impacted nearly 6,000 hectares (14,830 acres). 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, areas that currently support the last remaining populations of many native forest bird species. 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 2014 boreal summer was the warmest on record, causing 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 1–2^{o}C above normal (29^{o}C); 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. Researchers predict that bleaching events, which occur when average temperatures are 1°C 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). 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. 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 may not be able to shift fast enough to stay ahead of sea level rise.

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 2014). 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.

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 Mauna Kea 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 Mauna Kea 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 increase risk of wildland fire, which potentially has even greater catastrophic effects and may wipe out a species or population in one event. A large fire on Mauna Kea 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 that transmit this disease (Benning et al. 2002, Atkinson and LaPointe 2009, Atkinson et al. 2014). This trend underscores the need to provide high-elevation refugia for susceptible native birds. Some populations of the ʻamakihi have developed immunity to malaria and now are found again in lowland habitats (Kilpatrick 2006), indicating that 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, Hawai‘i’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. Vulnerability assessment models are being developed to predict climate-related changes in the distribution of forest birds on Kaua‘i and Hawai‘i, where the combined effects of disease (avian malaria) prevalence and habitat constriction are expected to accelerate declines, especially in the most rare species (Alkinson et al. 2014). 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. Declines in populations of the endangered ‘akikiki (*Oreomystis bairdi*) and ‘akeke‘e (*Loxops caeruleirostris*) and retreat of even more common native forest birds to the last high-elevation habitat indicate that this is occurring. 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 O‘ahu, are at increased risk; in particular, species with greater susceptibility to avian malaria are at extreme risk.

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 Mauna Loa 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
New bottomfish regulations have been developed to ensure sustainability of this high-value fishery resource. Regulations include the establishment of 12 Bottomfish Restricted Fishing Areas, which are subject to annual catch limits and closed seasons to prevent overfishing. Other open ocean and nearshore fish populations are probably at levels that are consistent with overfishing, and the importance of this issue needs to be elevated.

Excessive extractive use constitutes a threat to other wildlife as well. Certain reef fishes are harvested for sale in the aquarium trade. Freshwater and marine fishes and invertebrates are collected for subsistence, recreation, and commercial purposes. A 2015 incident of mass harvest of sea cucumbers (class *Holothuroidea*) from nearshore waters on Maui and Oʻahu 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 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, and the potential for dolphin and whale watching and shark feeding tours to change the behavior of these species. Turtle feeding is another area where increased human-interactions may change behaviors. 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
As in 2005, enforcement of conservation laws remains a concern for the well-being of native wildlife populations. Although the situation has improved markedly since 2005, 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, and up to $12.4 million with 143 positions in 2015. 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 5 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 budget increase in 2015 is intended to help expand the program to Hawaiʻi, Oʻahu, and Kauaʻi. 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. Hawaiʻi's 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. The same applies for invasive species and pests affecting them.

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.

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, 138 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. An additional 50 species are on the candidate list.

Inadequate Funding

Limited funding to implement identified 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 is the State of Hawai‘i. 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 $35 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 Hawaiʻi, 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 Hawaiʻi'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 Hawaiʻi 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.

STATEWIDE CONSERVATION OBJECTIVES

The goal of this SWAP is to guide conservation efforts across the state to ensure protection of Hawaiʻi's Species of Greatest Conservation Need and the diverse habitats that support them. Given limited conservation dollars, management of habitats to benefit multiple species is the focus of the SWAP. Hawaiʻi'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 Hawaiʻi'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 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 (Monitoring, Implementation, 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 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>

- 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 recovery and management plans where needed to guide management, including short-term implementation plans, for species, species groups, or habitats;
- Implement effective habitat management through a variety of activities: landscape-level predator management; invasive plant control, fencing and ungulate removal, predator control, wetland enhancement, riparian restoration, native species outplanting, fire threat mitigation, and management of human activity in sensitive areas;
- 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 Hawaiʻi;
- 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 degrade and destroy remaining native habitat and eliminate native species. A more robust biosecurity implementation plan is needed in Hawaiʻi to ensure proper and more broad screening and early detection. Continual monitoring and responsive management is needed to prevent the introduction and establishment of invasive plants, algae, marine invertebrates, predators, parasites and pathogens in priority areas and to control or remove invasive plant and animal species from areas managed for natural resources

protection. Prevention and rapid response to novel threats is critical to preventing the establishment of new threats into the state.

Highest priority

- 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 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.

High priority

- 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 West Nile Virus Prevention Group and the Brown Treesnake 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*), kāhili 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 secondary 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.

<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.

<u>Highest priority</u>

- 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.

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.

Highest priority

- 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.

<u>Highest priority</u>

- 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).

<u>High priority</u>

- 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 DOFAW management guidelines regarding game management to ensure consistency with 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.

<u>Highest priority</u>

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

<u>High priority</u>

- 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.

Bibliography:

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.

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.

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.

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.

Freed LA, Cann RL, Goff ML, Kuntz WA, Bodner GR (2005) Increase in avian malaria at upper elevation in Hawaiʻi. 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.

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.

Hawaiʻi Conservation Alliance. 2004. "Draft Hawaiʻi biodiversity strategy."

Hawaiʻi 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).

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

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

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

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

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

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

Hawaiʻi 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.

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

Hawaiʻi'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.

Hawaiʻi Coastal Zone Management Program and Department of Health. 2000. Hawaiʻi 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.

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.

Kilpatrick AM. 2006. Facilitating the evolution of resistance to avian malaria in Hawaiian birds. Biol. Cons. 128:475-485.

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.

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

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.

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 Hawaiʻi 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. Hawaiʻi 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).

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. Hawaiʻi's plants and animals: biological sketches of Hawai'i Volcanoes National Park. Honolulu: Hawaiʻi Natural History Association.

Sumiye J. 2002. Koʻolau Mountains Watershed Partnership management plan. Koʻolau 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 Hawaiʻi 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 Hawaiʻi. Honolulu: University of Hawaiʻi Press.

Titcomb M. 1978. Native use of marine invertebrates in old Hawaiʻi. 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 ʻAlala (*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.

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 CONSERVATION NEEDS

Due to the large number and the varied geology of the islands, Hawaiʻi 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. However, introduced mangroves have altered native coastal habitats in a number of places. Because of Hawaiʻi'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, Hawaiʻi has relatively low marine species richness, with approximately 580 different shallow reef fish in contrast to areas of the Pacific further west with thousands of species. In total though, Hawaiʻi still has over 6,000 marine species.

The distribution of marine ecosystems in Hawaiʻi 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 Hawaiʻi 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 Oʻahu and Kauaʻi 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.

OVERVIEW

Geology

The Hawaiian Archipelago consists of eight large islands and approximately 124 small islands. 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 Oʻahu and Kauaʻi. 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 Hawaiʻi 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: Hawaiʻi 428 kilometers (266 miles), Maui 193 kilometers (120 miles), Kahoʻolawe 47 kilometers (29 miles), Lānaʻi 76 kilometers (47 miles), Molokaʻi 142 kilometers (88 miles), Oʻahu 180 kilometers (112 miles), Kauaʻi 145 kilometers (90 miles), Niʻihau 72 kilometers (45 miles), and NWHI 50 kilometers (30 miles).

Climate and Oceanography

The waters surrounding Hawaiʻi are affected by seasonal variations in climate and ocean circulation. The surface temperature of the oceans around Hawaiʻi 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 Hawaiʻi. 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 out to 19 to 322 kilometers (12 to 200 miles) are regulated by a variety of federal agencies. The Hawaiʻi Department of Land and Natural Resources (DLNR) Division of Conservation and Resource Enforcement 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 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 Hawaiʻi Department of Transportation (DOT), the Hawaiʻi 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 Kauaʻi, parts of the north and southeast coast of Oʻahu, and the northwest coast of the island of Hawaiʻi are protected as a part of the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) and expanded sanctuary boundaries are proposed that include an additional protection on the northern shores of Oʻahu and Kauaʻi, Penguin Bank and Maui Nui. Managed jointly by NOAA, USFWS, and the State of Hawaiʻi, Papahānaumokuākea Marine National Monument and World Heritage Site (PMNM) 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 (*Monachus schauinslandi*), and the threatened green sea turtle or hōnu (*Chelonia mydas*). PMNM 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 Hawaiʻi DLNR continues to manage conservation initiatives at the State Bird Sanctuary at Kure Atoll. USFWS helps manage hawksbill sea turtle nesting off the Keālia Pond NWR on Maui. The NPS manages marine habitats off Kalaupapa National Historic Park (NHP), Kaloko-Honokōhau NHP, and

Hawaiʻi Volcanoes National Park. The U.S. Navy is responsible for Pearl Harbor and waters near Kāneʻohe Marine Corps Base on Oʻahu, the Pacific Missile Range Facility off Kauaʻi, 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 11 Marine Life Conservation Districts, 19 Fishery Management Areas (FMAs), nine Fish Replenishment Areas, two Wildlife Sanctuaries, 18 Bottomfish Restricted Areas, and the South Kona ʻŌpelu fishing area, in addition to implementing general, statewide fishing regulations. The DLNR Division of Forestry and Wildlife (DOFAW) manages the waters of ʻĀhihi Kīnaʻu Natural Area Reserve (NAR) on Maui. The Kahoʻolawe Island Reserve Commission manages waters from the shores of Kahoʻolawe out to 3 kilometers (2 miles). The DOT-Harbors Division controls access to the ten commercial harbors in the state and numerous recreational harbors.

Human Landscape

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. In 2002, the Hawaiʻi Coral Reef Initiative funded a study regarding the economic valuation of the coral reefs of Hawaiʻi, where the value of coral reefs to the Hawaiʻi economy was estimated to be about $380 million dollars a year. 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 and 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, ten oil refineries and terminals, 25 power plants, 1,860 storm drain wells, and 100,000 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 *ahupuaʻa* (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 151 marine fishes, 197 species of marine invertebrates, and 26 species of marine mammals. Marine species in Hawaiʻi 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 Hawaiʻi. Over 5,000 marine invertebrates are known from Hawaiʻi 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 Hawaiʻi; two are common residents that nest on Hawaiʻi'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 Hawaiʻi. 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*). Koholā (humpback whales), false killer whales, and Hawaiian monk seals are common marine mammals in Hawaiʻi 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 Hawaiʻi's coasts. There are 78 species of endemic marine algae, 24 species of endemic freshwater algae, and two aquatic plants included in the list of SGCN under flora.

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.

- 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, ʻopihi (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;
- 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) (main bullet below) and throughout Chapter 6 (Island Conservation Needs), additional strategies for marine species and habitats 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;
    - 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, and other marine managed areas and consider modifying or expanding boundaries and management strategies as necessary.

- 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 Hawaiʻi'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 Hawaiʻi, 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.
- 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 Hawaiʻi Marine Gap Analysis for the MHI (2005) and maintain an integrated decision-making process to facilitate management of Hawaiʻi's marine resources;
  - Improve information sharing among agencies, non-governmental organizations, and academia through support of programs such as the Hawaiʻi Marine Gap Analysis program, the Western Pacific Fisheries Information Network, the Pacific Basin Information Node, and the Bishop Museum Hawaiʻi Biological Survey; and
  - Seek to expand funding for monitoring of other habitats (e.g., deep waters, sandy habitats, shallow water, tide pools, anchialine pools, etc.).

- 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 Hawaiʻi 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 support for local involvement in stewardship initiatives and management of marine resources by developing community-based subsistence fishing areas following the initial successes in communities such as Haʻena and encourage community-based management programs like the West Hawaiʻi 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 kupuna and collaborating with landowners to broaden opportunities that incorporate cultural knowledge and understanding into marine and freshwater conservation policies and incorporate the ahupuaʻa approach;
    - 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.
- Expand and strengthen outreach and educational efforts to improve understanding of our native wildlife resources among the people of Hawaiʻi.
    - 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.
- 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.
- 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. (Hawaiʻi 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/.

MANAGEMENT NEEDS

Current Management of Species and Habitats

Under Hawai‘i Revised Statutes 190-1, 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 PMNM in 2006 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.

***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 Hawaiʻi. 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, Levels of Abundance and Status of Humpbacks (SPLASH) project to monitor population size, 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 Marine National Monument*, 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 (11 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, Wai‘ōpae Tidepools)**

***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 (19 Areas – Kaua‘i: Hanamā‘ulu Bay, Nāwiliwili Harbor, Port Allen, Waimea Bay; O‘ahu: He‘eia Kea Wharf, Honolulu Harbor, Pōka‘i Bay, Waialua Bay, Waikīkī-Diamond Head Shoreline; Moloka‘i: Kaunakakai Harbor; Lāna‘i: Mānele Harbor; Maui: Kahekili Herbivore Management Area, Kahului Harbor; Hawai‘i : Hilo Harbor, Kailua Bay, Kawaihae Harbor, Keauhou Bay, Kīholo Bay, Kona Coast Puakō Bay and Reef)**

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

Habitats: Marine and estuary ecosystems.

***Current Management*:** Waikīkī-Diamond Head Shoreline is no take during odd-numbered years. Established in 2009, the Kahekili Herbivore Management Area is managed to control non-native algae on nearshore reefs by enhancing herbivorous fish species abundance. Limited take, gear, size, season, and other FMA-specific restrictions.

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.

***Bottomfish Restricted Areas*, DAR (12 Areas – Niʻihau (2), Kauaʻi (1), Oʻahu (2), Penguin Bank (1), Maui and Molokaʻi (3), Hawaiʻi (3). See Bibliography for resource listing exact coordinates)**

***Species*:** Seven bottomfish species ("Deep 7").
Habitats: Marine ecosystems.
***Current Management*:** No targeting or take of bottomfish.
Future Needs: Continue to evaluate, document, and report the purpose and management effectiveness for all Bottomfish Restricted Areas, and consider the need for new or modified restricted fishing areas.

***Marine Wildlife Sanctuaries*, DAR (Three Marine Areas – Coconut Island, Paikō Lagoon, 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**

***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.

***Fishery Replenishment Areas*, DAR (Nine Areas – all on the Kona Coast of Hawaiʻi and part of the West Hawaiʻi Regional FMA)**

***Species*:** Species associated with shallow coral reef, sandy beach, and rocky habitats.

Habitats: Marine ecosystems including shallow coral reef, sandy beach, and rocky habitats.
***Current Management*:** New management rules that include restrictions on SCUBA spearfishing, reef fish collecting for the aquarium trade, and area closures aimed at reducing impacts on fish species of special concern.
Future Needs: Evaluate, document, and report the purpose and effectiveness of current management for all Fishery Replenishment Areas 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.

***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.

***Hawaiʻi 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.

Bibliography:

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.

Kahoʻolawe 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 Hawaiʻi 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]. Hawaiʻi 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 Hawaiʻi 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.

KAUAʻI

Kauaʻi 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 Kauaʻi 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, Kauaʻi 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. Kauaʻi 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. Kauaʻi also has three offshore islets.

Climate

Elevation ranges from sea level to 1,598 meters (5,243 feet). Kauaʻi is directly exposed to the prevailing tradewinds that deliver rain, conditions which make Mount Waiʻaleʻale 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 2014, the County of Kauaʻi had a population of nearly 70,475 residents. The total County population amounted to almost 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. Tourism counts declined during the 1990s, due largely to the destruction caused by Hurricane Iniki in 1992, but visitor numbers have since increased, with Kauaʻi hosting 1.1 million visitors in 2013. Visitor accommodations are located throughout the island, but are primarily at Poipu, Princeville, and Waimea/Kapaʻa. Agriculture has shifted recently from primarily sugarcane, with the closure of four of five plantations, to diversified agriculture and aquaculture. Taro (*Colocasia esculenta*) farming is an important crop on Kauai and in the lower Hanalei Valley. Kalo, the Hawaiian name for taro, has cultural and historic significance to native Hawaiians, and 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

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. 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, Mokuaeʻae, and Kaula, 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 Kauaʻi cave wolf spider (*Adelocosa anops*) 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 ‘ā (*Sula leucogaster* [brown booby]) colony in the state.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on Kaua‘i and its associated offshore islands. Species endemic to Kaua‘i include the puaiohi (*Myadestes palmeri*), ‘akikiki, ‘anianiau (*Hemignathus parvus* [lesser ‘amakihi]), ‘akeke‘e, Newcomb’s snail, Kaua‘i cave wolf spider, Kaua‘i cave amphipod, and two species of picture-wing flies (*Drosophila musaphila* and *D. sharpi*). Additional forest birds include the ‘i‘iwi (*Vestiaria coccinea*), ‘apapane (*Himatione sanguinea*), and Kaua‘i ‘elepaio (*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 Kaua‘i. Increasing numbers of nēnē, ‘alae ‘ula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen], and ‘alae ke‘oke‘o (*Fulica alai* [Hawaiian coot]) are feeding in taro ponds in Hanalei Valley and causing significant damage to farmers crops.

Two Hawaiian endemic seabirds, the ‘a‘o (*Puffinus newelli* [Newell’s shearwater]), ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]), are known to breed in the steep mountainous interior of Kaua‘i in crevices and burrows often beneath dense understory of native ferns and canopy structure. The ‘akē‘akē (*Oceanodroma 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 Kaua‘i is poorly understood. Kaua‘i 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 ‘īlio-holo-i-ka-uaua, or Hawaiian monk seals (*Monachus schauinslandi*), basking on Kaua‘i’s beaches has increased. Finally, Kaua‘i 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 Kaua‘i 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 silvestris*] 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 rats [*Rattus* spp.] that prey on 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 Kaua‘i’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 Kaua‘i;
- 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 ‘ōpe‘ape‘a, or Hawaiian hoary bat [*Lasiurus cinereus*], seabirds, nēnē, and waterbirds) and utility lines (for seabirds), and by seabird fallout associated with light attraction;
- Risk of nēnē-aircraft collisions at the Lihu‘e 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 insure 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 Po‘ipū area; and
- Human interactions with monk seals, which are much more common off Kaua‘i than the other Main Hawaiian Islands.

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 Kaua‘i 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 on offshore islands used by seabirds for nesting and in key 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;
    - Continue to relocate nēnē away from the Lihuʻe 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;
    - Assess impacts on seabirds 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 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.
- 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 Kauaʻi 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 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), the Recovery Plan for the Kauaʻi 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 Na 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 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 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 Nene 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.

***Hono o Na 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, 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.

***Alaka'i 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.

***Kaua'i 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., Līhu'e Land Company, Kealia Ranch, LLC, B.A. Dyer, and Princeville Development, LLC)**

Species: Forest birds, seabirds, pueo, 'ōpe'ape'a, 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, 'ōpe'ape'a.
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.

***Hulē'ia NWR* (241 acres), USFWS**

Species: Waterbirds, 'ōpe'ape'a.
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 Moku ʻAeʻae), DOFAW**

Species: Nesting seabirds: ‘ua‘u kani (*Puffinus pacificus* [wedge-tailed shearwater]), ‘ou (*Bulweria bulwerii* [Bulwer’s petrel]), ‘ā (*Sula sula* [red-footed booby]), ‘ā (*Sula leucogaster* [brown booby]),‘ā (*Sula dactylatra* [masked booby]), mōlī (Laysan albatross), ka‘upu (*Phoebastria nigripes* [black-footed albatross]), noio (*Anous minutus* [black noddy]), noio-kōhā (*Anous stolidus* [brown noddy]), manu-o-Kū (*Gygis alba* [fairy tern]), Christmas shearwater (*Puffinus nativitatis*), ‘a‘o, koa‘e ‘ula (*Phaethon rubricauda* [red-tailed tropicbird]), koa‘e kea (*Phaethon lepturus* [white-tailed tropicbird]), ‘iwa (*Fregata minor* [great frigatebird]), ‘akē‘akē.
Habitats: Coastal offshore communities.
Current Management: Surveys and monitoring, planned eradication of rats and rabbits on Lehua, habitat restoration.
Future Needs: Continue monitoring of seabird populations, follow up on monitoring of predator populations to prevent re-establishment. Repeat large-scale predator control on Lehua island seabird sanctuary.

***Hawaiian Islands Humpback Whale National Marine Sanctuary* (about 900,000 acres), Co-Managed by NOAA and DLNR**
***Species*:** Humpback whale (*Megaptera novaeangliae*).
Habitats: Marine ecosystem.
***Current Management*:** Management plan exists. Humpback whale 91 meter (100-yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the Endangered Species Act, lead agency for the Main Hawaiian Islands component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, volunteer whale counts and other community events, and other educational activities, research support, and enforcement.
***Future Needs*:** Review other marine species, including seabirds, and habitats for inclusion in Sanctuary, and increase research, education, and enforcement actions.

***Four Fishery Management Areas (FMAs)*, DAR (Hanamā‘ulu Bay, Nāwiliwili Harbor, Port Allen, Waimea Bay)**
***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 purpose and management effectiveness and consider need for new marine managed areas.

***Two Bottomfish Restricted Fishing Areas (BRFAs)*, DAR**
***Species*:** Seven bottomfish species.
Habitats: Marine ecosystem.
***Current Management*:** No take of bottomfish.
***Future needs*:** Evaluate all BRFAs for purpose and management effectiveness and consider need for new marine managed areas.

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 Kauaʻi, and often involve island-wide research and management that extend across boundaries.

***Kauaʻi Resource Conservation Program*, Public-Private Partnership**

***Species/Habitats*:** All species and habitats present in Kōkeʻe 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.

***Kauaʻi Forest Bird Recovery Project*, DOFAW, USFWS, University of Hawaiʻi**

Species/Habitats: Kauaʻi forest birds, primarily focused on the puaiohi, ʻakikiki and ʻakekeʻe. 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.

***Kauaʻi Endangered Seabird Recovery Project*, DOFAW, USFWS, University of Hawaiʻi**

Species: **ʻ**Aʻo (Newell's shearwater), ʻuaʻu (Hawaiian petrel), ʻakēʻakē (band-rumped storm-petrel).

Habitats: Mountainous interior, outer coastal areas.

Current Management: Seabird population monitoring, colony protection, predator control, and development of conservation strategies to slow the decline of ʻaʻo.

Future Needs: Continue to advance the use of acoustics and other monitoring technologies that help inform the development of risk minimization measures, and advance long-term solutions that address predator control at nesting colonies. Strengthen existing partnerships.

***Kauaʻi 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, Kauaʻi Island Utility Cooperative**

***Species*:** **ʻ**Aʻo (Newell's shearwater), ʻuaʻu (Hawaiian petrel), ʻakēʻakē (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 Kauaʻi'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, ʻakikiki, ʻiʻiwi (*Vestiaria coccinea*), Kauaʻi ʻelepaio, ʻanianiau, Kauaʻi ʻamakihi, ʻakekeʻe (Kauaʻi ʻākepa), ʻapapane, pueo, ʻaʻo, 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 *Kauaʻi Watershed Alliance Management Plan*. Last remaining suitable habitat for puaiohi, ʻakikiki; last known habitat for Kauaʻi 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, Haʻena 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*:** Kauaʻi cave wolf spider, Kauaʻi cave amphipod.

***Basis for Priority Designation*:** Designated as critical habitat for endangered cave wolf spider 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.

Bibliography:

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

Decision Analysts Hawaiʻi, Inc. and Research Solutions, LLC. 2002. Draft economic analysis of proposed Critical Habitat designations for threatened and endangered plants on Kauaʻi and Niʻihau. Hawaiʻi 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.

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. Undated. Interim State of Hawaiʻi strategic plan for invasive species prevention, control, research and public outreach. Honolulu, (HI).

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

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

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 2011. Hono o Na 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.

Hawaiʻi Coastal Zone Management Program and Department of Health. 2000. Hawaiʻi 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.

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 Kaua'i cave arthropods: the Kaua'i cave wolf spider (*Adelocosa anops*) and the Kaua'i 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.

NI‘IHAU

Ni‘ihau is a small, privately owned island located approximately 27 kilometers (17 miles) west of Kaua‘i. The island’s highest point is 390 meters (1,281 feet). Among Ni‘ihau’s most unique natural features are several intermittent lakes, which provide habitat for ‘alae ke‘oke‘o (*Fulica alai* [Hawaiian coot]), ae‘o (*Himantopus mexicanus knudseni* [Hawaiian stilt]), and koloa maoli (*Anas wyvilliana* [Hawaiian duck]). Due to restricted access, there is limited biological information available about Ni‘ihau (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

Ni‘ihau was formed from a single shield volcano approximately 4.89 million years ago, making it slightly younger in age than Kaua‘i. 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. Ni‘ihau has no perennial streams. Halulu Lake is a natural freshwater lake covering approximately 74 hectares (182 acres) and Halāli‘i Lake is an intermittent lake covering approximately 340 hectares (841 acres).

Climate

Located inside Kaua‘i’s rain shadow, Ni‘ihau 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 Kaua‘i, Ni‘ihau 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 Ni‘ihau includes only lowland dry systems and coastal systems. It is thought that Ni‘ihau may have some of the best coastal habitats in the state.

Information on species’ distribution on Ni‘ihau is limited. Appendix A provides information on the wildlife Species of Greatest Conservation Need present on Ni‘ihau. There are no wildlife species known to be endemic to Ni‘ihau. Known species present are primarily waterbirds, seabirds, migratory shorebirds, and marine species in the surrounding near waters. Hawaiian monk seals (*Monachus schauinslandi*) 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 (*Anas wyvilliana* [Hawaiian duck]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), and aeʻo (Himantopus mexicanus knudseni [Hawaiian stilt]) 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, *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 *Brighamia insignis* (alula or olulu). Alula 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 Niʻihau; Eradicate predators on offshore islands used by seabirds for nesting and control predators at any active nesting colonies on Niʻihau;
    - 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 Niʻihau (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 Niʻihau (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 Hawaiʻi.
    - 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 Niʻihau 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

The following section addresses the current management actions and future needs of key habitats on Niʻihau. 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).

Bottomfish Restricted Fishing Area, Division of Aquatic Resources

***Species*:** Seven bottomfish species.
Habitats: Marine ecosystem.
***Current Management*:** No take of bottomfish.
Future Needs: Evaluate BRFA for purpose and management effectiveness and consider need for new marine managed areas.

Bibliography:

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. 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‘olaus, 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 (41%; 63,466 hectares or 156,829 acres), Agricultural District (33%; 51,678 hectares or 127,698 acres), and the Urban District (26%; 41,140 hectares or 101,661 acres). The Conservation District encompasses most of the

Koʻolau and Waiʻanae mountain ranges. About 16,592 hectares (41,000 acres), primarily in the Conservation District, are managed by the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) (11% of the total land area). Approximately 35,942 hectares (88,817 acres) of conservation-zoned forest land is under private ownership or management. 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 36,853 hectares (91,066 acres, 24% of the total land area) is under the control (through ownership or lease) of the military. The largest private landowners are Kamehameha Schools, Castle and Cooke, Dole Food Company, and Amfac.

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

In 2014, the total resident population of Oʻahu was estimated at 991,788, accounting for 70 percent of the state's population. This number is supplemented by an average daily visitor population of 96,054. 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 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 O‘ahu ‘elepaio (*Chasiempis sanwichensis ibidis*). Habitat essential for the recovery of the O‘ahu tree snails (*Achatinella* spp.) has also been identified.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on O‘ahu and its associated offshore islands. Known taxa endemic to O‘ahu include the O‘ahu ‘elepaio (endemic at the subspecies level), O‘ahu ‘alauahio (*Paroeomyza maculata* [O‘ahu creeper], potentially extinct), O‘ahu ‘amakihi (*Hemignathus flavus*), several damselflies (*Megalagrion* spp.), several endemic bees (*Hylaeus* spp.), and the O‘ahu tree snails (*Achatinella* spp.). The endangered ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]) occurs and has breeding populations on the island, as do the following birds: ‘apapane (*Himatione sanguinea*), ‘i‘iwi (*Vestiaria coccinea*) (state-listed as endangered on O‘ahu), and pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]) (state-listed as endangered on O‘ahu). Significant populations of endangered waterbirds occur on O‘ahu, including the ae‘o (*Himantopus mexicanus knudseni* [Hawaiian stilt]), ‘alae ke‘oke‘o (*Fulica alai* [Hawaiian coot]), ‘alae ‘ula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), and the koloa maoli (*Anas wyvilliana* [Hawaiian duck]). The seabird, ‘a‘o (*Puffinus auricularis newelli* [Newell’s shearwater]), is believed to nest in the Ko‘olau mountains, mōlī (*Phoebastria immutabilis* [Laysan albatross]) nest at Ka‘ena Point Natural Area Reserve, wedge-tailed shearwaters (*Puffinus pacificus*) nest at Ka‘ena Point and on beach strands at other sites on the island, and eight species of seabirds nest on the offshore islands. O‘ahu 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. ‘Ōpae‘ula (*Holocaridina rubra*) occur in natural and man-made anchialine and aquaculture ponds. Native freshwater fishes, including several species of ‘o‘opu, native freshwater invertebrates, including *Oahuhawaiian kazukolinda*, and several species of crustaceans, are found within several stream systems. Finally, hōnu (*Chelonia mydas agassizi* [green sea turtles]), monk seals (*Monachus schauinslandi*), 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 O‘ahu 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 insure 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):

- 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 O‘ahu;
- 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 O‘ahu;
- 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 O‘ahu 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 Kāne‘ohe Bay and other watersheds 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 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 O‘ahu (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 O‘ahu 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 O‘ahu native tree and land snails;

    - Expand control of mammalian predators (e.g., feral cats, mongoose, rats) in waterbird, seabird, and ‘elepaio 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.
- 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.
- 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.
- 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, Hamakua 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.
- 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 sea turtle and Hawaiian monk seal 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, Kaala 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.

***O'ahu 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: Lowland communities.
***Current Management*:** No management plan exists. Fencing, ungulate removal from fenced areas, predator control, invasive plant removal, outplanting, management of snail-predator-proof exclosure.
***Future Needs*:** Complete proposed Kapuna fencing, develop management plan, formalize partnership with U.S. Army for habitat and rare plant management, continue existing management, and retrofit or build a new replacement snail-predator-proof exclosure.

***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 dry communities.
***Current Management*:** Management plan exists. Fencing, invasive plant removal, maintenance of fencing, predator control.
***Future Needs*:** Formalize partnership with U.S. Army for habitat and rare plant management, continue existing management, and implement ungulate and predator control.

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

***Species*:** Forest birds, terrestrial invertebrates, rare plants.
Habitats: Lowland communities.
***Current Management*:** Fencing, fire prevention, predator (rat) control, invasive weed removal, ungulate control, habitat restoration, 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 exclosures.

***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, 'o'opu, 'ōpae kala'ole (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).

***Nu'upia Pond Wildlife Management Area* (482 acres), U.S. Marine Corps Base Hawai'i**
***Species*:** Waterbirds, migratory shorebirds, seabirds, particularly 'ua'u 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, 'ōpae'ula (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*:** Construction of first predator-proof fence on O'ahu, management of human access and activities, invasive weed removal, predator control, outplanting, monitoring, research.
***Future Needs*:** Continue existing management, maintain predator control fence, increase 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.

***Five Fishery Management Areas (FMAs),* DAR*:* He‘eia Kea Wharf, Honolulu Harbor, Pōka‘i Bay, Waialua Bay, 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.

***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 Kāne‘ohe 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 He‘eia 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.

***Two Bottomfish Restricted Fishing Areas (BRFA),* DAR**

***Species*:** Seven bottomfish species.

Habitats: Marine ecosystems.

***Current Management*:** No take of bottomfish.

Future Needs: Evaluate all BRAs for 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.

Habitats: Marine ecosystems.

***Current Management*:** Management plan exists. Humpback whale 91-meter (100-yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the Endangered Species Act, lead agency for the MHI component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, volunteer whale counts and other community events, and other educational activities, research support, and

enforcement.
Future Needs: Review other marine species, including seabirds, and habitats for inclusion in Sanctuary and increase 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 Oʻahu'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.

Koʻolau forested watershed

***Species*:** Forest birds, terrestrial invertebrates, 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.

Manoa 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.

Bibliography:

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. 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.

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 Hawaiʻi: 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. 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. 1992. Recovery plan for the Oʻahu 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 Oʻahu, Hawaiʻi. 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 Hawaiʻi. Natural resources conservation – small installations. FY01-03. Available at: https://www.denix.osd.mil/denix/Public/News/OSD/SecDef03/NRC/nrc_Hawai'i.pd

MOLOKAʻI

Molokaʻi 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 Molokaʻi 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 Molokaʻi include lava tube caves, montane bogs, and wet forests. Important geographic features include the state's third largest perennial stream, and the highest sea cliffs in the world.

OVERVIEW

Geology and Hydrology

Molokaʻi 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 Molokaʻi 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 Molokaʻi 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 Molokaʻi. 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. Molokaʻi has 36 perennial streams, 16 of which are continuous. Wailau-Pulena and Pelekunu have the largest discharges: 27 and 25 million gallons per day (mgd), respectively. Molokaʻi has nine offshore islets.

Climate

Annual rainfall ranges from 406 centimeters (160 inches) at the top of the East Molokaʻi 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 Molokaʻi 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 Home Lands (16% of the island). Within native dominated landscapes, major landowners include the State of Hawaiʻi and private entities such as The Nature Conservancy of Hawaiʻi, Kamehameha Schools, Puʻu O Hoku Ranch, and Molokaʻi Ranch. One stream (Kamalo) has an altered channel. The Waikolu canal in the northeast is the largest man-made stream system at five mgd. Kualapuʻu 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 2010 was estimated at 7,345, with an average daily visitor count of about 1,000. 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. The major industries are now agriculture, ranching, and flower cultivation. Ranching had been a longtime industry and tradition on Molokaʻi, and commercial ranching operations continue there.

SPECIES AND HABITATS OF IMPORTANCE

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 Maui parrotbill (*Pseudonestor xanthophrys*) and ʻākohekohe (*Palmeria dolei* [crested honeycreeper]). 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 *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 proposed in 2013 for 60 plant species (many of the species are also included in previously designated critical habitat) and two forest bird species (ʻākohekohe [*Palmeria dolei*] and Maui parrotbill [*Pseudonestor xanthophrys*]); if the proposed critical habitat becomes final, it would significantly increase 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 ʻiʻiwi (*Vestiaria coccinea*), ʻamakihi (*Hemignathus virens*), and ʻapapane (*Himatione sanguinea*) still persist at low numbers. In addition, Molokaʻi supports populations of several endangered and threatened species, such as ʻōpeʻapeʻa (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), the nēnē (*Branta sandvicensis* [Hawaiian goose]), aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), ʻaʻo (*Puffinus auricularis newelli* [Newell's shearwater]), and the Blackburn's sphinx moth. 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 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 pristine, high-quality 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);
- 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;
- 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; and
- Expanding eco-tourism activities that disrupt animal behaviors and habitats.

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 Molokaʻi 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 Molokaʻi;
  - Increase active and strategic management in, or acquisition of, extremely rare habitats on Molokaʻi;
  - 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;
    - 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;
    - Develop and/or revise management plans for all marine managed areas; and
    - 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.
- 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.
- 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.
- Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawaiʻi.
    - 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.
- 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:

- 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); 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 threatened and endangered plants on Molokaʻi;
- Management Plans for the State Natural Area Reserves (NARs): Olokuʻi NAR (1991) and Puʻu Aliʻi NAR (1991);
- 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; 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 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 nēnē re-introduction 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 Moloka‘i.

***East Moloka‘i 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**

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 (*Phaethon lepturus* [white-tailed tropicbird]), koaʻe ʻula (*Phaethon rubricauda* [red-tailed tropicbird]), ʻā (*Sula leucogaster* [brown booby]), ʻou (*Bulweria bulwerii* [Bulwer's petrel]), ʻuaʻu kani (*Puffinus pacificus* [wedge-tailed shearwater]), cave invertebrates, Hawaiian monk seal, hōnu and hōnu ʻea (green and hawksbill sea turtles, respectively), five native diadromous fish species (gobies), native snails, 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.

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 (*Nycticorax nycticorax* [black-crowned night-heron]), ʻūlili (*Tringa incana* [wandering tattler]), koaʻe kea, *Partulina mighelsiana*, *P. tessellata*, *Megalagrion santhomelas*, *M. pacificum*, beetles, five native freshwater fishes, freshwater snail, hihiwai (*Neritina granosa*), two native crustaceans, ʻopae kalaʻole (*Atyoida bisulcata*), ʻopaeʻoheaʻa (*Macrobrachium grandimamus*), rare aquatic insects, *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.

Olokuʻi NAR **(1,620 acres), DOFAW**

Species: ʻApapane, ʻamakihi, ʻiʻiwi, koaʻe kea, ʻaʻo, ʻuaʻu, native insects (crickets, katydid, flies, spiders), 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 Olokuʻi 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.

Puʻu Aliʻi NAR **(1,330 acres), DOFAW**

Species: Olomaʻo (*Myadestes lanaiensis* [Molokaʻi thrush]), ʻiʻiwi (*Vestiaria coccinea* [scarlet Hawaiian honeycreeper]), pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), ʻapapane (*Himatione sanguinea*), ʻamakihi (*Hemignathus virens*), ʻaʻo, ʻuaʻu, 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 to strategically restrict ungulate movement in a larger portion of the NAR, intensify ungulate removal, and broaden existing efforts.

Kakahaiʻa NWR **(45 acres), USFWS**

Species: Aeʻo, ʻalae keʻokeʻo, 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 (*Calidris alba* [sanderling]), kōlea (*Pluvialis fulva* [Pacific golden plover]), 'iwa (*Fregata minor* [great frigatebird]), mōlī (*Phoebastria immutabilis* [Laysan albatross]), Hawaiian monk seal, hōnu (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: 'Auku'u, 'ua'u kani, 'ou, koa'e kea, koa'e 'ula, 'ā (brown booby), kōlea, 'ūlili, 'akekeke (*Arenaria interpres* [ruddy turnstone]), 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 Area (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.

***One Bottomfish Restricted Fishing Area (BRFA),* DAR**

Species: Seven bottomfish species ("Deep 7").
***Habitats*:** Marine ecosystems.
***Current Management*:** No take of bottomfish.
***Future needs*:** Evaluate existing BRFAs for purpose and management effectiveness and consider the need for new and/or expanded BRFAs.

***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.
***Current Management*:** Current management plan being revised to incorporate ecosystem-level provisions. Humpback whale 91-meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, lead agency for the Main Hawaiian Island component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, volunteer whale counts and other community events, and other educational activities, research support, and enforcement.

***Future needs*:** Include management provisions for other marine species, including seabirds and sea turtles, and habitats; increase research opportunities, education, and necessary enforcement capacity.

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 Molokaʻi, and often involve island-wide research and management that extend across boundaries and jurisdictions.

***Molokaʻi 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 Molokaʻi's native wildlife and habitats. 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.

***Molokaʻi Forest Reserve* (16,030 acres), DOFAW**

***Species*:** Forest birds, terrestrial 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.

Potential Conservation Actions: 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, 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.

***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, Pālaau 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, Hawaiian monk seal, hōnu.
***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.

Bibliography:
Duvall, F. Wildlife Biologist, Division of Forestry and Wildlife. Personal communication. 2005.

East Molokaʻi Watershed Partnership. East Molokaʻi Watershed Partnership Strategic Plan: for the south slope FY1998-FY2003 Summary, FY2004-2009 Projections.

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.

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 Moloka'i. Personal communication.

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).

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, 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, 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 of Hawai'i. Hawaiian High Islands Ecoregional Plan.

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. 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.

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. 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. 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 Moloka‘i, Hawai‘i : 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.

LĀNA‘I

Lāna‘i is the third smallest of the Main Hawaiian Islands. Because of the 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 Lāna‘i 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, Lāna‘i, Moloka‘i, and Kaho‘olawe) occurs on Lāna‘i. This forest provides habitat for several taxa of native invertebrates. The upland area surrounding the island's highest point, Lāna‘ihale, contains most of the remaining native-dominated mesic forest and provides habitat for the ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]), ‘apapane (*Himatione sanguinea* [Hawaiian honeycreeper]), and rare native land snails. Waterbird species rely primarily on human-made reservoirs (e.g., golf-course ponds, the Lāna‘i Sewage Treatment Plant), rather than natural wetlands.

OVERVIEW

Geology and Hydrology

Lāna‘i 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 Lāna‘ihale, 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; only 6 percent of the island is above 610 meters (2,000 feet) in elevation. Lāna‘i has five offshore islets. There are no perennial streams or lakes.

Climate

Located in the rain shadow of Maui, Lāna‘i is generally dry, with an average rainfall of 75 to 100 centimeters (30 to 40 inches) over Lāna‘ihale 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 Moloka‘i 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 Conservation District, located primarily around Lāna‘ihale and on the western end of the island. This area partly overlaps the Lāna‘i 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 Lāna‘i 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 Lāna‘i Resorts LLC and managed by Pulama Lāna‘i. 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 Lāna‘i Cooperative Game Management Area.

Human Landscape
In 2000, the residential population of the island was estimated at 3,193 persons, and that number remained roughly unchanged according to U.S. Census Bureau statistics for 2010. 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 grew from 46,052 in 1990 to a high of 106,036 in 1997 and has remained fairly stable since then.

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 snail (*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 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 (*Vestiaria 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: *Tetramolopium remyi, Portulaca sclerocarpa,* and *Bidens micrantha kalealaha*.

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 silvestris*), dogs (*Canis familiaris*), barn owls (*Tyto alba*), cattle egrets (*Bubulcus ibis*), and rodents (e.g., *Rattus* spp.);
- 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) (main bullet), additional island-specific strategies for Lānaʻi 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;
    - 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.
- 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.
- 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.
- Strengthen existing collaboration and develop new opportunities with Pulama 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.
- Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawaiʻi.
    - 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.
- 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:

- Long-range management plan for Natural Area Partnership Preserve: Kānepuʻu 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);
- 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 *Hawaiʻi 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 Hawaiʻi.

MANAGEMENT NEEDS

Current Management of Species and Habitats

The following section addresses the current management actions and future needs of key habitats on Lānaʻi. The discussion of future management needs is highlighted within each current managed area. In comparison to other islands, Lānaʻi 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. Pulama Lānaʻi has a natural resources management program that oversees most of the resource conservation and management activities on Lānaʻi.

Management Areas

***Kānepuʻu Preserve* (590 acres), The Nature Conservancy (TNC) and ʻIke ʻĀina**

> ***Species:*** ʻApapane, 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]), koaʻe ʻula (*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-Hulopoʻe Marine Life Conservation District (MLCD), **Division of Aquatic Resources (DAR)**

Species**:** Species associated with shallow coral reef, sandy beach, and rocky habitats, Hawaiian monk seals (*Monachus schauinslandi*), hōnu (*Chelonia mydas* [green sea turtles]), spinner dolphins (*Stenella longirostris*) 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.
Habitats: Marine ecosystems.
Current Management**:** Revised management plan exists. Humpback whale 91-meter (100-yard) approach rule and other regulations protecting humpback whales and their habitat, lead agency for the Main Hawaiian Islands component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, volunteer whale counts and other community events, and other educational activities, research support, and enforcement.
Future needs**:** Incorporate new provisions for ecosystem-based approach to sanctuary management of marine species, including seabirds, sea turtles, and habitats; encourage increased research, education, and enforcement capacity.

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.

Bibliography:

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).

Hawaiʻi Natural Heritage Program [now known as the Hawaiʻi Biodiversity and Mapping Program]. 2005. Hawaiʻi GAP Analysis. Personal communication.

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

Juvik JO, Juvik S, editors. 1998. Atlas of Hawaiʻi Third Edition. Honolulu: University of Hawaiʻi 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: Hawaiʻi atlas. Seattle (WA): National Oceanic and Atmospheric Administration.

Nature Conservancy of Hawaiʻi. Hawaiian High Islands Ecoregional Plan.

Nature Conservancy. 2004. Kanepuʻu 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. 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. 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, Hawaiʻi.

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 Hawaiʻi 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 ʻōhiʻa (*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 Puʻu Kukui in West Maui coming in second at 1,764 meters (5,788 feet). Maui is the only island (other than Hawaiʻi) containing 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), Honokohau stream (the longest stream channel in west Maui), and ʻĪao stream. Maui has 90 perennial streams, 56 of which are continuous. Waiheʻe and ʻĪao 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 land owners in West Maui include the State of Hawaiʻi, Maui Land and Pineapple, Inc., Makila Land Company, Kahoma Land Company, Kaanapali Land, LLC, Kamehameha Schools, and Maui County (Department of Water Supply). In East Maui, major land owners are the State of Hawaiʻi (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. ʻĪao 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

Estimated human population on Maui is 144,000 (2010) with most of the island's population located in central, south, and west Maui in areas such as Kahului and Wailuku, Kīhei, Lahaina, and Kaʻanapali. The average daily visitor population is approximately 45,000. 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 Kipahulu and Kaupō area. These habitats support a diversity of native species including forest birds, invertebrates, ʻōpeʻapeʻa (*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 a few 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 *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 proposed in 2013 for 91 plant species (many of the species are also included in previously designated critical habitat), two forest bird species (ʻākohekohe [*Palmeria dolei*] and Maui parrotbill [*Pseudonestor xanthophrys*]), and three snail species (*Partulina semicarinata*, *P. variabilis*, and *Newcombia cumingi*); if the proposed critical habitat becomes final, it would significantly increase the total area of critical habitat on Maui. Recovery habitats for the Maui parrotbill (*Pseudonestor xanthophrys*) and ʻākohekohe (*Palmeria dolei* [crested honeycreeper]) 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*), poʻouli (*Melamprosops phaeosoma*), and Maui parrotbill. 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]), ʻaʼo (*Puffinus newelli* [Newell's shearwater]), ʻōpeʻapeʻa, Hawaiian monk seal (*Monachus schauinslandi*), hōnu ʻea (*Eretmochelys imbricata* [hawksbill turtle]), and hōnu (*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 native bees (*Hylaeus* spp.), 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 is slowly spreading across East Maui 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);
- 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 silvestris*), 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 veiled chameleons (*Chamaeleo calyptratus*), 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;
- Avian disease transmitted by mosquitoes restricts forest birds to habitat located at elevations above the mosquito-line, and as temperatures warm because of climate change, mosquitos are moving up in elevation, enabling disease transmission to susceptible forest birds in previously disease-free high-elevation forests;

-
- 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 insure 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 ʻĀhihi Kīnaʻu 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) (main bullet), additional island-specific strategies for Maui 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 Maui;
    - Increase active management in, and acquisition of, extremely rare habitats on Maui;
    - Continue captive propagation of Maui parrotbill;
    - 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;
    - Increase the total acreage of ungulate-free and predator-free areas inside existing fenced management areas;
    - 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;
    - 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.
- 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.
- 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.
- 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 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.
- 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; 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 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); 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 threatened and endangered plants on Maui;
- HCPs and Safe Harbor Agreements (SHAs): Renewable energy programs like Kaheawa Wind Power (Phase I and II, West Maui) and Auwahi Wind (East Maui) and high-technology astronomy installations like the Daniel K. Inouye Memorial Solar Telescope on the summit of Haleakalā developed HCPs that contain provisions designed to promote a net conservation benefit for affected species listed under the Endangered Species Act (ESA) (e.g., ʻuaʻu [*Pterodroma sandwichensis*], ʻaʼo [*Puffinus newelli*], ʻōpeʻapeʻa [*Lasiurus cinereus semotus*], nēnē [*Branta sandvicensis*], and Blackburn's sphinx moth [*Manduca blackburni*]); 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 Piiholo 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.
- Hawaiian petrel monitoring protocol for Hawaiʻi and Maui (2015);
- Management plans for the State Natural Area Reserves (NARs): ʻAhihi-Kīnaʻu NAR (Draft 1992), Kanaio NAR (1993), West Maui NAR (1988), and Hanawī NAR (1989);

- Long-range management plans for Natural Area Partnership Preserves (NAPPs): Kapunakea NAPP (Maui), Waiakamoi NAPP (Maui), Puʻu Kukui NAPP (Maui), Kanepuʻu NAPP (Lānaʻi), Pelekunu NAPP (Molokaʻi), Kamakou NAPP (Molokaʻi), Moʻomomi NAPP (Molokaʻi), and Kaʻu 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* and the *West Maui Mountains Watershed Partnership Management Plan*;
- 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 *Hawaiʻi 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 Hawaiʻi; and
- D.T. Fleming Arboretum at Puʻu 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 www.flemingarboretum.org.

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], Hanā 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 (Hawaiian goose), ʻuaʻu (Hawaiian petrel), endemic land snails 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 wet native forest communities containing recovery habitat for 21 species of rare forest birds.
> ***Current Management***: Major fencing projects across East Maui including the Hāna Forest Reserve and intense ungulate control inside 7,000-acre core management area, invasive weed control, 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.

***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 bats.
> ***Future Needs***: Continue to secure monitoring and management resources for seabirds, bat, 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, Maui parrotbill, ʻākohekohe, and Maui nuku puʻu. Other forest birds, pueo, native invertebrates, rare plants.
> ***Habitats:*** Subalpine communities, montane wet communities, perennial streams.
> ***Current Management***: Control of pig populations, weed-control activities, fencing, resource monitoring, public education and volunteer program, facilitation of Maui Forest Bird Recovery Project activities.

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: 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.

***Kanaio NAR* (876 acres), DOFAW**

Species: ʻŌpeʻapeʻa, pueo, kōlea, nēnē, ʻuaʻu, terrestrial invertebrates including Blackburn's sphinx moth, yellow-faced bees (*Hylaeus* spp.), 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: 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, *Megalagrion* damselflies, and rare achatinellid land snails, 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.

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.

***West Maui NARS* (6,702 acres—Three Distinct Sections), DOFAW**

Species: Forest birds, ʻuaʻu, ʻaʻo, nēnē, migratory birds, terrestrial invertebrates including rare land snails, 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.

***Puʻu Kukui Preserve* (8,661 acres), Maui Land and Pineapple, Inc.**

Species: ʻŌpeʻapeʻa, forest birds, pueo, nēnē, migratory birds, seabirds, terrestrial invertebrates including rare land snails, 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 tree snails.

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 Kihei 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); rangers perform enforcement, 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. Fencing of anchialine pools has been proposed and may be implemented in the future. 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-Mokuleia, Molokini Shoal**

Species: Species associated with shallow and offshore coral reef ecosystems, sandy beach, and rocky habitats. Hawaiian monk seals, hōnu, 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.

***One Fishery Management Area (FMA)*, DAR: Kahului Harbor**

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.

***Three Bottomfish Restricted Fishing Areas (BRFAs)*, DAR**

Species: Seven bottomfish species ("Deep 7").
***Habitats*:** Marine ecosystems.
***Current Management*:** No take of bottomfish in BRFAs.
***Future Needs*:** Evaluate all BRFAs for purpose and management effectiveness and consider whether need for new BRFAs are warranted.

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

***Species*:** Humpback whale and other marine protected species.
Habitats: Marine ecosystems.
***Current Management*:** Strategic management plan exists and has been revised. Humpback whale 91-meter (100-yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the Endangered Species Act and Marine Mammal Protection Act, lead agency for the Main Hawaiian Island component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, organization and management of volunteer whale counts and other community events, other educational activities including research support, and enforcement.
***Future Needs*:** Engage the community in the implementation of ecosystem-based management plan initiatives and increase support for research, education, and enforcement needs.

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.

***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.

***Makamakaole Seabird Mitigation Preserve, West Maui*, SunEdison (Kaheawa Wind Energy Habitat Conservation Plan)**

Species: Seabirds (‘ua‘u [Hawaiian petrel] and ‘a’o [Newell’s shearwater])

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 ‘ua‘u and ‘a’o 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 ‘ōhi‘a 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 Makena 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, Ukumehamehe, North Shore, Cape Hanamanioa, Nuʻu, Pauwalu Point, Keʻanae Peninsula, East Maui stream, loʻi)**

***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*:** Hawaiʻi 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.

Bibliography:

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 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 Hawaiʻi. 2003. Kapunakea Preserve: long range management plan fiscal years 2004-2009. Honolulu, Hawaiʻi: 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 Hawaiʻi. 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 Hawaiʻi Volcanoes National Park. Honolulu: Hawaiʻi 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. 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. 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 an endangered moth, seabirds, and Hawaiian monk seals (*Monachus schauinslandi*).

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 Conservation District under the State Land Use Code.

The island of Kahoʻolawe and the waters 2 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 o 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 (e.g., ʻuaʻu

[*Pterodroma sandwichensis* or Hawaiian petrel], ʻakēʻakē [*Oceanodroma castro* or band-rumped storm petrel]), and migratory birds (e.g., kioea [*Numenius tahitiensis* or 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]), and marine 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 silvestris*), 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) (main bullet), additional island-specific strategies for Kahoʻolawe 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;
    - 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.
- 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.
- 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.
- 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.
- 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.

***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: Hawaiian monk seals, coral reef organisms, pelagic and bottomfishes, green sea turtles.
***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.

Bibliography:

Dames and Moore. July 1997. Kaho‘olawe ocean management plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

Kaho‘olawe 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 Kaho‘olawe. Kaho‘olawe Island Reserve Commission.

PBR Hawai‘i. December 1995. Kaho‘olawe use plan. Available at: http://www.state.hi.us/kirc/plans.html (accessed 9 March 2005).

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).

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. 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. In spite of this, they 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 insects and diseases such as avian pox and malaria. 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.

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, Mauna Loa, 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 (Mauna Kea 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 Hawaiʻi 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. Hawaiʻi has three offshore islets.

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 Mauna Loa and Mauna Kea have permanent frost.

Land and Water Use

Hawaii'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 (620,000 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 Hawaiʻi 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 2014 there were 194,190 residents on the island of Hawaiʻi. 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 Hawaiʻi 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 29,255 (by air alone) with 80 percent of visitors arriving in Kona. Over 1.5 million people visited the Hawaiʻi Volcanoes National Park in 2013. 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 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. Eighty percent of the known worldwide anchialine pools are on Hawaiʻi. 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*) 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 picture-wing fly species (*Drosophila heteroneura, D. ochrobasis*, and *D. mulli*, respectively; total 3,240 hectares or 8,000 acres). Over 90 percent of land designated critical habitat is managed by state or federal agencies.

Appendix A provides information on what wildlife Species of Greatest Conservation Need are present on the island of Hawaiʻi. The island of Hawaiʻi supports a great number of endemic species, including forest birds (palila, ʻakiapōlāʻau (*Hemignathus munroi*), ʻōmaʻo (*Myadestes obscurus* [Hawaiʻi thrush]), and Hawaiʻi ʻākepa (*Loxops coccineus coccineus*)) and terrestrial invertebrates, including several species of land snails, the wekiu bug (*Nysius wekiuicola*), and bees. Because of its size and the loss of habitat on other islands, Hawaiʻi also provides abundant habitat for species such as the ʻio (*Buteo solitarius* [Hawaiian hawk]), ʻiʻiwi (*Vestiaria coccinea*), nēnē (*Branta sandvicensis* [Hawaiian goose]), and anchialine pond fauna. Other federally listed species include the ʻōpeʻapeʻa (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), ʻalae keʻokeʻo (*Fulica alai* [Hawaiian coot]), aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]), and koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), Blackburn's sphinx moth, and sea turtles. For terrestrial invertebrates, in general, Hawaiʻi is characterized by high levels of endemism and diversity within many orders. Hawaiʻi 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.

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 Hawaiʻi 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 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 Mauna Kea;
- Uncontrolled populations of feral sheep-mouflon hybrids (*Ovis aries–Ovis musimon*) at high elevations on Mauna Loa and on Hualālai threaten native vegetation and regeneration, thereby indirectly affecting forest species. They may also be directly affecting nesting resources for ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]) and ʻakēʻakē (*Oceanodroma castro* [band-rumped storm petrel]). Recent fencing and ungulate control conducted by DLNR have reduced this threat on Mauna Kea;
- Recent introduction of axis deer (*Axis axis*) to Hawaiʻi island. Axis deer are a huge threat to Hawaiʻi's agriculture and native forests. The population is believed to be small enough to enable removal of all animals from Hawaiʻi island before they become established.

However, if left unchecked, axis deer can rapidly increase by 20 to 30 percent each year. Eradication will require public support and considerable funds;

- Wide-ranging populations of pigs (*Sus scrofa*), sheep (*Ovis aries*), 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 Hawaiʻi 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 wasps are known to affect invertebrate communities in Hawaiʻi Volcanoes National Park and in palila habitat at Puʻu Lāʻau. 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 Hawaiʻi 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 Hawaiʻi Department of Agriculture to control and monitor efforts on Hawaiʻi island;
- ʻAlalā (*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 need to proceed as scheduled in 2016 to return the species to the wild and avoid overcrowding in the captive facilities;
- Mongoose, feral cats, and feral dogs continue to threaten establishment of new populations of nēnē on Hawaiʻi. Continuing the relocation program of nēnē from Kauaʻi 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 human activity, especially intentional release of alien fish and shrimp into these ponds and human disturbance;
- 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 ʻōhiʻa wilt (*Ceratocystis fimbriata*), a fungal disease, can kill up to 50 percent of ʻōhiʻa in a stand. ʻŌhiʻa wilt is currently found in the Puna distict, but there is fear it will be spread island-wide and to the other islands, putting ecosystems at risk; and
- Overharvesting for marine aquarium trade.

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 the island of Hawaiʻi 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 ʻManagement Needsʼ section;
    - Implement conservation actions identified below in the ʻPotential Areas for Enhanced Conservation Managementʼ 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;
    - 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 non-point source pollution 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, West Nile virus, Argentine fire ant) or present in the Main Hawaiian Islands but not yet established on the island of Hawaiʻi;
    - Increase efforts to prevent establishment of or eradicate priority invasive plants in pristine areas (e.g., miconia), to control spread of 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.
- 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.
- Strengthen existing and create new partnerships and cooperative efforts.
    - 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;
    - Encourage additional landowner participation and involvement in the Kohala Watershed Partnership, Mauna Kea Watershed Alliance, and Three Mountain Alliance watershed partnership;
    - 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 Kulani Correctional Facility 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);

- o
- 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.

- 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 Hawaiʻi, and development of community-based Makai Watch program;
    - Support development of community-based marine managed areas on Hawaiʻi 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 Hawaiʻi;
- Hawaiian petrel monitoring protocol for Hawaiʻi 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): Kahaualeʻa NAR (1992), Kīpāhoehoe NAR (2002), Laupāhoehoe NAR (1989), Manukā NAR (1992), Puʻo o Umi (1989), and Puʻu Makaʻala (2013);
- DOFAW and State Parks jointly developed a management plan for the ahupuaʻa of Puʻu Waʻawaʻa and the makai lands of Puʻu 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 *Mauna Kea Alliance Management Plan* (2010);
- USFWS *Hakalau Forest National Wildlife Refuge Comprehensive Conservation Plan* (2010);
- The Cave Conservancy of Hawaiʻi has developed a management plan for the Kīpuka Kanohina Cave Preserve (2003);
- The Office of Mauna Kea Management produced a natural resources management plan for the University of Hawaiʻi-managed areas on Mauna Kea (2009);
- A summary of research and information on offshore islands management developed by the Oʻahu 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* (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 on the island of Hawaiʻi. The island of Hawaiʻi 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, eight 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.

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 Hawai‘i.

***Mauna Kea 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.

***Mauna Kea 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 Mauna Kea Management ranger staff. Public hunting for ungulate (mouflon sheep) control in surrounding Mauna Kea Forest Reserve.

Future Needs: Complete management plan. Continue collaboration with Office of Mauna Kea 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 Mauna Kea.

***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**

<u>Hakalau Forest NWR (32,733 acres)</u>
Species: 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.

<u>Kona Forest Unit of Hakalau Forest NWR (5,341 acres)</u>
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, Kau, Kapapala, South Kona, and North Kona.

***Kohala Mountains Watershed Partnership* (>30,000 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 (DHHL), Hawaiʻi County Department of Water Supply, TNC)**

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.

***Hawaiʻi Volcanoes National Park* (333,086 acres), NPS**

Species: ʻŌpeʻapeʻa, forest birds, ʻio, nēnē, seabirds (including ʻuaʻu and ʻakēʻakē), 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 ʻuaʻu on Mauna Loa, 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 Hawaiʻi 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.

***Puʻu Makaʻala NAR* (18,730 acres), DOFAW**

Species: Forest birds, ʻalalā, ʻio, 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.
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, ‘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, fencing around rare communities, coqui frog control, monitoring, *Vespula* eradication.
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, ‘io, 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*.

***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*), Hawaiʻi creeper (*Oreomystis mana*), 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]) possible, terrestrial invertebrates including rare snails and insects, rare plants.
Habitats: Montane wet communities.
Current Management: Management plan exists. Fencing, ungulate removal, weed 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, hōnu (*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.

***Pu‘uhonua O Honaunau NHP* (182 acres), NPS**

Species: Migratory birds, hōnu.
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.

***Pu‘ukoholā 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>.

***Five Marine Life Conservation Districts (MLCDs)*, Division of Aquatic Resources (DAR): Kealakekua Bay, Lapakahi, Old Kona Airport, Wailea Bay, Wai‘opae Tidepools**

***Species*:** Species associated with shallow coral reef, sandy beach, and rocky habitats, Hawaiian monk seals (*Monachus schauinslandi*), hōnu, 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.

***Seven Fishery Management Areas (FMAs),* DAR: Hilo Harbor, Kailua Bay, Kawaihae Harbor, Keauhou Bay, Kīholo Bay, Kona Coast, Puako Bay and Reef**

*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 purpose and management effectiveness and consider need for new marine managed areas.

***Three Bottomfish Restricted Fishing Areas (BRFAs),* DAR**

*Species***:** Seven bottomfish species ("Deep 7" bottomfish).

Habitats: Marine ecosystems.

*Current Management***:** No take of bottomfish.

*Future Needs***:** Evaluate all BRFAs for purpose and management effectiveness and consider need for new or revised marine managed areas.

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

*Species***:** Humpback whale (*Megaptera novaeangliae*).

Habitats: Marine ecosystems.

*Current Management***:** Management Plan exists. Humpback whale 91 meter (100 yard) approach rule and other regulations protecting humpback whales and their habitat, increased fines for violating provisions of the Endangered Species Act, lead agency for the Main Hawaiian Island component of the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) project to determine population size, volunteer whale counts and other community events, and other educational activities, research support, and enforcement.

*Future needs***:** Review other marine species, including seabirds, and habitats for inclusion in Sanctuary and increase 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 Kauaʻi adjacent to the airport and relocated to a 44-acre predator-proof pen in the Saddle Road Puʻu Oʻo area of Hawaiʻi. 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 Kauaʻi 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 Kauaʻi. One pair from the Big Island relocated to Kauaʻi.

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 Hawaiʻi. 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.

Waipiʻo and Waimanu Valley, Kīholo Springs Pond and Marsh, Opaeʻula Pond, Kealakekua Bay Pond, Lokoaka Pond, Waiākea Pond, and Keʻanae Pond
Species: Aeʻo, ʻalae keʻokeʻo, 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*. Waipiʻo and Waimanu have extensive wetlands and taro loʻi, 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 aeʻo and ʻalae keʻokeʻo 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, aeʻo, migratory shorebirds.

Basis for Priority Designation: There are only about 700 anchialine pools worldwide, 80 percent of which are on Hawaiʻi. 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, Pahaoehoe, Kapue, Kolekole, Kilau, Haakoa, Kaiwilahilahi, and Pahale, and additional protection below Kohala watershed and others

Species: ʻOʻopu (*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.

Bibliography:

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 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 Hawai‘i. 2003. Kipuka Kanohina Cave Preserve management plan. Cave Conservancy of Hawai‘i.

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, Hawaii. Technical Report #69. Cooperative National Park Resources Studies Unit. National Park Service Contract No. CA 8015-2-0001. 37 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, 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.

Giffin, J. Department of Land and Natural Resources, Division of Forestry and Wildlife. Personal communication.

Giffin J. 2003. Pu‘u Wa‘awa‘a biological assessment. State of Hawai‘i 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 Hawaiʻi with comments on additional land snail species. Honolulu: Department of Zoology, University of Hawaiʻi.

Hart, PJ. USGS. Personal communication.

Hawaiʻi Audubon Society. 1993. Hawaii's birds. Honolulu: Hawaiʻi Audubon Society.

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

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

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

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

Hawaiʻi Department of Land and Natural Resources. 2014. Division of Forestry and Wildlife Snail Extinction Prevention Program Strategic Plan: 2015 – 2019. Honolulu.

Hawaiʻi Department of Land and Natural Resources. 2013. Division of Forestry and Wildlife Snail Extinction Puu Makaʻala Natural Area Reserve (NAR) Management Plan. Honolulu.

Henry AR. 2005. Pacific coast joint venture Hawaiʻi: strategic plan for wetland conservation in Hawaiʻi 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 Hawaiʻi Third Edition. Honolulu: University of Hawaiʻi 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.

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. Hawaiʻi Forest and Trail. Personal communication.

Pacheco R. Hawaiʻi Forest and Trail. Personal communication.

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.

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.

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.

Warshauer R. USGS. Personal communication.

Wood KR, Polhemus J. Unpublished data.

NORTHWESTERN HAWAIIAN ISLANDS

The Northwestern Hawaiian Islands (NWHI) extend approximately 1,600 kilometers (1,000 miles) from Niʻihau and Kauaʻi to Kure Atoll in the north. They consist of ten main atoll systems, each of which has one or more islands. The total number of islands varies as storms and climate change affect the presence of some small, sandy islands. 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 habitats and lower 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. 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. Laysan has a large euryhaline lake that helps support the endemic and endangered Laysan ducks (*Anas laysanensis*) as well as some unique aquatic fauna. Laysan 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 species of seabirds 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. French Frigate Shoals serves as the most important nesting grounds for the hōnu, or green sea turtle (*Chelonia mydas*), in the state, and all of the islands and atolls of the NWHI provide essential breeding and pupping habitat for ʻīlio-holo-i-ka-uaua, or Hawaiian monk seal (*Monachus schauinslandi*); both of these species are protected by the ESA.

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 humans 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 resources in the form of Native Hawaiian archaeological sites and historical ship and airplane wrecks occur 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 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 Midway Atoll. Because of the age of the islands, they have undergone extensive erosion and subsidence of their basaltic rock foundations. Only Mokumanamana Island (Necker), Nihoa, La Perouse Pinnacle, and 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 more 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 and federal jurisdiction. Papahānaumokuākea Marine National Monument (PMNM) encompasses approximately 140,000 square miles from Nihoa to Kure Atoll and 50 miles out from shore. Within the boundary of PMNM are several other entities, including the NWHI Coral Reef Ecosystem Reserve under National Oceanic and Atmospheric Administration (NOAA) management, the Hawaiian Islands National Wildlife Refuge (HINWR), and Midway Atoll National Wildlife Refuge (Midway Atoll). Both NWRs are managed by the U.S. Fish and Wildlife Service (USFWS). The Kure Atoll Field Station is managed by the Hawaiʻi Department of Land and Natural Resources (DLNR) as a seabird sanctuary and

resource management area. All the islands are part of the County of Honolulu with the exception of Midway Atoll, which is technically under U.S. government jurisdiction.

Overlapping jurisdictions and shared stewardship responsibilities among state and federal agencies have resulted in multi-agency co-management of the NWHI. For example, waters from the shore out to ten fathoms (18.3 meters) deep around most of the islands and to 20 fathoms deep off Mokumanamana Island are co-managed by DLNR, NOAA, and USFWS. Federal waters from 5 kilometers (3 miles) offshore to 80 kilometers (50 miles) offshore are part of the NWHI Coral Reef Ecosystem Reserve, under NOAA, and the PMNM, which is co-managed by DLNR, NOAA, and USFWS in close coordination with the Office of Hawaiian Affairs (OHA).

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 Hawaiʻi (i.e., not including 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 HINWR staff at Midway Atoll, Laysan, and Tern Island at French Frigate Shoals. The U.S. Coast Guard (USCG) operated active long-range navigation (LORAN) installations at Tern Island (French Frigate Shoals) and Green Island (Kure Atoll) until 1979 and 1992, respectively. Midway Atoll was occupied by the U.S. Navy until 1996, when management authority was transferred to USFWS. Archaeological sites point to prehistorical occupation of Mokumanamana Island and Nihoa. Numerous incidents of feather poaching, unregulated harvest and marketing of wildlife resources, and guano mining took place from 1850 to1909, 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 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 and 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.

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, Kure is a typical atoll comprising 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. Kure 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 National Marine Fisheries Service (NMFS) and State of Hawaiʻi summer field camps, and since 2010 DLNR has maintained a full-time presence at the field station. Kure Atoll is managed as a State Seabird Sanctuary. Conservation initiatives at Kure Atoll 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 hapuʻupuʻu (*Epinephelus quernus*) appear more abundant in shallow water at Kure Atoll 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.

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. Midway was discovered in 1859 and claimed by the United States. 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 in 1902 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), and the construction of an airport in 1935 by Pan American Airways. Midway 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. Midway is now managed by USFWS as the Midway Atoll NWR and is not technically part of the State of Hawaiʻi. The world's largest breeding colony of mōlī) nests here, as does the second largest colony of kaʻupu). The NWR also contains important habitat for the Hawaiian monk seal, the hōnu, 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).

Pearl and Hermes Reef, 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. The reef was unknown prior to 1822 when 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, hōnu, and Hawaiian monk seal nesting and pupping occur here. About 160,000 seabirds from 17 species nest at Pearl and Hermes Reef, including about 20 percent of the world population of ka‘upu. 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 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. 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.

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 area varying in depth to 18 meters (60 feet). It has about 125,400 hectares (310,000 acres) of reef habitat. The island was discovered in 1805 by Captain Urey Lisianski, a Russian explorer. During the same period, Lisianski Island was visited by expeditions harvesting fish, turtles, guano, bêche-de-mer (sea cucumbers), and sharks, as well as Hawaiian monk seals. More concentrated exploitation of the island took place from 1904 to 1910 by Japanese feather poachers, but this activity was apparently halted by 1911 through more aggressive enforcement. 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. Lisianski Island is an important breeding and pupping island for Hawaiian monk seals and provides significant nesting habitat for seabirds, including the largest Bonin petrel colony in the world.

Laysan, 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 Laysan Hawaiian monk seal population, nearly eliminating it. These activities were followed in 1909 to 1910 by intensive harvesting of bird skins and feathers by the Japanese, who carried out an additional poaching raid in 1915. Since that time, visits to Laysan 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 Laysan (though a group of Laysan ducks was successfully introduced outside its native range to Midway Atoll, and Laysan finches were introduced to Pearl and Hermes Atoll). About 2 million individuals from 17 seabird species nest on the island. Laysan has the state’s largest nesting colonies of mōlī and ka‘upu. Laysan also has the largest colonies of ‘ua‘u kani and Christmas shearwaters and a significant colony of koa‘e ‘ula. 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. Laysan is the northernmost area where *Acropora* corals occur in the NWHI.

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 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. Hawaiian monk seals and hōnu 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.

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. The atoll was discovered by the French in 1786 and claimed by the United States in 1859. 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. 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 Hawaiʻi 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. Plans are underway to rebuild the field station. French Frigate Shoals has the largest breeding populations of Hawaiian monk seals and hōnu 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. Reconstruction of the seawall supporting the runway foundation along the northern margin of the island is a priority ongoing project because the dilapidated wall can trap and harm seals and other wildlife. This is the only location in the NWHI where all 18 species of seabirds known to nest in the NWHI occur.

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. The two volcanic rocks serve as roosting and breeding sites for smaller populations of 12 species of seabirds, including blue-gray noddies. A few Hawaiian monk seals 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.

Mokumanamana Island (Necker), 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 a French navigator, La Perouse, in 1786, but prehistoric habitation of the island was noted about 1879 by one of the early landing parties. Ships periodically visited the island during the mid- and late-1800s, but heavy seas often thwarted landings. During the period of feather poaching by the Japanese early in the 20th century, patrol vessels visited Mokumanamana Island, 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 Hawaiian monk seals 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. Nihoa was discovered by Europeans in 1779, though, like Mokumanamana Island, there is some evidence of prehistoric human occupation. 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. During the 1960s, military personnel occupied Nihoa briefly. This island is rarely visited and 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 now roughly 160 individuals. The island supports the largest known colony of ʻou in the world. It also supports the largest colonies of ʻiwa, brown boobies (or ʻā), red-footed boobies (or ʻā), black noddies (or noio), blue-gray noddies, brown boobies (or noio-kōhā) and white terns (or manu-o-kū). 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. Hōnu and Hawaiian monk seals have their largest reproductive groups at French Frigate Shoals. Data on Hawaiian monk seals and hōnu 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 Hawaiian monk seals, 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;

- Introduced species on land or in water (historically, rabbits on Laysan and rats on Kure; currently, *Schistocerca* grasshoppers on Nihoa, 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 hōnu and Hawaiian monk seal;
    - 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 French Frigate Shoals.
- 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.
- 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; and
    - Better understand the population dynamics and important ecological factors explaining declines in Hawaiian monk seals, especially at French

    - Frigate Shoals. 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.

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, federal wildlife refuge, 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, areas, and 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 Coral Reef Ecosystem Reserve 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, 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, Hawaiian monk seals, 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, Hawaiian monk seals, hōnu, 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 hōnu and Hawaiian monk seals and leads a multi-partner effort to remove marine debris from beaches and reefs of the NWHI, collaborate with marine researchers, and conduct 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, Hawaiʻi,* Agency Co-Trustees: DLNR, NOAA, USFWS**

Species: Hawaiian monk seals, hōnu, 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: Hawaiian monk seals, hōnu, 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.

Bibliography:

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.

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.

Rauzon M. 2001. Isles of refuge: wildlife and history of the Northwestern Hawaiian Islands. Honolulu: University of Hawai’i Press.

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, 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

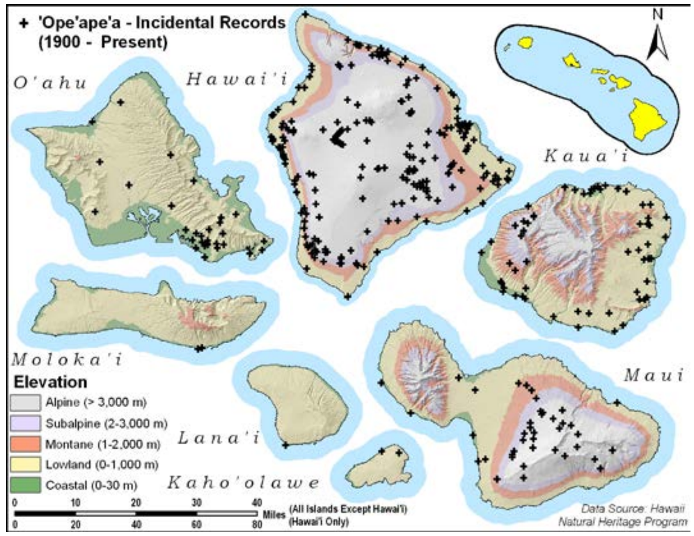
Lasiurus cinereus semotus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Indigenous (at the Species Level and Endemic at the Subspecies Level)
NatureServe Heritage Rank G5/T2 – Species Secure/Subspecies Imperiled
Recovery Plan for the Hawaiian Hoary Bat – USFWS 1998

SPECIES INFORMATION: The ʻōpeʻapeʻa, or Hawaiian hoary bat (Family: Vespertilionidae), is Hawaiʻi's only native terrestrial mammal, although sub-fossil evidence indicates that at least one other bat species was native to the islands. Additionally, the hoary bat has dispersed to the Hawaiian Islands from the mainland at least twice, forming two different populations of Hawaiian hoary bats (Russell et al. 2015). The first emigrant arrived approximately ten thousand years ago, and the more recent emigrant arrived an estimated 600 years ago (Russell et al. 2015). 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.

Little research has been done on the ʻōpeʻapeʻa, and little is known about its habitat requirements or population status. Fewer than 30 accounts of roosting are known statewide, but these indicate that ʻōpeʻapeʻa roost in native and non-native vegetation from 1 to 9 meters (3 – 29 feet) above ground level; the species is rarely observed using lava tubes, 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; altitude also may affect activity patterns. ʻŌpeʻapeʻa 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. Water courses and edges (e.g., coastlines and forest/pasture boundaries) appear to be important foraging areas; the species also is attracted to insects that congregate near lights. Breeding bats (e.g., lactating females) have been documented only on the islands of Hawaiʻi, Kauaʻi, and Oʻahu (Dave Johnston pers. obs.). Mating most likely occurs between September and December, and females usually give birth to twins during June. Mother bats likely stay with their pups until they are six to seven weeks old. Little is known regarding dispersal or movements, but inter-island dispersal is possible.

DISTRIBUTION: The hoary bat is the most widely distributed bat in North America. In Hawaiʻi, 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.



ABUNDANCE: Mostly unknown, although Pinzari et al. 2014 suggested that the population on the island of Hawaiʻi has been stable or is slightly increasing based on occupancy models from acoustic monitoring. Survey methods to count or estimate populations of solitary roosting bats have not been established. Although based on incomplete data, Kauaʻi and the island of Hawaiʻi may support the largest populations.

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. Recent work 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.

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 sometimes collide with wind turbines. Lastly, bats of many species are affected by predation, so this may also be a problem for ʻōpeʻapeʻa.

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 bat populations.
- Support Hawaiian hoary bat research.

MONITORING: Continue surveys of population 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.
- Conduct occupancy surveys of all the Main Hawaiian Islands to examine distribution and population trends.
- Identify key breeding 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:

Frank J. Bonaccorso, FJ, CM Todd, AC Miles, and PM Gorresen. 2015. Foraging range movements of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus* (Chiroptera: Vespertilionidae). Journal of Mammalogy 96(1):64-71. 2015

Hawaiian Hoary Bat Research Cooperative. Available at: http://www.dofaw.net/fbrp/projects.php?id=39.Hawaiʻi Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawaiʻi, 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 51:1-19Russell 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.0127912U.S. Fish and Wildlife Service. 1998. Recovery plan for the Hawaiian hoary bat. Portland, (OR): U.S. Fish and Wildlife Service. 50 pp.

Photo: Mark Collins

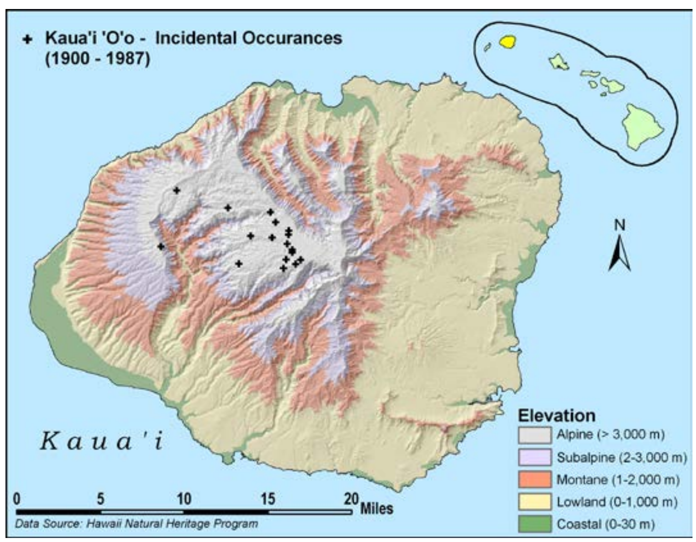
Forest Birds

Kauaʻi ʻō ʻō

Moho braccatus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
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, and 2000 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.
- Hunting. Although other ʻōʻō species were historically exploited by Native Hawaiians for their feathers, the role this activity played in the decline of the Kauaʻi ʻōʻō is equivocal, but likely minimal given the species' plumage.

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.

Bibliography

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.

Picture: Rothschild Collection

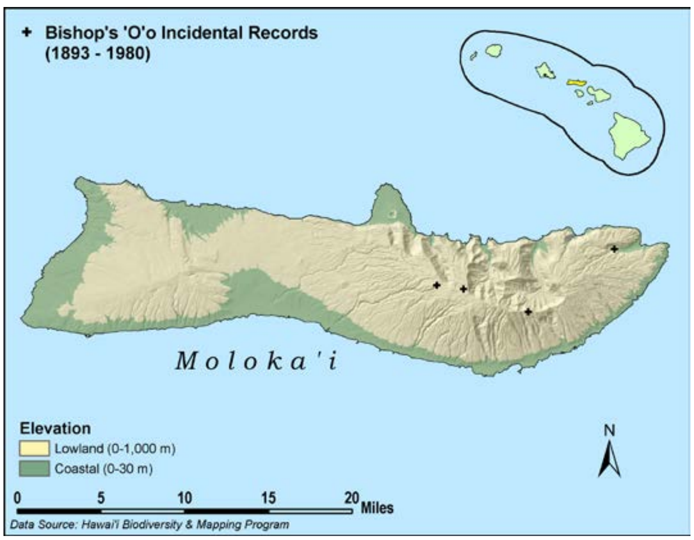
Forest Birds

Bishop's ʻō ʻō

Moho bishopi

SPECIES STATUS:
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: 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. For Bishop's ʻōʻō populations, the following likely were of particular concern:

- Disease. 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.

- Hunting. Bishop's ʻōʻō were exploited for their feathers, which were used in Hawaiian featherwork articles such as capes and *kāhili* (feather standard). Exploitation may have increased with the introduction of firearms by Europeans.

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, 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 ʻōʻō.

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.

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.

Photo: DOFAW

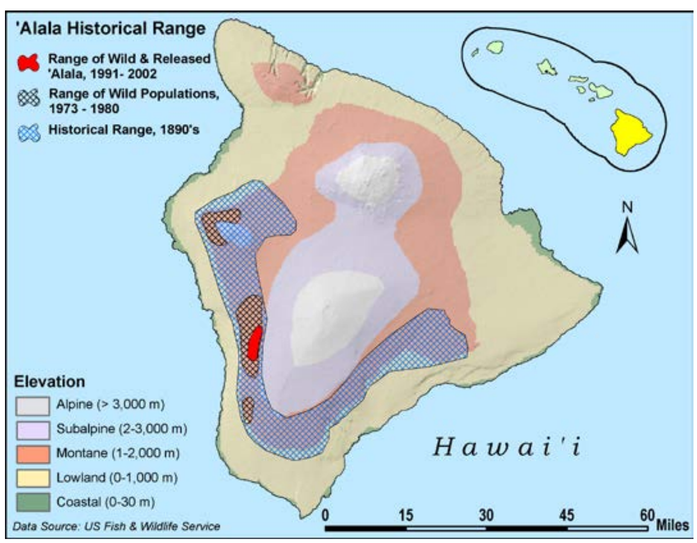
Forest Birds

ʻAlalā or Hawaiian crow

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 flocks 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 Hawaiʻi.

ABUNDANCE: World population of 114 individuals in 2014, housed entirely in the Keauhou and Maui Bird Conservation Centers.

LOCATION AND CONDITION OF KEY HABITAT: Historically, ʻalalā occupied dry and seasonally wet ʻōhiʻa and ʻōhiʻa/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 Hawaiʻi and the U.S. Fish and Wildlife Service.

THREATS: ʻAlalā 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 ʻalalā populations, the following are of particular concern:

- Predation. The small Indian mongoose, rats, and feral cats prey on ʻalalā. The ʻio (*Buteo solitarius*) and presumably pueo (*Asio flammeus sandwichensis*) also prey on juvenile and adults. ʻIo 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 ʻalalā 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 mosquito-borne diseases. Seasonal movement may have increased exposure to diseases. In addition, ʻalalā are susceptible to toxoplasmosis carried by feral cats.
- Habitat degradation. Habitat conversion by human activity as well as by grazing ungulates has severely degraded former ʻalalā habitat. These changes may have limited food or nesting resources and may have increased the vulnerability of ʻalalā to predation by ʻio. 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 ʻalalā has been legally protected by the State of Hawaiʻi 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 ʻAlalā Recovery Team was formed to facilitate the species recovery, and a related second group, the ʻAlalā 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. To date, legal and operational constraints have impeded this effort. Restoration of future re-introduction sites is ongoing and re-introductions are expected to occur in the near future. 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.
- Maintain and increase the captive flock without further loss of genetic diversity.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING: The captive flock is monitored. If and when re-introduction occurs, wild populations will be intensively monitored.

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 that must be met prior to release of birds at a 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.

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: DOFAW

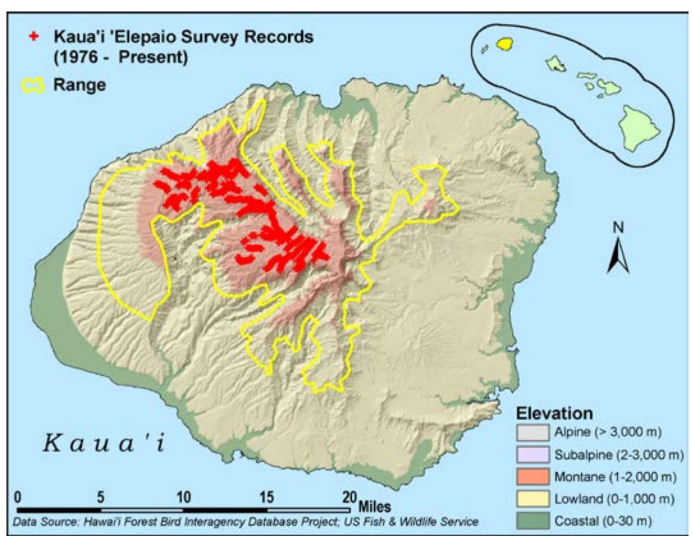
Forest Birds

Kauaʻi ʻelepaio

Chasiempis sclateri

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G2—Imperiled
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The Kauaʻi ʻelepaio is a small, adaptable monarch flycatcher (Family: Monarchiade) endemic to the island of Kauaʻi. ʻElepaio also occur on the islands of Hawaiʻi (*C. sandwichensis*) and Oʻahu (*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. Little detailed life history information is available from Kauaʻi. On Hawaiʻi and Oʻahu, they 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, ʻelepaio 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 Kauaʻi, there is no information on plant species used, although ʻōhiʻa (*Metrodiseros polymorpha*) is likely. On the island of Hawaiʻi, 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 Alakaʻi Plateau. Original range likely included all forested regions of Kauaʻi.

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. Densities peak in ʻōhiʻa forest between 1,300 and 1,500 meters (4,500 - 5,000 feet).

LOCATION AND CONDITION OF KEY HABITAT: Most common in dense wet ʻōhiʻa 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. ʻElepaio 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 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 Kauaʻi ʻelepaio, 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 O'ahu, predation by black rats have been implicated in the loss of nests and death of adult females. Rat control in these populations resulted in large increases in nest success and in the survival of adult females. Other predators, including cats, pueo, and barn owls, occur throughout the forests of Kauaʻi.

CONSERVATION ACTIONS: Kauaʻi ʻelepaio 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, 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 ʻelepaio 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.
- 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.

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. 428 pp.

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.

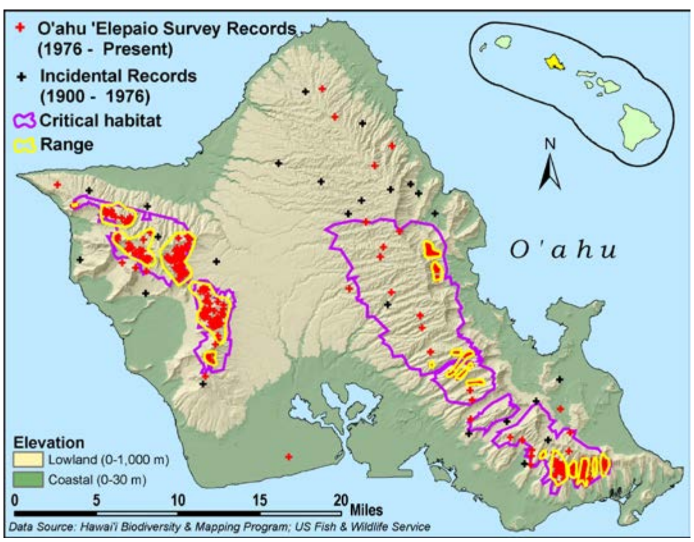
Photo: DOFAW

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 were 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:

- <u>Predation</u>. 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.
- <u>Low reproductive potential</u>. The species' low annual productivity, even in quality habitat, makes it very susceptible to factors that reduce population size.
- <u>Disease</u>. 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*).
- <u>Population size</u>. 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.
- <u>Fire</u>. 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 Hawaiʻi, 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 Oʻahu

ʻelepaio also benefits from management activities designed to conserve other endangered forest birds including the establishment of the Oʻahu Forest National Wildlife Refuge in the Koʻolau 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 Oʻahu ʻelepaio should include the following:

- Continue and expand rat control.
- Protect remaining forests on Oʻahu, 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.

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 Oʻahu ʻelepaio 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., Hawaiʻi ʻelepaio (*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. 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.

VanderWerf EA, Rohrer JL, Smith DG, Burt MD. 2001. Current distribution and abundance of the Oʻahu ʻelepaio. Wilson Bulletin 113:10-16.

VanderWerf EA, Lohr MT, Titmus AJ, Taylor PE, Burt MD. 2013. Current distribution and abundance of the Oʻahu 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: Mark Collins

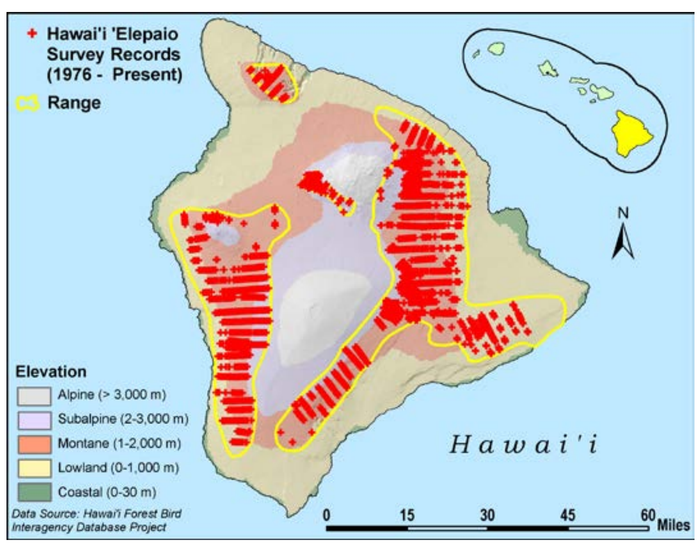
Forest Birds

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. Some scientists recognize three subspecies on the island of Hawai‘i (*C.s. sandwichensis, C. s. ridgewayi,* and *C. s. bryani*). Adults are dark brown above and white below with variable amounts of brown streaking; 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 statewide population of all subspecies at more than 270,000 birds. The island of Hawai‘i contains three populations (150,000 birds) of *C. s. ridgwayi*, plus one population each of *C. s. sandwichensis* (63,000) and *C. s. bryani* (2,500).

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.

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.

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.

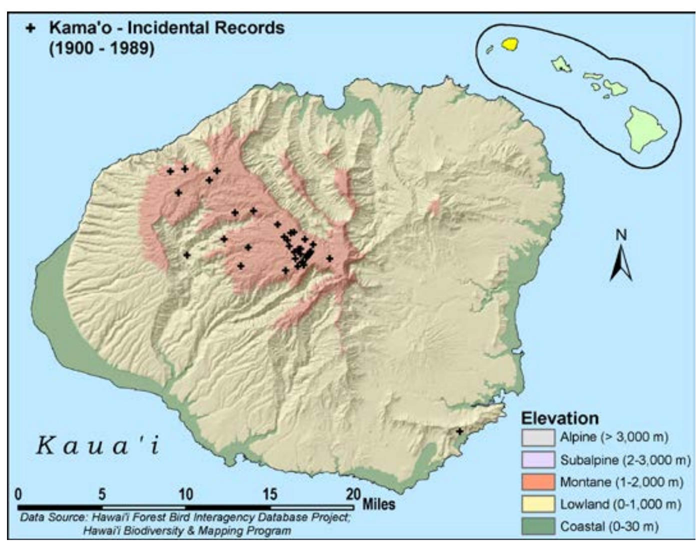
Rothschild Collection

Kāmaʻo or large Kauaʻi thrush

Myadestes myadestinus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank GH – Possibly Extinct
IUCN Red List Ranking — Extinct
Revised Recovery 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, 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 is often heard before dawn and after dusk. The diet is reported to consist of fruits and berries, particularly the bracts of ʻieʻie (*Freycinetia arborea*). 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. If the species persists, it is 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 Kauaʻi Forest Bird Survey. 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.

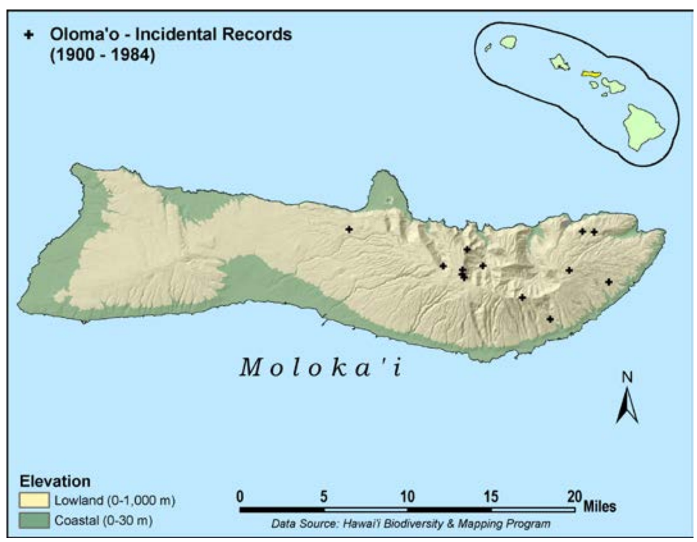
Picture: Rothschild Collection

Olomaʻo

Myadestes lanaiensis rutha

SPECIES STATUS:
Federally Listed as Endangered
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 olomaʻo is one of five species of Hawaiian solitaires (family: Turdidae). All adult Hawaiian solitaires have olive-brown and gray plumage. Olomaʻo 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. Olomaʻo 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 ʻōmaʻo (*M. obscurus*).



DISTRIBUTION: Unknown. Probably extinct. The historic range included the native forests of eastern Molokaʻi and Lānaʻi. Historically the species also may have occurred on Maui, where subfossils of Hawaiian solitaires are abundant.

ABUNDANCE: Probably extinct. Since 1907, olomaʻo 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, olomaʻo were not detected during surveys in the late 1980s and 1990s. 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).

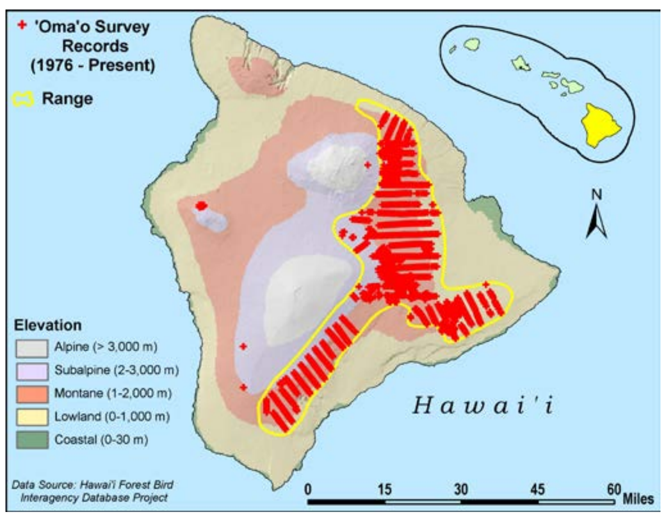
Forest Birds

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 3,000 meters (6,500 – 9,750 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:

- <u>Disease</u>. 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.
- <u>Predation.</u> Nests are very accessible and vulnerable to predation by rats (*Rattus* spp.). Predation by native raptors also is likely.
- <u>Habitat degradation</u>. 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.

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. 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.

THREATS: Unknown. However, olomaʻo 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 olomaʻo, 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.

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 olomaʻo.

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. 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.

Photo: Jim Denny

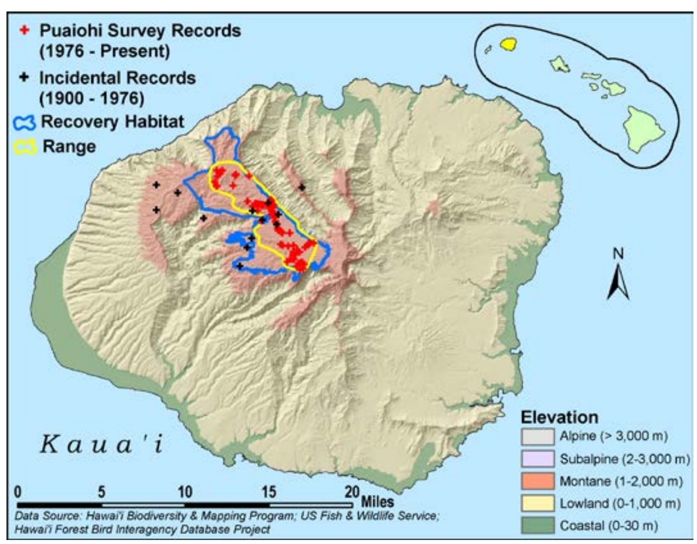
Puaiohi or Small Kauaʻi thrush

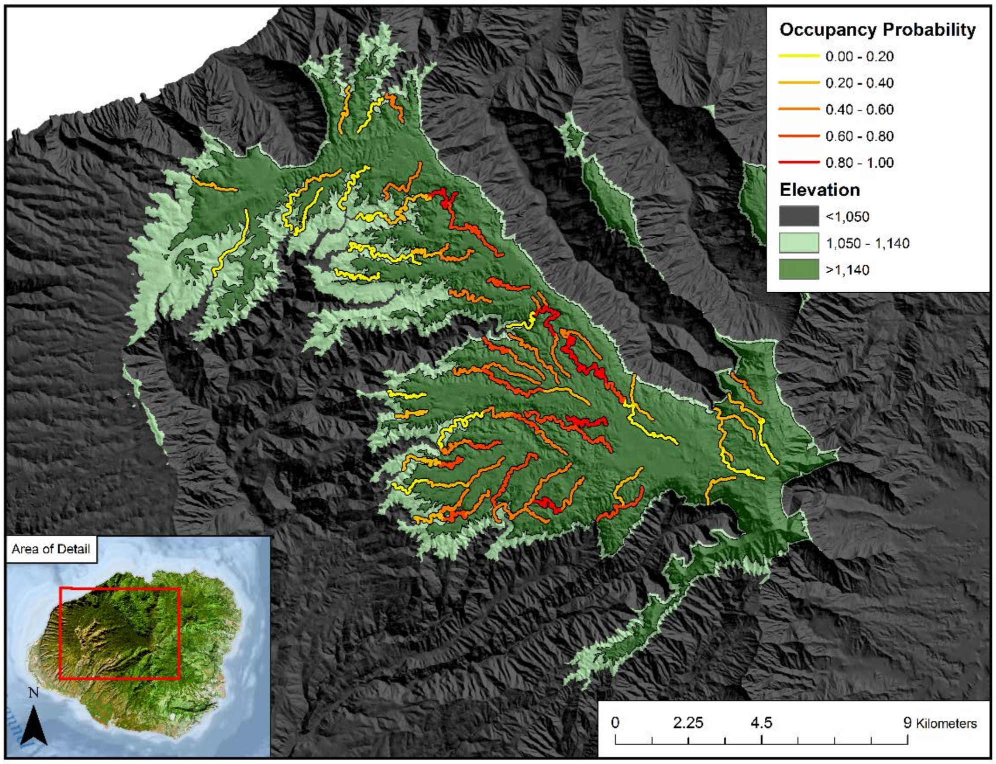
Myadestes palmeri

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 Kauaʻi thrush, is the smaller of two solitaires (family: Turdidae) endemic to Kauaʻi, 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 kāmaʻo, or large Kauaʻi 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 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 Alakaʻi 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.





All known streams above 1,050 meters on the Alakai Plateau, Kaua'i, 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 487 (95% confidence interval: 405-579) individuals. Occupancy during these surveys ranged from 0.12 to 0.81 on 12 streams across the range. 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 Hawaiʻi. However, models predict that low numbers of puaiohi occur on private lands adjacent to these areas.

THREATS:

- Disease. In 1995-1997, seven puaiohi were tested for disease; none carried malarial (*Plasmodium relictum*) antibodies. Since 2007, 15/66 puaiohi have tested positive for malarial antibodies. 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 three other instances of predation on adults at the nest, and the lower survival of females (0.46 $\pm$ 0.12) compared to males (0.71 $\pm$ 0.09) is indicative of predation on females at the nest. 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.

- Competition. Several non-native birds, including the introduced Japanese 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 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 Kauaʻi. 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 has been placed on hold.

In addition, puaiohi likely have benefited from management activities to conserve other endangered forest birds including 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. 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.
- 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.
- Eradicate rats and feral cats from the Alakaʻi Wilderness Preserve.

- 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.

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 do control mosquito populations. Research priorities specific to the puaiohi include the following:

- 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.

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.

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.

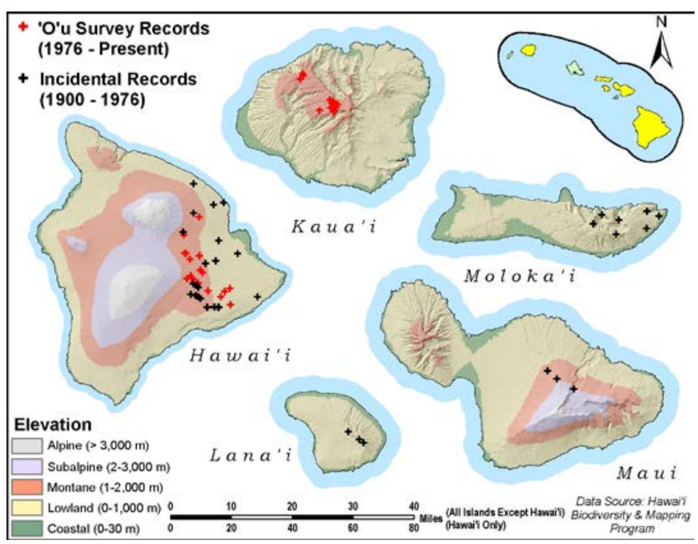
Photo: Bishop Museum

ʻŌʻū

Psittirostra psittacea

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 (Possibly Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ʻōʻū 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 ʻōʻū had a strong musky odor, which is retained in museum specimens. Like several of Hawaii's nectivorous birds, ʻōʻū are strong fliers and ranged widely in search of fruit. ʻIeʻie (*Freycinetia arborea*) inflorescences apparently are an important part of the species' diet, although ʻōʻū 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 Kauaʻi and Hawaiʻi. Historically widespread, ʻōʻū 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 Kauaʻi and Hawaiʻi.

ABUNDANCE: Possibly extinct. The Hawaiian Forest Bird Surveys (1976-1981) estimated the population at 400 ± 300 (95% confidence interval) birds on the island of Hawaiʻi and nine or fewer individuals on Kauaʻi. ʻŌʻū 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 Kauaʻi.

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 ʻOʻu (*Psittirostra psittacea*) and Lanaʻi 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.

Photo: DOFAW

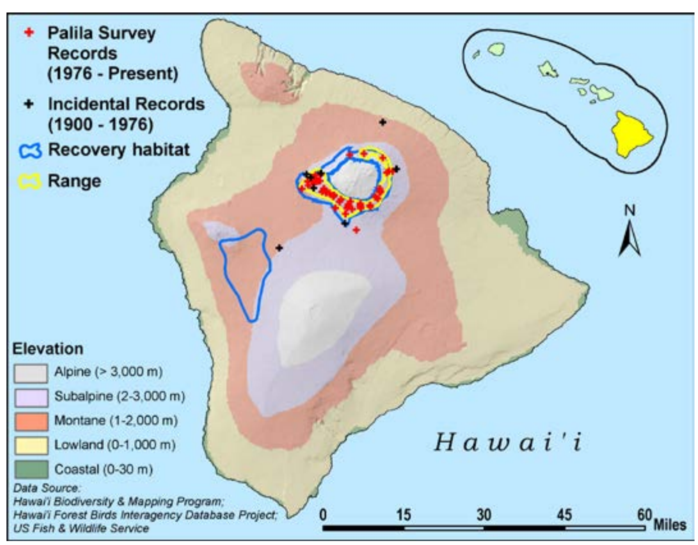
Forest Birds

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 Hawaiʻi. Subfossil evidence indicates palila also occurred in māmane forest on Oʻahu and Kauaʻi.

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. 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 Hawaiʻi.

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. 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 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 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.
- 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.

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.

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: Robby Kohley

Forest Birds

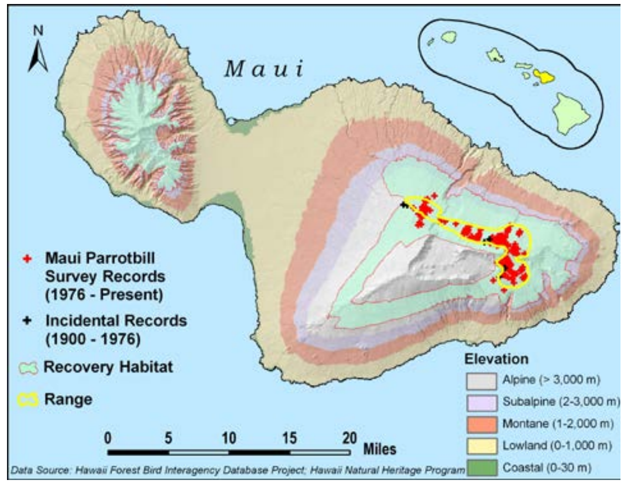
Kiwikiu or Maui parrotbill

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 stocky, bull-headed 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 are variable. Males are larger than females with a larger bill. They feed on a variety of shrubs and small trees, especially ʻakala (*Rubus hawaiensis*), kanawao (*Broussaisia arguta*), ʻōhiʻa (*Metrosideros polymorpha*), and koa (*Acacia koa*) where it gleans prey from moss-covered branches or uses its bill to chisel, crack, crush, dig, and tear bark and softer wood in search of beetle and Lepidoptera larvae and pupae. Also opens fruit in search of insects. Pairs defend relatively large (6-8 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 fledglings. They will renest after a nest failure, but are not known to attempt another nest 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.

DISTRIBUTION: Restricted to a ~50 square kilometer (19 square mile) on the northeastern slopes of Haleakalā between 1,230 and 2,370 meters (4,000 – 7,700 feet). Subfossils indicate they once occurred island-wide including at low elevations and leeward (southeastern) forests and on the island of Molokaʻi.



ABUNDANCE: The Hawaiian Forest Bird Survey (1980) estimated the population at 502 ± 116 (95% confidence interval) birds. More recent surveys reported densities similar to those from the 1980 survey.

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), and 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 1,350 meters (4,500 feet), kiwikiu are not found in these areas, suggesting that disease may be restricting populations to higher elevations.
- 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 kiw The rare Maui Parrotbill— Photo by Eric Nishibayashi
- Habitat loss. Historical accounts suggest that kiwikiu f and ranching has 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. 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 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: In 1997, a captive breeding program was initiated. As of 2015, 14 kiwikiu are in captivity at the Maui Bird Conservation Center. The kiwikiu also 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:

- 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.
- 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.
- Conduct public outreach and education about the importance of invasive species control and forest restoration.
- 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, 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.
- Investigate habitat use in forests that kiwikiu do not currently inhabit to design and implement large-scale restoration.

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).

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 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.

U.S. Fish and Wildlife Service. 2006. Revised Recovery plan for Hawaiian forest birds. Portland, (OR): U.S. Fish and Wildlife Service.


Photo: Chris Eckart

Hawaiʻi ʻamakihi

Hemignathus virens

SPECIES STATUS:
State Listed Endangered on Lānaʻi
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable

SPECIES INFORMATION: The Hawaiʻi ʻamakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae). Until 1995, the Hawaiʻi ʻamakihi, and the Oʻahu (*H. flavus*) and Kauaʻi ʻamakihi (*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 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 Hawaiʻi ʻamakihi is brighter and smaller than the Kauaʻi ʻamakihi. Hawaiʻi ʻamakihi 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 ʻōhiʻa (*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 Hawaiʻi ʻamakihi usually raise two broods in a season.

DISTRIBUTION: Occurs between 300 and 2,900 meters (1,000 – 9,500 feet) on Hawaiʻi, Maui and Molokaʻi; not common below 500 meters (1,625 feet). Widely distributed on Hawaiʻi and Maui. Original range likely included all forested regions of the above islands as well as those on Lānaʻi, 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 Hawaiʻi, 44,000 ± 1,786 birds on east Maui, 3,000 ± 408 on west Maui, and 1,800 ± 357 birds on Molokaʻi. Populations on Hawaiʻi and Maui are probably stable; the Molokaʻi population is probably declining.

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. 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 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.

CONSERVATION ACTIONS: Hawaiʻi ʻamakihi likely have benefited from management actions to conserve other endangered forest birds in the 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:

- 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.

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 Hawaiʻi ʻamakihi populations.
- Conduct translocation experiments using Hawaiʻi ʻamakihi to help reestablish this and other Hawaiian honeycreeper populations.

References:

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.

Photo: Eric VanderWerf

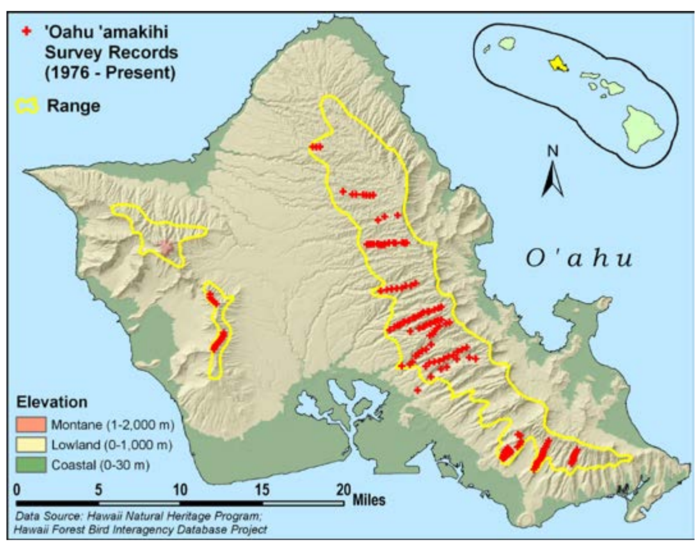
O'ahu 'amakihi

Hemignathus flavus

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The O'ahu 'amakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of O'ahu. Until 1995, the O'ahu 'amakihi, and the Hawai'i (*H. virens*) 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 similar, but duller. All have decurved bills. The plumage of some male O'ahu amakihi is variable in having yellow above eyes and more yellow breasts, and compared to the other species, female O'ahu 'amakihi have two dull wing bars. The O'ahu 'amakihi is brighter and smaller than the Kaua'i 'amakihi. O'ahu 'amakihi 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 Hawai'i 'amakihi.

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 O'ahu.



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.

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 Oʻahu ʻamakihi extends to low-elevation forest dominated by non-native plant species. Among introduced forests, ʻamakihi 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 Hawaiʻi.

THREATS: Although Oʻahu ʻamakihi 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 Oʻahu ʻamakihi, the following is of particular concern:

- <u>Fire</u>. Non-native plants and military training activities often result in wildfires that threaten Oʻahu ʻamakihi habitat on military lands.

CONSERVATION ACTIONS: Oʻahu ʻamakihi likely have benefited from management activities to conserve other endangered forest birds including the establishment of the Oʻahu Forest National Wildlife Refuge in the Koʻolau mountains, rat control directed at protecting nesting Oʻahu ʻelepaio (*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 Oʻahu ʻamakihi 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 Oʻahu 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 Oʻahu ʻamakihi 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 Oʻahu ʻamakihi 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.

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. 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.


Photo: Jim Denny

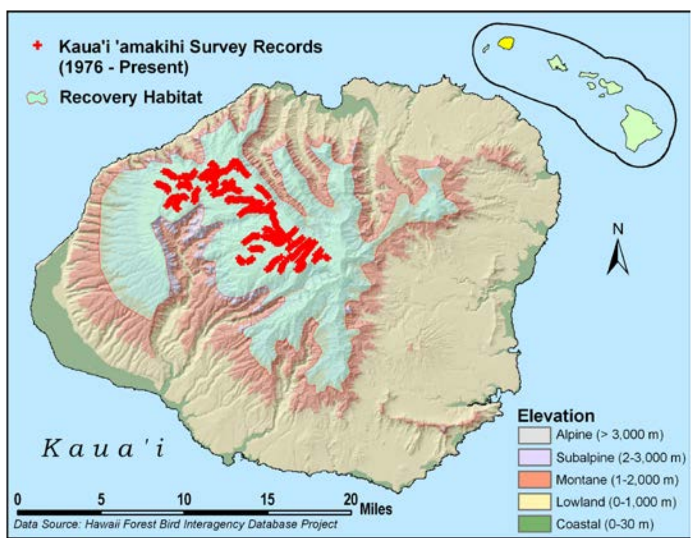
Forest Birds

Kauaʻi ʻamakihi

Hemignathus kauaiensis

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The Kauaʻi ʻamakihi is a small, generalist Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Kauaʻi. Until 1995, the Kauaʻi ʻamakihi, Hawaiʻi (*H. virens*), and Oʻahu ʻamakihi (*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 Kauaʻi ʻamakihi 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 ʻōhiʻa (*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 ʻōhiʻa tree, although the female does most of the construction while the male sings in adjacent trees. Females incubate a clutch of three eggs and brood nestlings at night and during inclement weather. Both parents feed nestlings. Fledglings are accomplished fliers. No information on post-fledgling behavior or parental dependency. Although weather has been implicated in nest failure, nest success is high.



DISTRIBUTION: Occurs above 600 meters (2,000 feet) in the forests of Waimea Canyon, Nā Pali Plateau, the Alakaʻi Swamp, and Makaleha Mountains. Original range likely included all forested areas of Kauaʻi.

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 Kauaʻi Forest Bird Survey (2000) estimated the population in the Alakaʻi Swamp and Kōkeʻe 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.

LOCATION AND CONDITION OF KEY HABITAT: Wet and mesic montane forests above 600 meters (2,000 feet) dominated by ʻōhiʻa, koa (*Acacia 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 accessible areas of the species' range, it is not effective in preventing habitat degradation. Occupied habitats above Waimea Canyon, in and west of the Alakaʻi Swamp, are managed by the State of Hawaiʻi.

THREATS: Although 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.

CONSERVATION ACTIONS: Kauaʻi ʻamakihi 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 education about Kauai's endangered forest birds. Future management specific to the Kauaʻi ʻamakihi may include the following:

- Aggressively control ungulates to improve habitat quality.
- Control non-native plants that degrade native habitat.
- Eradicate rats (*Rattus* spp.), feral cats (*Felis silvestris*), and barn owls (*Tyto alba*) from the Alakaʻi Wilderness Preserve.
- 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.
- Determine the species' susceptibility to avian malaria and avian pox.
- 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.

Photo: Jim Denny

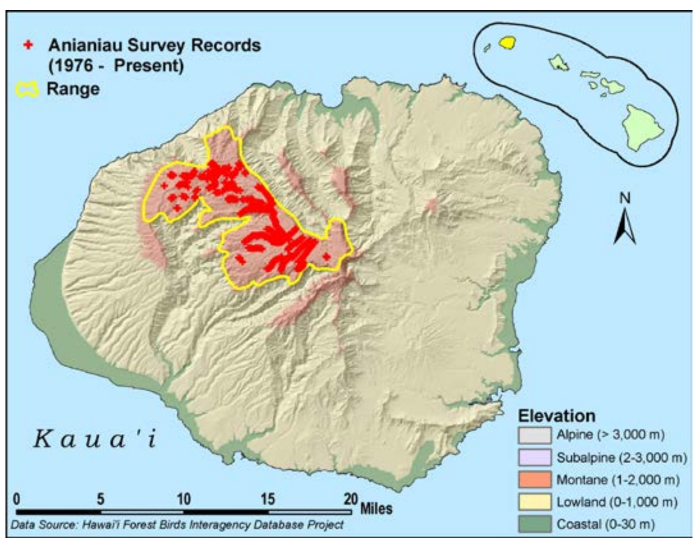
Forest Birds

ʻAnianiau or Lesser ʻamakihi

Magumma (Hemignathus) parva

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking—Vulnerable

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 duller. 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.



DISTRIBUTION: Occurs above 600 meters (2,000 feet) elevation in native forests of the Kōkeʻe, Alakaʻi, and Waimea regions. They may occur as low as 100 meters (330 feet) elevation on the island's northwestern coast. Original range likely included all forested regions of Kauaʻi. Currently, they occupy an estimated 15 percent of their former range.

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 and Kōkeʻe region at close to 35,000 individuals, with a significant population increase between 1981 and 2000. Subsequent surveys suggest that in 2008 the population appeared stable in its current range; however, the range-wide distribution of

ʻanianiau may be contracting coincident with an increase in the bird densities within the interior of the Alakaʻi.

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forests above 600 meters (2,000 feet), with the highest densities above 1,100 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 above Waimea Canyon, in and west of the Alakaʻi Swamp, are managed by the State of Hawaiʻi.

THREATS:

- Disease. Only one of 94 ʻanianiau tested positive for malarial parasites (*Plasmodium relictum*) in areas where parasites were common in other species. This either indicates low transmission rates, possible resistance, or very high mortality for this species.
- 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. Although predation on adult ʻanianiau or their nests has not been documented, rats, and cats occur in the Alakaʻi Wilderness Preserve.

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 public education featuring Kauai's endangered forest birds. Since the population appears stable, no future management specific to the species is anticipated. However, conservation efforts 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. 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.
- Determine if diseased individuals exist, and if so, if resistance is passed to offspring. Disease-resistant individuals could be used as founders for new populations.
- Determine if competition with Japanese white-eyes occurs, and if so, its effect on ʻanianiau 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 Alakaʻi Swamp region.

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).

Lepson JK. 1997. ʻAnianiau (*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.

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.

Picture: Rothschild Collection

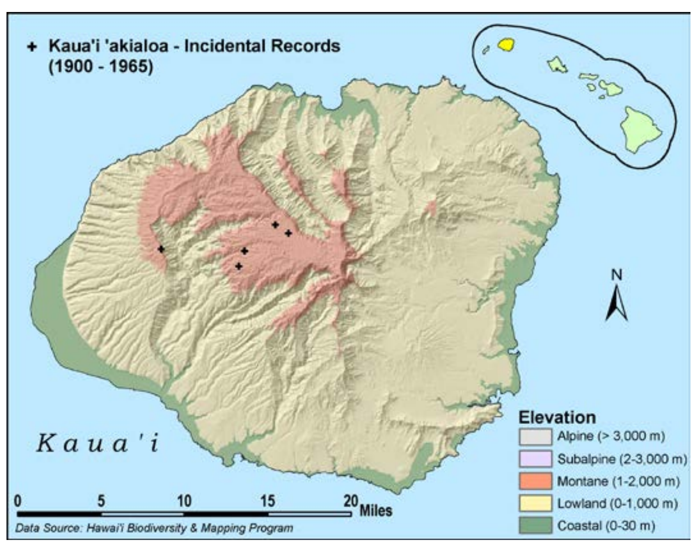
Kauaʻi ʻakialoa

Hemignathus procerus

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
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 hapuʻu 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 Lānaʻi. Some scientists consider each island population as a separate species, others lump all into a single, polytypic species. Regardless, none have been observed for at least 60 years.

DISTRIBUTION: Unknown. Probably extinct. The Kauaʻi ʻakialoa was last seen in the Alakaʻi swamp. 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, and 2006 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."

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.

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK, Johnston SM. 2000. Greater ʻakialoa (*Hemignathus ellisianus*) and lesser ʻakialoa (*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.

Picture: Rothschild Collection

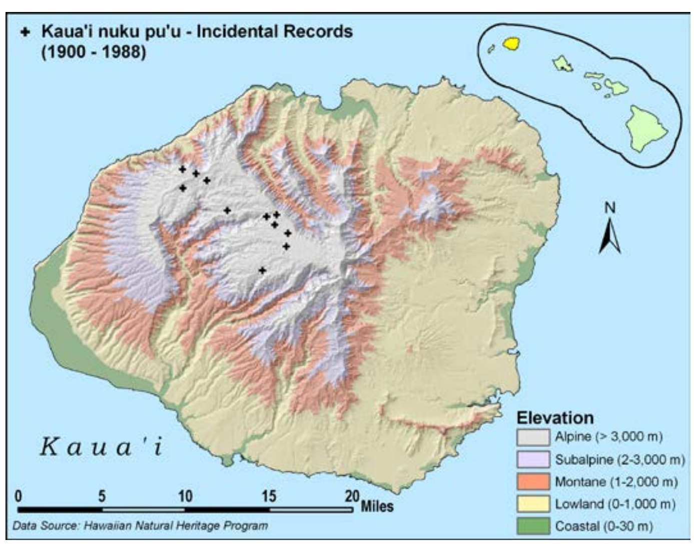
Kauaʻi nuku puʻu

Hemignathus lucidus hanapepe

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
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 large, short-tailed Hawaiian honeycreeper (Family: Fringillidae) with a long, thin decurved bill; the lower mandible is half the length of the upper mandible. Nuku puʻu also are known from Oʻahu (*H. l. lucidus*) and Maui (*H. l. affinis*); the Oʻahu subspecies is certainly extinct. Currently, all nuku puʻu are considered one species, however, ongoing research suggests that populations occurring on the three islands are distinct species. 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 (*Koa acacia*) 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 nuku puʻu 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 nuku puʻu. Extensive surveys in 1989, 1994, 1996, 2000, and 2005 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 nuku puʻu were most recently been observed are managed by the State of Hawaiʻi.

THREATS: Unknown. However, the Kauaʻi nuku puʻu 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 nuku puʻu, the following likely was of particular concern:

- Disease. The precipitous decline of all nuku puʻu taxa suggests that mosquito-borne diseases played an important role in the species' demise.

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 nuku puʻu.

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).

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.

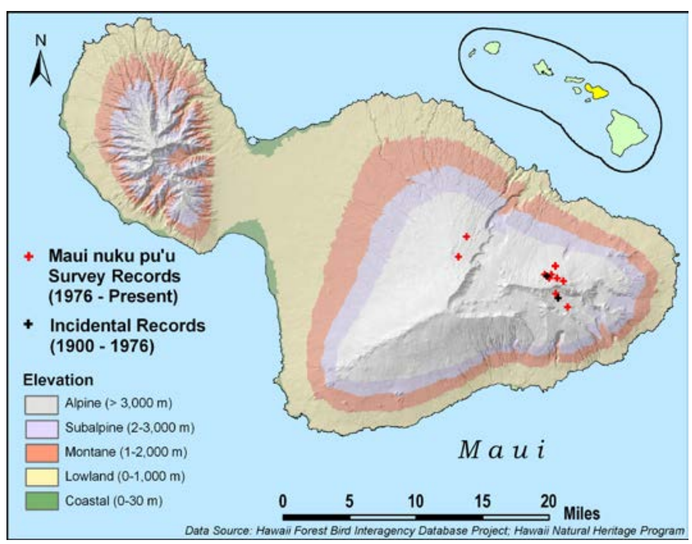
Picture: Rothschild Collection

Maui nuku puʻu

Hemignathus lucidus affinis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1T1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered (Possibly Extinct)
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The Maui nuku puʻu 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. Nuku puʻu also are known from Oʻahu (*H. l. lucidus*) and Kauaʻi (*H. l. hanapepe*); the Oʻahu subspecies is certainly extinct. Currently, all nuku puʻu are considered one species, however, ongoing research suggests that populations occurring on the three islands are distinct species. 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 ʻōhiʻa (*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 ʻakiapōlāʻau (*H. munroi*), and used its upper mandible to fish out prey from excavations. No information on the species' reproduction, but is likely similar to ʻakiapōlāʻau.



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 nuku puʻu. Historically considered uncommon.

LOCATION AND CONDITION OF KEY HABITAT: Mixed ʻōhiʻa/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 nuku puʻu were most recently sighted are managed as a Forest Reserve by the State of Hawaiʻi or by the National Park Service.

THREATS: Unknown. However, the Maui nuku puʻu 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 nuku puʻu, the following was likely of particular concern:

- <u>Disease</u>. The precipitous decline of all nuku puʻu taxa suggests that disease 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 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 nuku puʻu.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

References:

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: UH EECB

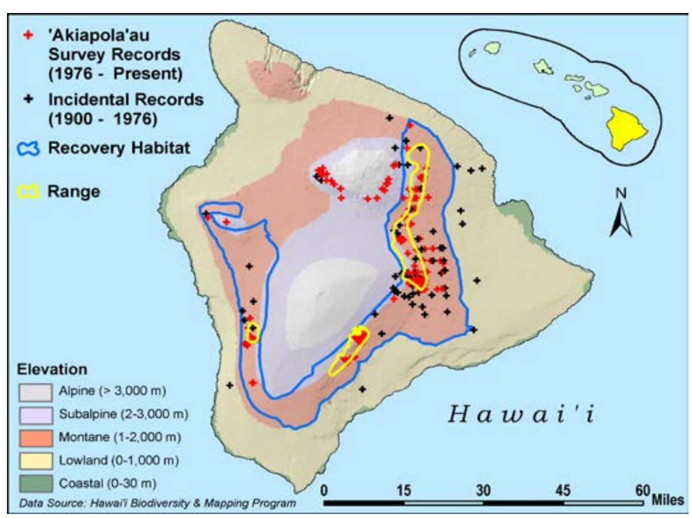
Forest Birds

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: The ʻakiapōlāʻau 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 February to July. 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 five months, is typical. 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 Hawaiʻi. Original range likely included all forested areas of the island.

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. Significant declines occurred in two of the four populations known in the 1980s. The Kaʻū /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 Mauna Kea and this population is now extinct. The Kaʻū /Kapāpala population has since stabilized or increased at upper elevations, but the status of the small Kona population is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in mesic and wet montane forests dominated by koa and ʻōhiʻa. The small and declining population on Mauna Kea occurred in subalpine dry forest dominated by māmane and naio. A recent study documented ʻakiapōlāʻau occurring entirely in areas reforested with koa (i.e., second-growth, young forests). Habitat quality varies across the species' occupied range. Most remaining populations occur on lands managed by the State of Hawaiʻi and the U.S. Fish and Wildlife Service.

THREATS: ʻAkiapōlāʻau 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 ʻakiapōlāʻau populations, the following are of particular concern:

- <u>Low reproductive potential</u>. Unlike many Hawaiian honeycreepers, ʻakiapōlāʻau 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.
- <u>Disease</u>. Unlike several other honeycreepers found on the island of Hawaiʻi (e.g., Hawaiʻi amakihi [*H. virens*]), the ʻakiapōlāʻau 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.
- <u>Predation</u>. Although little evidence exists, predation by rats (*Rattus* spp.), cats (*Felis* silvestris), small Indian mongoose (*Herpestes auropunctatus*), and owls (*Asio flammeus sandwichensis, Tyto alba*) may limit ʻakiapōlāʻau populations. Recent surveys have determined that rat density in the Hakalau Forest National Wildlife Refuge, which supports a significant portion of the ʻakiapōlāʻau population, is high. In addition, the loud, persistent begging of juveniles may make them especially vulnerable to predators.
- <u>Habitat degradation</u>. Habitat loss and degradation from development, logging, and grazing has greatly fragmented the species' habitat.
- <u>Population size</u>. 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.
- Continue koa forest restoration and fencing in the Hakalau Forest National Wildlife Refuge.
- Continue restoration of māmane forests on Mauna Kea.
- Conduct public outreach and education.
- Continue protection and management of wildlife sanctuaries and refuges.

MONITORING:

- Continue forest bird surveys and habitat monitoring.
- 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.

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).

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).

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.

Photo: Jim Denny

Forest Birds

ʻAkikiki or Kauaʻi creeper

Oreomystis bairdi

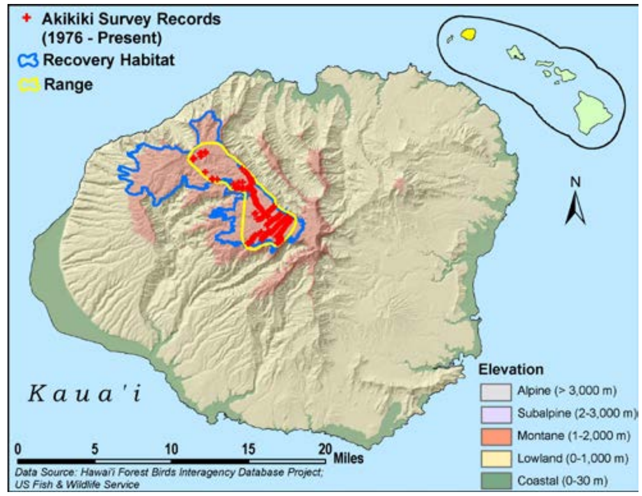
SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

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) in the terminal branches of ʻōhiʻa, but one female has been observed nesting in ōlapa 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, four cases of double brooding has been observed, with the male provisioning both the incubating female and the older chicks. Causes of nest failure include predation, likely by rats, poor female attendance, infertility, and hatch failure.

DISTRIBUTION: Restricted to a 36 square kilometer (13.8 square mile) area of the Alakaʻi Wilderness Preserve, but very rare in the northwestern part of this range and appears to be undergoing a severe range contraction. 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. Historically occupied high- and low-elevation forests, although by the 1960s was most common above 1,140 meters (3,750 feet). 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.

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forests between 600 and 1,600 meters (2,000 – 5,300 feet). Rainfall and topography varies across the species' range, resulting in enormous habitat variation. Thus key habitat variables are difficult to quantify, however, occupancy is correlated with large trees (i.e., canopy height) and canopy density. The montane forests of Kaua'i are dominated by 'ōhi'a with a subcanopy comprising 'ōlapa or lapalapa (*Cheirodendron* spp.) and 'ōhi'a hā (*Syzygium sandwicensis*). Common understory species include 'ōhelo (*Vaccinium calycinum*), kanawao (*Broussaisia arguta*), 'ōhā wai (*Clermontia* spp.), kāwa'u (*Ilex anomala*), kōlea (*Myrsine lessertiana*), na'ena'e (*Dubautia spp*.), and pūkiawe (*Styphelia tamieameiae*). Occupancy is very low in areas invaded by non-native plants.



THREATS:

- <u>Disease</u>. Mosquitoes likely are ubiquitous on Kaua'i, and avian malaria and avian pox are likely the most important factors limiting the species' distribution. To date, two of 22 'akikiki have tested positive for malarial antibodies, and were later resighted, indicating that some individuals have resistance or tolerance. No pox lesions have been observed.
- <u>Habitat degradation</u>. 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.
- <u>Natural disasters</u>. Hurricanes in 1982 and 1992 likely caused the death of an unknown number of individuals.
- <u>Competition</u>. Although little evidence exists, it has been suggested that competition with introduced Japanese 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 nati
feed. The role of non-native insects in native Hawaiian
- <u>Predation</u>. Predation by rats (*Rattus* spp.), on nests has been documented in at least two instances, and suspected in others. Rats, cats (*Felis silvestris*), 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.
- <u>Population size</u>. 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: ʻAkikiki likely have benefited from actions to conserve other endangered forest birds including establishment of the Alakaʻi 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, and public education efforts. In 2015, a grid of 100 self-resetting traps was installed in the core ʻakikiki range, and may reduce predation on nests and juveniles. Also in 2015, an effort to form a captive flock was initiated by collecting ʻakikiki eggs from the wild, resulting in a dozen chicks in captivity. This effort will continue in subsequent years. In addition to these efforts, future management specific to the recovery of ʻakikiki may include:

- 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.
- Eradicate or manage mosquito breeding habitat on the Alakaʻi Plateau and release sterile mosquitoes.
- Eradicate rats and feral cats from the Alakaʻi Wilderness Preserve.
- Prevent the introduction of the small Indian mongoose and other potential 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. Research priorities specific to the ʻakikiki include the following:

- Conduct life history studies to quantify population structure, dispersal patterns, survivorship, nesting phenology and success of this poorly known species.
- 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 if competition with Japanese white-eyes or other species occurs, and if so, its effect on ʻakikiki populations.
- Determine the effects of recently established non-native insects on native arthropods, especially those that are part of the species' diet.
- 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 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, 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.

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.


Photo: Jack Jeffrey

Hawaiʻi creeper

Oreomystis (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 Hawaiʻi creeper 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 (*Hemignathes 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 11 hectares (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. Hawaiʻi creepers 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.

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 10,000 ± 1,200 birds.

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 feral pigs. Most of the current range of the Hawaiʻi creeper 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. Hawaiʻi creepers place their nests near the main trunks of trees which may facilitate predation by rats.
- Disease. The Hawaiʻi creeper'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 Hawaiʻi creepers.

CONSERVATION ACTIONS: Past or ongoing actions specific to the Hawaiʻi creeper 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 Hawaiʻi creepers may include the following:

- Reintroduce the Hawaiʻi creeper 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 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 Hawaiʻi creeper include determining the efficacy and health implications of broadcast rodenticide.

References:

IUCN Red List of Threatened Species. 2015. Version 2014.3. Available at: www.iucnredlist.org. (Accessed May 2015).

Lepson JK, Woodworth BL. 2001. Hawaiʻi 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.

Picture: Rothschild Collection

Forest Birds

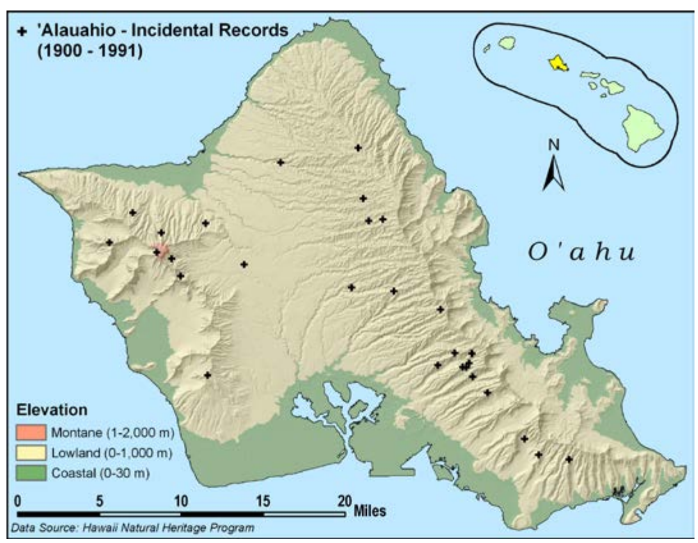
O'ahu 'alauahio

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 creeper (*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/'ōhi'a forest between 300 and 600 meters (1,000 – 2,000 feet). Forests where the O'ahu 'alauahio historically occurred are largely managed by the State of Hawai'i, the U.S. Fish and Wildlife Service (USFWS), or the U.S. Military.

THREATS: Unknown. However, the O'ahu 'alauahio 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 O'ahu 'alauahio, the following was likely of particular concern:

- Disease. The fact that no habitat above 1,250 meters (4,100 feet) occurs on O'ahu, 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.

CONSERVATION ACTIONS: Unfortunately, few forest birds remain on O'ahu, and little if any, specific management is directed at forest birds other than the O'ahu 'elepaio (*Chasiempis sandwichensis ibidis*). The O'ahu Forest National Wildlife Refuge in the Ko'olau 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 O'ahu.

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 O'ahu 'alauahio.

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.

Picture: Rothschild Collection

Forest Birds

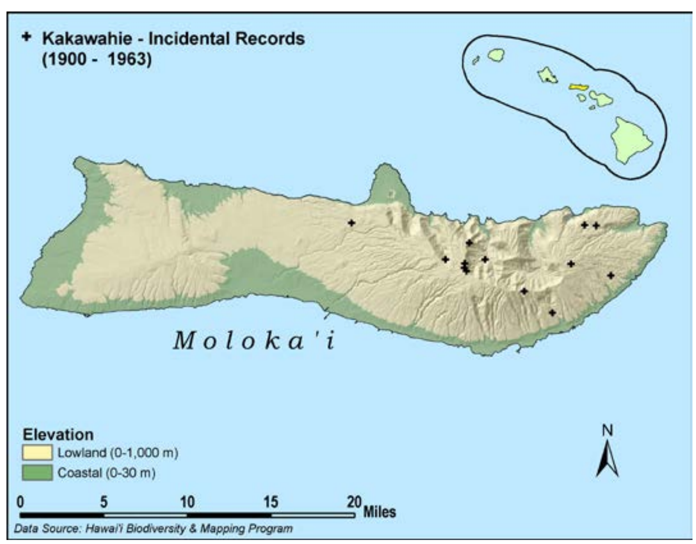
Kākāwahie or Molokaʻi creeper

Paroreomyza flammea

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
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: The kākāwahie, or Molokaʻi creeper, is a small, sexually dichromatic, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the forests of eastern Molokaʻi. Males are scarlet red; females are a 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 ʻōhiʻa (*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 less than 100 years later.

DISTRIBUTION: Unknown. Probably extinct. Last observed on the west rim of Pelekunu Valley. Kākāwahie were common in native forests of eastern Molokaʻi at the end of the 19th century. Original range likely included all forested regions of Molokaʻi.



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 ʻōhiʻa (*Metrosideros polymorpha*) forests from low to high elevations, and other heavily wooded native areas of eastern Molokaʻi. 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 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).

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: Jack Jeffrey

Maui ʻalauahio or Maui creeper

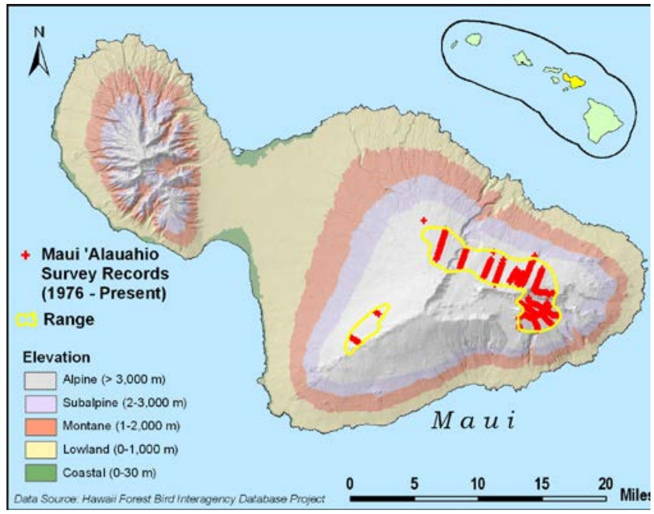
Paroreomyza montana

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G4—Apparently Secure
IUCN Red List Ranking—Endangered

SPECIES INFORMATION: The Maui ʻalauahio, or Maui creeper, is a small insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to Maui. The species also occurred on Lānaʻi 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 ʻalauahio gleans invertebrates from woody and leafy parts of a variety of plants. Adults defend 1 to 2 hectare (2.5 – 5 acre) home ranges against conspecifics year round and will chase ʻapapane (*Himantione sanguinea*) and Japanese white-eyes (*Zosterops japnicus*) 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. Fledglings are fed for two to three months, and young remain with their parents in family groups for 18 - 20 months.

DISTRIBUTION: Above 900 meters (3,000 feet) on the slopes of Haleakalā. Historically common in west Maui and on Lānaʻi; these populations are now extirpated. Fossil evidence suggests they were common across the south side of the island and in lowland forests.

ABUNDANCE: The Hawaiian Forest Bird Survey (1980) estimated the population at 35,000 ± 5,000 (95% confidence interval) birds. Surveys conducted in 1995-1997 found similar numbers, but densities decreased below 1,600 meters (5,250 feet) and the range appears to have contracted.



LOCATION AND CONDITION OF KEY HABITAT: Primarily wet and mesic montane forests dominated by ʻōhiʻa (*Metrosideros polymorpha*), although they also occur in subalpine māmane scrub (*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 900 meters (2,925 feet) elevation. Habitat conditions vary greatly across the species' range. The northeastern part of the species' range is actively 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. The remainder of the species' range occurs on State and Federally owned lands, where management efforts vary considerably.

THREATS:

- Predation. Rats (*Rattus* spp.) have been observed depredating nests and females. Female behavior of begging near nests may make them particularly susceptible to rats.
- Disease. Susceptibility to avian malaria has been documented, and likely prevents the establishment of populations in lowland areas. In Kahikinui, few individuals show signs of avian pox, although it is prevalent in ʻamakihi (*Hemignathus virens*) and ʻapapane (*Himatione sanguinea*). These data are equivocal, indicating low transmission rates, possible resistance, or very high mortality for this species.
- 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 and ungulate control on Department of Hawaiian Home Lands at Kahikinui will likely benefit the small population there. In general, actions should include continued protection and management of wildlife sanctuaries and refuges.

MONITORING: Continue forest bird surveys and habitat monitoring.

RESEARCH PRIORITIES: Research priorities for Hawaiian forest birds include improving methods for controlling rats 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 high-elevation forests.

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).

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.

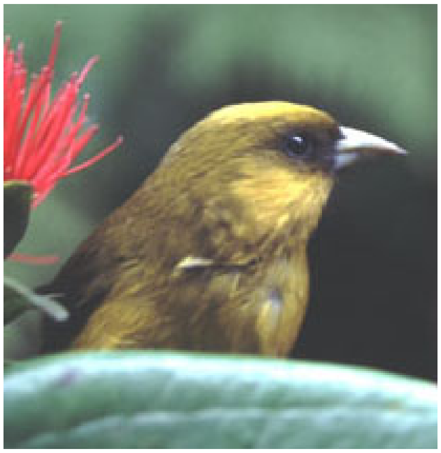


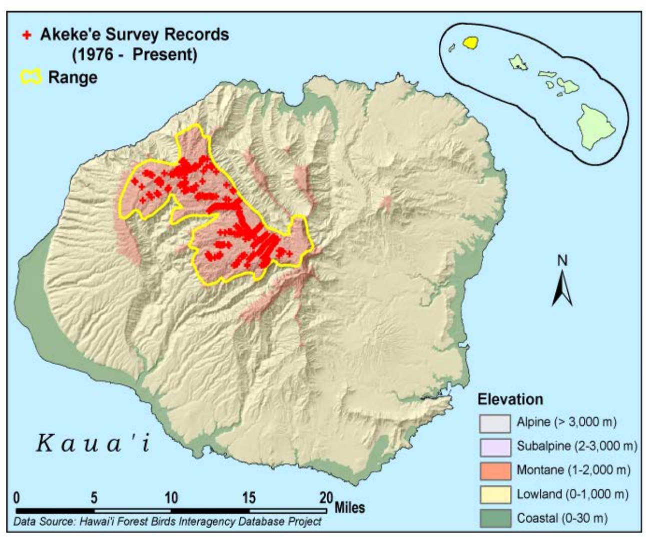
Photo: Jim Denny

ʻAkekeʻe or Kauaʻi ʻākepa

Loxops caeruleirostris

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G2—Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ʻakekeʻe, or Kauaʻi ʻākepa, is a small, slightly sexually dichromatic, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to Kauaʻi. 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 Kauaʻi amakihi (*Hemignathus kauaiensis*), the ʻakekeʻe's bill is conical. Although not visible in the field, the lower mandible of the ʻakekeʻe is slightly bent to one side which results in the mandible tips being offset; a characteristic shared with the ʻākepa (*L. coccineus*). The ʻakekeʻe uses its bill to pry open ʻōhiʻa (*Metrosideros polymorpha*) leaves and flower buds in search of arthropods, primarily spiders, psyllids, and caterpillars. The species is an ʻōhiʻa 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. ʻAkekeʻe are most often observed in pairs or family groups. Fewer than 20 ʻakekeʻe nests have been found and the species' breeding biology is virtually unknown. In a sample of eight nests, mean nest height was 11.1 ± 2.3 m, and all nests were located in the small terminal branches of ʻōhiʻa. At one nest, the male and female both participated in nest construction, but in the sample of eight nests, only females were observed building. In three nests that have been directly accessed during incubation, two had clutch sizes of two eggs, and the third nest contained three eggs. In another study, five nests were observed to fledge two chicks, and the sixth fledged one chick. Two nests did not fledge, one due to hatching failure and the other due to poor attendance by the female. Immediately post-hatch, only females fed nestlings, but thereafter both parents fed chicks. It is not clear whether this species renests or double broods.



DISTRIBUTION: Found in native forests of the Alakaʻi swamp, upper Waimea, and Kōkeʻe regions mostly above 1,000 meters (3,280 feet) elevation, but are becoming less common in the latter. Although historically widespread, ʻakekeʻe apparently did not occur at lower elevations. Occupancy rates in 2012 increased from west to east along the plateau (ψ = 0.03 ± 0.10 to 0.53 ± 0.33), but were low throughout its range. Currently estimated to occupy 10-12 percent of their original range.

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 (U.S. Geological Survey 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 occurs in Kōkeʻe State Park and the Alakaʻi Wilderness Preserve. 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. ʻAkekeʻe may be highly susceptible to mosquito-borne avian malaria. Only one of 20 ʻakekeʻe caught since 1994 has tested positive for malarial anitibodies; since malaria seems to be established on the Alakaiʻ Plateau, the most likely explanation for this result is high mortality after infection with malaria. Disease and habitat degradation 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 ʻakekeʻe feed. The role of non-native insects in native Hawaiian forests is unclear.
- Predation. Although predation on adults or their nests has not been documented, rats (*Rattus* spp.), cats (*Felis silvestris*), Hawaiian short-eared owls (*Asio flammeus sandwichensis*), and barn owls (*Tyto alba*) occur throughout the forests of Kauaʻi and may prey on young and adults.
- Small population dynamics. The observed hatching failures may indicate genetic issues associated with small population sizes.

CONSERVATION ACTIONS: ʻAkekeʻe likely benefited from actions to conserve other endangered forest birds 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 featuring Kauaiʻs endangered forest birds. In 2015, an effort to form a captive flock was initiated by collecting ʻakekeʻe eggs from the wild. Five eggs were harvested from two nests; all eggs hatched but only one chick survived to fledging. This project will continue in subsequent years. In addition to these efforts, future actions specific to the ʻakekeʻe 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 Alaka'i Plateau and release sterile mosquitoes.
- Eradicate rats, feral cats, and barn owls from the Alaka'i Wilderness Preserve.
- Prevent the introduction of the small Indian mongoose (*Herpestes auropunctatus*) and other 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 mosquito populations. Research priorities specific to the 'akeke'e include the following:

- 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.
- 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 Alaka'i swamp region.

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, 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, 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. '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.

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.

Picture: Rothschild Collection

Forest Birds

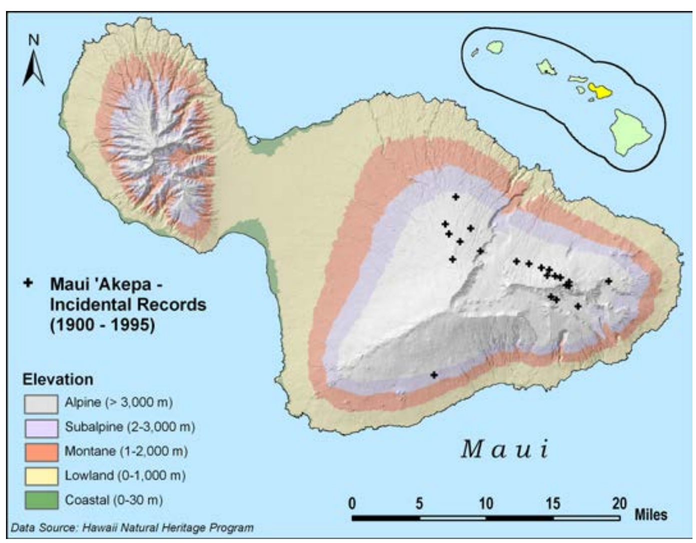
Maui ʻākepa

Loxops coccineus ochraceus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1/TH—
Critically Imperiled/Subspecies Possibly Extinct
IUCN Red List Ranking—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 at the subspecies level. ʻĀkepa also are known from the island of Hawaiʻi (*L. c. coccineus*) and Oʻahu (*L. c. rufus*); the latter subspecies is certainly extinct. Currently, all ʻākepa are considered one species, although they are recognized as critically imperiled at the subspecies level. Adults are less colorful compared to the Hawaiʻi ʻākepa, and there is no information on the plumage sequence of the Maui subspecies. 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 Hawaiʻi ʻākepa. Although almost nothing is known about its life history, the Maui ʻākepa likely forages in a similar manner to the Hawaiʻi ʻākepa, and is 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.

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.

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.

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.

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: DOFAW

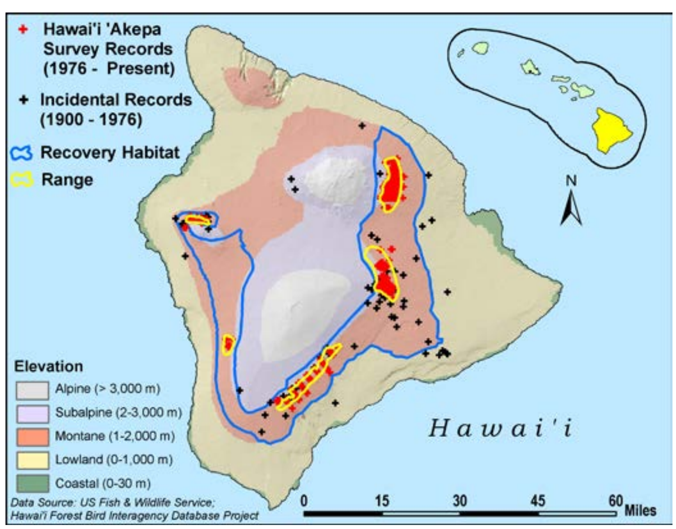
Hawaiʻi ʻākepa

Loxops coccineus 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 Hawaiʻi ʻākepa is a small, insectivorous Hawaiian honeycreeper (Family: Fringillidae) endemic to the island of Hawaiʻi. ʻĀkepa also are known from Maui (*L. c. ochraceus*) and Oʻahu (*L. c. rufus*); both of which are likely extinct. Currently, all ʻākepa are considered one species, although they are recognized as critically imperiled at the subspecies level. After three 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 breast band. 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*). 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. They often join mixed-species foraging flocks, particularly those with Hawaiʻi creepers (*Oreomystis mana*). They feed mainly on ʻōhiʻa (*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. ʻĀkepa are obligate cavity nesters, with most nests placed in natural cavities found in old-growth ʻōhiʻa 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 five disjunct populations above 1,300 meters (4,300 feet) elevation on the windward side of the island of Hawaiʻi. 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. The south Kona and Hualālai populations were estimated at 660 ± 250 birds and are apparently declining.

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 Hawaiʻi ʻākepa 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 ʻōhiʻa 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.

References:

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.

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: Eric VanderWerf

ʻIʻiwi

Vestiaria coccinea

SPECIES STATUS:
State Listed as Endangered on Oʻahu, Molokaʻi, Lānaʻi
State Recognized as Endemic
NatureServe Heritage Rank G4/T1/TH—Apparently Secure/
Critically Imperiled Globally on Oʻahu and Molokaʻi/Possibly Extinct on Lānaʻi
IUCN Red List Ranking—Vulnerable

SPECIES INFORMATION: The ʻiʻiwi 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 capes using hundreds of thousands of ʻiʻiwi feathers; such capes signified power and prestige. Like ʻapapane (*Himatione sanguinea*), ʻiʻiwi often fly long distances in search of flowering ʻōhiʻa (*Metrosideros polymorpha*) trees and are important ʻōhiʻa pollinators. 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, ʻiʻiwi 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 ʻōhiʻa 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 (4,100 feet) elevation on the islands of Hawaiʻi, Maui, and Kauaʻi; and may occur at reduced densities below. Relict populations occur on Oʻahu and Molokaʻi. Historically, ʻiʻiwi were common down to low elevations on all the Main Hawaiian Islands.

ABUNDANCE: The following island population estimates are based on Paxton et al. (2013): 543,009 ± 26,697 (95% confidence interval) birds on island of Hawaiʻi, 59,859 ± 5,290 on east Maui, 176 on west Maui, 80 on Molokaʻi, and 2,551 ± 617 on Kauaʻi. Oʻahu supports a population of less than 50 birds. The population is probably declining, but 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 Hawai'i and Maui, 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 'i'iwi, the following is of particular concern:

- Disease. 'I'iwi 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 Moloka'i and O'ahu 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: 'I'iwi likely have benefited from actions to conserve other endangered forest birds on northeastern Haleakalā, Hakalau Forest National Wildlife Refuge, Alaka'i Wilderness Preserve and surrounding areas, Hawai'i Volcanoes National Park, and the 'Ōla'a/Kīlauea Watershed Partnership. 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 'i'iwi may include the following:

- Control mosquitos in degraded habitats.
- Conduct public education and outreach.
- Continue 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. Research priorities specific to 'i'iwi 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 'i'iwi 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.

References:

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.

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).

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.

VanderWerf EA, Rohrer JL. 1996. Discovery of an ʻIʻiwi population in the Koʻolau Mountains of Oʻahu. ʻElepaio 56:25–28.

Photo: DOFAW

ʻĀkohekohe or Crested honeycreeper

Palmeria dolei

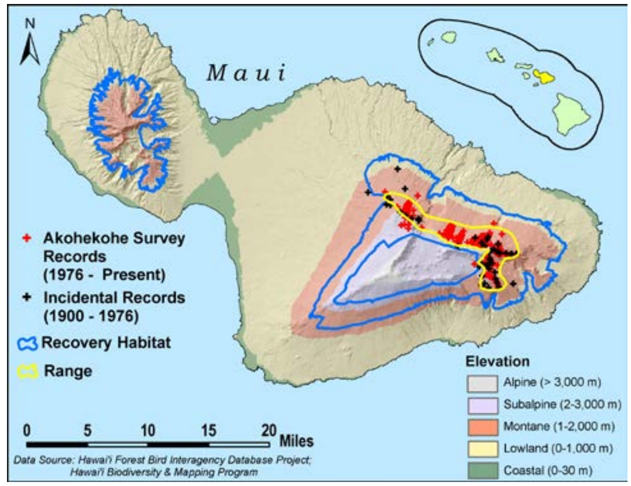
SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
NatureServe Heritage Rank G1—Critically Imperiled
IUCN Red List Ranking—Critically Endangered
Revised Recovery Plan for Hawaiian Forest Birds—USFWS 2006

SPECIES INFORMATION: The ʻākohekohe, or crested honeycreeper (Family: Fringillidae), is the largest extant honeycreeper on Maui Nui (Lānaʻi, Molokaʻi, Maui, and Kahoʻolawe). Although primarily black, the plumage of the ʻākohekohe 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 ʻōhiʻa (*Metrosideros polymorpha*), but also from the flowers of other trees and shrubs. Like ʻapapane (*Himatione sanguinea*) and iʻiwi (*Vestiaria coccinea*), ʻākohekohe are strong fliers and will move from low to high elevations in search of blooming ʻōhiʻa. Arthropods, mainly gleaned from ʻōhiʻa, 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 ʻōhiʻa, 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 58 square kilometer (22 square mile) area on the northeastern slope of Haleakalā at 1,100 to 2,300 meters (3,600 – 7,550 feet). Subfossil evidence indicates they once occurred in Maui's lowland dry forests, and they also once occurred eastern Molokaʻi. They currently occupy 5 percent of the historical range.

ABUNDANCE: The Hawaiian Forest Bird Survey (1980) estimated the population at 3,800 ± 700 (95% confidence interval) individuals. Surveys in 1992 and 1995-97 indicated similar densities across the same range.

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 1,500 and 2,100 meters (5,000 – 6,000 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) or Federally (e.g., National Park) managed lands.



THREATS: ʻĀkohekohe 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 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*) damage to 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 has been attempted, but to date has been unsuccessful. ʻĀkohekohe likely benefited from actions to conserve 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.
- Continue attempts at establishing a captive population, especially if a second wild population cannot be establish.
- Implement additional fencing and feral pig control to improve understory conditions in occupied habitat and potentially facilitate expansion of ʻākohekohe populations.
- 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. 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.

References:

Berlin KE, VanGelder EM. 1999. ʻAkohekohe (*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).

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.

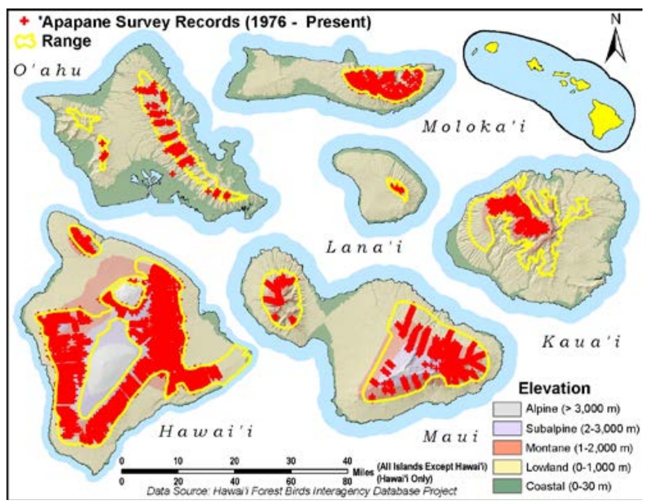
Photo: Eric Nishibayashi

ʻApapane

Himatione sanguinea

SPECIES STATUS:
State Recognized as Endemic
NatureServe Heritage Rank G3—Vulnerable
IUCN Red List Ranking— Least Concern

SPECIES INFORMATION: The ʻapapane is a small, crimson, primarily nectarivorous Hawaiian honeycreeper (Family: Fringillidae) and is an important ʻōhiʻa (*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 ʻōhiʻa. Wide-ranging movements may facilitate disease transmission among native forest birds. ʻApapane often forage in conspecific flocks, likely to overwhelm ʻiʻiwi (*Vestiaria coccinea*) and ʻākohekohe (*Palmeria dolei*), which often defend flower-rich trees. Outside the breeding season, ʻapapane 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 above 1,250 meters (4,100 feet) on the islands of Hawaiʻi, Maui, and Kauaʻi. On Oʻahu, occurs in the Koʻolau Range from 300 meters (975 feet) to summit at 946 meters (3,075 feet), and are less common in the Waiʻanae Range above 600 meters (1,950 feet). Rare on Molokaʻi and Lānaʻi. 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 Hawaiʻi, 110,000 ± 9,000 on Maui (86% on Haleakalā), 39,000 ± 5,000 on Molokaʻi, 540 ± 213 on Lānaʻi, and 30,000 ± 1,500 on Kauaʻi (Oʻahu was not included in surveys). On Kauaʻi, populations declined after the 1992 hurricane but have significantly increased since, estimated at 64,972 ± 2,014 (SE) birds in 2000. Rare on Molokaʻi and Lānaʻi.

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). 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 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 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.

CONSERVATION ACTIONS: ʻApapane likely benefited 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 in degraded habitats.
- Conduct public education and outreach.
- Continue 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 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.

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.

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.

Photo: DOFAW

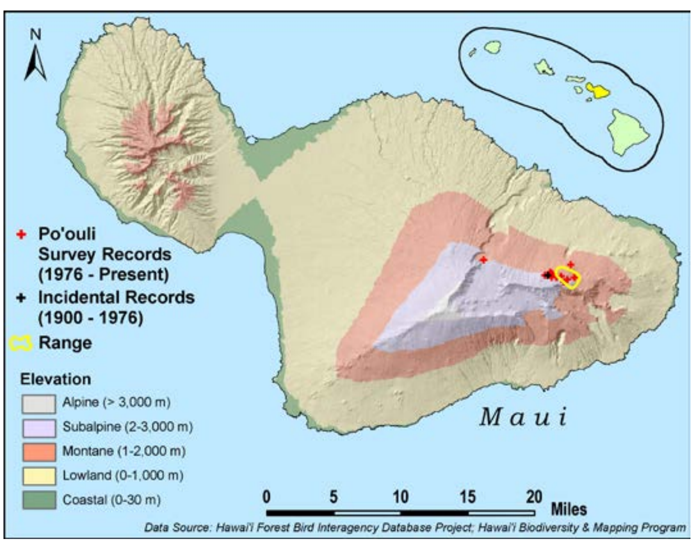
Forest Birds

Po‘ouli

Melamprosops phaeosoma

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 (Potentially Extinct)
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.



DISTRIBUTION: Likely 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 po‘ouli once occurred over a wider geographic range.

ABUNDANCE: The Hawaiian Forest Bird Survey (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 is potentially 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*], kawaʻu [*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:

- <u>Habitat degradation</u>. 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*).
- <u>Predation</u>. Rats (*Rattus* spp.) are abundant in poʻouli habitat and may depredate adults and nests.
- <u>Competition</u>. In addition to direct predation on adults and nests, rats also may compete with poʻouli for food resources, especially snails. Also, the non-native garlic snail (*Oxychilus alliarius*) is abundant and preys on native snails.

CONSERVATION ACTIONS: Major efforts to conserve poʻouli 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 poʻouli 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.

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 po'ouli 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.


Photo: Jack Jeffery

Raptors

ʻIo

Buteo solitarius

SPECIES STATUS:
Federally Listed as Endangered,
Proposed for Delisting
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

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.

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.

However, the species was proposed to be federally delisted in 2008, and again in 2014, because it was determined that the species is resilient enough to maintain itself in a variety of non-native and native habitat types.

- 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.

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.

MONITORING: Conduct regular island-wide surveys to monitor abundance, distribution, and disease.

RESEARCH PRIORITIES: Evaluate potential effects of land management and changes in fire frequency and intensity on the species.

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.

Hawaiʻi Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawaiʻi, 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.

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. 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.

Photo: NRCS

Pueo or Hawaiian Short-eared Owl

Asio flammeus sandwichensis

SPECIES STATUS:
State listed as Endangered on Oʻahu
State recognized as Endemic at the subspecies level
NatureServe Heritage Rank G5/T2 – Species secure/Subspecies imperiled

SPECIES INFORMATION: The pueo, or Hawaiian short-eared owl, is an endemic subspecies of the nearly pandemic short-eared owl (*Asio flammeus*; Family: Strigidae). The species is thought to have colonized the Hawaiian Islands sometime after the arrival of Polynesians. Unlike most owls, pueo are active during the day (i.e., diurnal), and are commonly seen hovering or soaring over open areas. Like short-eared owls in continental environments, those in Hawaiʻi primarily consume small mammals. Their relatively recent establishment on Hawaiʻi may have been tied to the rats (*Rattus exulans*) that Polynesians brought to the islands. Little is known about the breeding biology of pueo, but nests have been found throughout the year. Males perform aerial displays known as a sky dancing display to prospective females. Nests are constructed by females and are comprised of simple scrapes in the ground lined with grasses and feather down. Females also perform all incubating and brooding. Males feed females and defend nests. Chicks hatch asynchronously and are fed by female with food delivered by male. Young may fledge from nest on foot before they are able to fly and depend on their parents for approximately two months.

DISTRIBUTION: Found on all the Main Hawaiian Islands from sea level to 2,450 meters (8,000 feet).

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, but are thought to be declining.

LOCATION AND CONDITION OF KEY HABITAT: Pueo occupy a variety of habitats, including wet and dry forests, but are most common in open habitats such as grasslands, shrublands, and montane parklands, including urban areas and those actively managed for conservation. 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 Sate of Hawaiʻi 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, 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:

- <u>"Sick owl syndrome"</u>. Mortality on Kauaʻi has been attributed to this syndrome, which may be related to pesticide poisoning or food shortages.
- <u>Predation</u>. Because pueo nest on the ground, their eggs and young are vulnerable to predation by rats (*Rattus* spp.), cats (*Felis silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*).
- <u>Habitat loss</u>. May be particularly important to Oʻahu pueo populations.
- <u>Contaminants or toxins</u>. Because pueo are top predators, fat-soluble contaminants may accumulate in prey species; may be related to "sick owl syndrome" (see above).
- <u>Human interaction</u>. Hunting behavior and habitat use predispose pueo to vehicular collisions, which have been documented on Lānaʻi and the island of Hawaiʻi.

CONSERVATION ACTIONS: Pueo likely have benefited from management activities designed to conserve other endangered birds. 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, especially on islands where "sick owl syndrome" has been documented.
- 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 Oʻahu.
- Determine the cause of "sick owl syndrome" and its potential effect on populations.
- Quantify the number of vehicular collisions and determine the level of threat to populations.

References:

Berger AJ. 1981. Hawaiian birdlife. Honolulu: University of Hawaiʻi 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 CS, Conant S. In prep. Diets of native and alien apex predators in Hawai'i.

NatureServe. 2003. Downloadable animal data sets. NatureServe Central Databases. Available at: http://www.natureserve.org/getData/vertinvertdata.jsp (August 10, 2005).

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.


Photo: Richard Palmer

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 are 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.

DISTRIBUTION: ʻAukuʻu (black-crowned night heron) is widely distributed throughout the MHI.

ABUNDANCE: Island-wide population numbers, based on semi-annual waterbird counts conducted by DOFAW, indicate that the population is variable, but appears stable. Between 1983 and 2003 the average number of ʻaukuʻu (black-crowned night heron) counted has been just over 400 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 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:

- <u>Habitat loss</u>. 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 ʻaukuʻu (black crowned night heron).
- Non-native 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. The most important disease affecting Hawaiian waterbirds is botulism (*Clostridium botulinum*).
- Environmental contaminants. Fuel and oil spills are the most important contaminant threat to Hawaiian waterbirds.

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 Hawaiʻi and the USFWS have protected 23 percent of the State's remaining coastal plain wetlands. In 1997, Ducks Unlimited developed a comprehensive, cooperative plan to protect and restore wetlands used by native waterbirds. Currently there are no conservation actions specifically directed at ʻaukuʻu (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 ʻaukuʻu (black-crowned night heron) should include:

- Continue protection and management of wildlife sanctuaries and refuges.

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 ʻaukuʻu (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 Hawaiʻi 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.

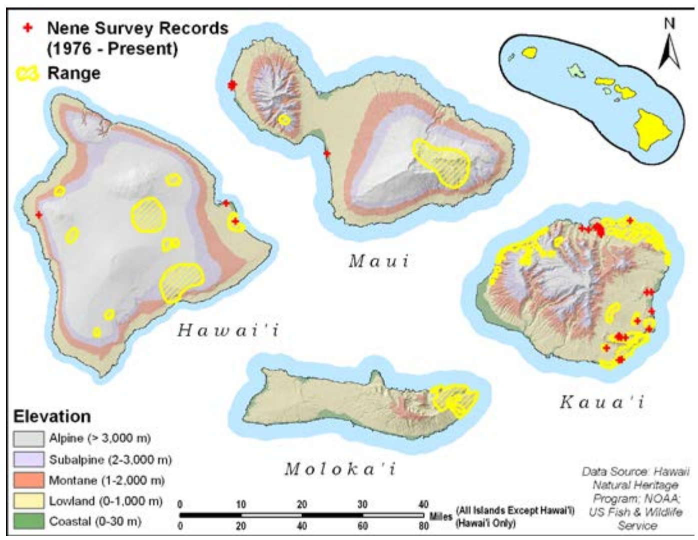
Pratt DH, Bruner PL, Berrett DG. 1987. Field guide to the birds of Hawaiʻi and the tropical Pacific. Princeton, (NJ): Princeton University Press.

Photo: Jack Jeffery

Nēnē
or Hawaiian goose
Branta sandvicensis

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
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 Hawaiʻi; 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 Hawaiʻi, Maui, Kauaʻi, and Molokaʻi, and a single pair was reported on Oʻahu in 2014. 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 current population is estimated at 2,450–2,550 birds, with 550 on the island of Hawaiʻi, 400 on Maui, 1,500 on Kauaʻi, 80 on Molokaʻi, and a single nesting pair reported on Oʻahu in 2014. During 2005-2010, about 224 nēnē were removed from near the Kauaʻi Airport and released at remote relocation sites on that island to reduce the risk of bird-aircraft strikes. Since 2011, the continued growth of the Kauaʻi nēnē population prompted the removal of an additional 600 nēnē from the vicinity of the Kauaʻi Airport and which were released into the wild on Hawaiʻi 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 Hawaiʻi and Maui, most nests are built under native vegetation, such as pūkiawe (*Styphelia tameiameiae*), ʻaʻaliʻi (*Dondonaea viscose*), and ʻōhiʻa (*Metrosideros polymorpha*). On Kauaʻi, 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 used by the species are managed for conservation by the State of Hawaiʻi and the U.S. Fish and Wildlife Service (USFWS).

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); 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, and wind turbines.
- Develop a statewide long-range management plan for nēnē that includes all of the distinct populations and anticipates changes resulting from 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.

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.

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 Hawaiʻi, Department of Land and Natural Resources, Division of Forestry and Wildlife. 2014. Kauaʻi 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

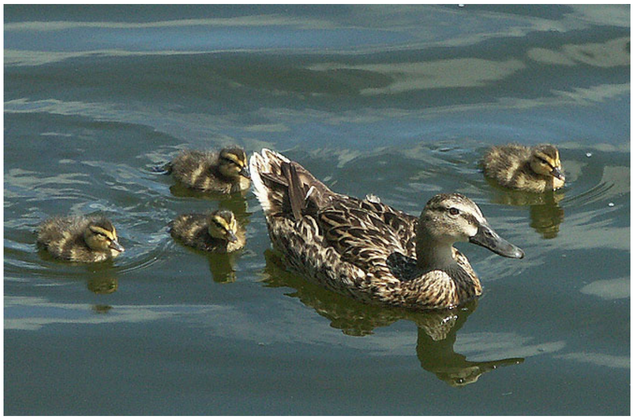


Photo: Richard Palmer

Koloa maoli or Hawaiian duck

Anas wyvilliana

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 Hawaiʻi and is closely related to the well-known, but nonnative 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 Kauaʻi and Niʻihau 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. Although some pairs nest in lowland habitats, on Kauaʻi, they nest in the upper Alakaʻi swamp. 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.

DISTRIBUTION: Wetland habitats from sea level to 3,000 meters (9,900 feet) elevation on all the Main Hawaiian Islands except for Kahoʻolawe; populations on all islands except for Kauaʻi originated from reintroduced birds. On Kauaʻi, koloa maoli are found in Hanalei National Wildlife Refuge and montane streams. On Oʻahu, they occur in Kawainui, Hāmākua, and Heʻeia marshes; James Campbell National Wildlife Refuge; and wetland habitats in or near Punahoʻolapa, Haleʻiwa, Pearl Harbor, and Lualualei Valley. On Maui, koloa maoli occur in Kahului, Kanahā, and Keālia ponds. On the island of Hawaiʻi, they occur in the Kohala Mountains; Pololū, Waimanu, and Waipiʻo valleys; and Mauna Kea. Historically, koloa maoli occurred on all the Main Hawaiian Islands except for Lānaʻi and Kahoʻolawe.

ABUNDANCE: The population is estimated at 2,200 individuals, with 90 percent of individuals occurring on Kauaʻi. Another 350 individuals occur on Oʻahu and Maui; some of these birds may be koloa maoli with the remainder being mallard-Hawaiian duck hybrids. The total population appears to be increasing due primarily to population increases on Kauaʻi, but numbers are declining on other islands due to hybridization. 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 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: Historically, hunting pressure likely reduced populations. Like the rest of Hawaiian native waterbirds, koloa maoli are threatened by:

- <u>Hybridization</u>. Currently, the most important threat to koloa maoli is hybridization with nonnative mallards, especially on Oʻahu, where most individuals are hybrids.
- <u>Habitat loss and degradation</u>. In the last 110 years, approximately 31 percent of coastal plain wetlands have been lost. A shift from wetland agriculture to other types of crops has also reduced the amount of wetland habitats. Feral pigs and goats are reducing nesting habitat suitability for koloa maoli along montane streams.
- <u>Introduced and native predators</u>. 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*), and non-native fish.
- <u>Altered hydrology</u>. Altering wetland habitats for flood control or to serve as municipal water sources makes them generally unsuitable for koloa maoli.
- <u>Nonnative invasive plants</u>. Several species of invasive plants, including pickleweed(*Batis maritime*), water hyacinth (*Eichornia crassipes*), and mangrove (*Rhizophora mangle*), reduce open water, mudflats, and shallows.
- <u>Avian diseases</u>. Botulism outbreaks result in mortality. West Nile virus and avian flu may pose a risk to Hawaiian waterbirds if these diseases reach Hawaiʻi.
- <u>Environmental contaminants</u>. Fuel and oil spills in wetlands result in toxicity and habitat degradation.

CONSERVATION ACTIONS: In order to establish new populations, 445 koloa maoli were released on the island of Hawaiʻi from 1958 to 1979, 350 birds were released on Oʻahu from 1968 to 1982, and 12 birds were released on Maui in 1989. 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 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 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 maolo 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: W.C. Gagne

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 Laysan duck is a small dabbling duck (Family: Anatidae) endemic to Hawaiʻi, and until recently was restricted to Laysan Island (370 hectares, or 911 acres) in the Northwestern Hawaiian Islands (NWHI). Even after recent successful translocation efforts to establish new populations on Midway and 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 sedentary; the species also is relatively long-lived. During the day, ducks take cover under vegetation such as bunchgrass or shrub. 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 2013 which has greatly facilitated the reintroduction effort. 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 Hawaiʻi, Molokaʻi, Oʻahu, Maui, and Kauaʻi. 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 present population at Kure Atoll is between 40-50 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. Potential future reintroductions of the Laysan duck to the MHI are complicated by the presence of nonnative predators, such as cats, dogs, pigs, mongooses, 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.
- Contaminants. Oil spills, pesticides, and other types of contaminants washing ashore are potentially a serious risk to the species.
- Climate change. Sea level rise due to climate change may result in loss or degradation of nesting habitat, 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, major storms, and tsunamis. For example, on Midway Atoll, some of the freshwater wetlands created for the ducks were damaged and inundated with saltwater by the 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*, and has begun replanting native vegetation and installing snow fences to stabilize sand dunes near the lake. 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 weeds and stabilizing dunes and planting vegetation to prevent sand from filling the lake).

- 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.
- 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.

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 population (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, 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 27:183-192.

U.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.

Photo: NRCS

ʻAlae ʻula or Hawaiian moorhen

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. The species' life history and breeding biology are poorly known. It uses a variety of freshwater 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 freshwater 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 are dependent on their parents for several weeks.

DISTRIBUTION:
ʻAlae ʻula generally occurs 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. 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 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. Historically, ʻalae ʻula occurred on all the Main Hawaiian Islands except for Lānaʻi and Kahoʻolawe.

ABUNDANCE: ʻAlae ʻula are quite secretive, and current survey methods are inadequate to accurately estimate population size. Based on biannual (summer and winter) waterbird counts conducted by the Division of Forestry and Wildlife in the years 2000 to 2008, counts of ʻalae ʻula varied from 200 to just under 450 individuals, with a slightly increasing trend. 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: ʻAlae ʻula 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 Kahuku and ʻUkoʻa wetlands and Waialua lotus fields 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, ʻalae ʻula 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. 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*) all potentially prey on adult or young ʻalae ʻula.
- Altered hydrology. Altering wetland habitats for flood control or to serve as municipal water sources makes them generally unsuitable for ʻalae ʻula.
- 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 Hawaiʻi.
- Environmental contaminants. Fuel and oil spills 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.

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 apparently failed because no birds have been sighted since 1985. 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.

- 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.
- 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.
- Conduct a population viability analysis to identify population numbers and time spans that can serve as predictors for the long-term recovery of the ʻalae ʻula.
- Use climate change models to predict sea-level rise, and assess key wetlands to protect/create in light of the analysis.

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.

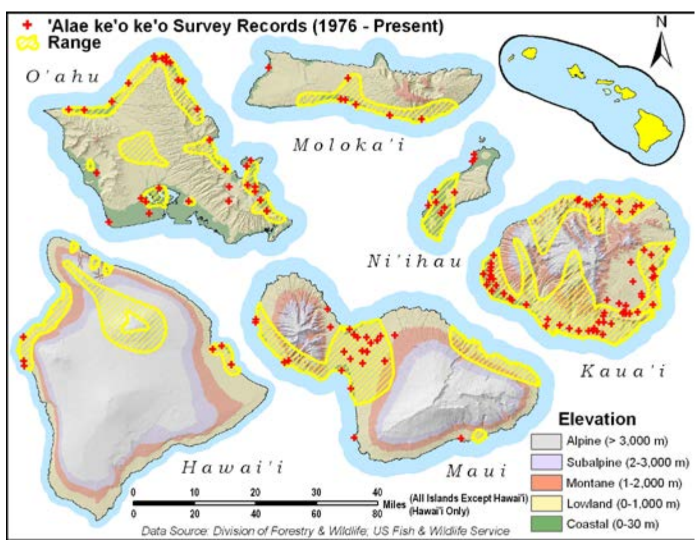

Photo: DOFAW

ʻAlae keʻokeʻo 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 ʻalae keʻokeʻo or Hawaiian coot is a small waterbird (Family: Rallidae) endemic to Hawaiʻi. 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 ʻalae keʻokeʻo 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., taro fields) wetlands and aquaculture ponds. ʻAlae keʻokeʻo 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 rainfall because appropriate 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 (Hanalei, Hulēʻia, Opaekaʻa), Oʻahu (coastal wetlands and reservoirs, such as Lake Wilson and Nuʻuanu

Reservoir, Kahuku Point, and along the windward shore), and Maui (Kanahā and Keālia Ponds, Nuʻu Pond). 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: According to the results of biannual (summer and winter) waterbird counts conducted by DOFAW in the years 1997 to 2006, the population is estimated at 1,500–2,800 individuals, with a slightly increasing population trend.

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 taro fields, but also freshwater reservoirs, canefield reservoirs, sewage treatment ponds, brackish wetlands, and, rarely, saltwater habitats. On Kauaʻi, some birds occur 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 moorhen), ʻalae keʻokeʻo forages in more open water. Logs, rafts of vegetation, narrow dikes, mud bars, and artificial island 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, approximately 31 percent of coastal plain wetlands have been lost. A shift from 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*), barn owls (*Tyto alba*), and bullfrogs (*Rana catesbeiana*) all potentially prey on adults or young.
- Altered hydrology. Altering wetland habitats for flood control or to allow them to serve as municipal water sources makes them generally unsuitable for ʻalae keʻokeʻo.
- 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 Hawaiʻi.
- Environmental contaminants. Fuel and oil spills 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.

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. Actions specific to conservation of ʻalae keʻokeʻo 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.

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 ʻalae keʻokeʻo.
- Conduct a population viability analysis to identify population numbers and time spans that can serve as predictors for the long-term recovery of the ʻalae keʻokeʻo.
- Use climate change models to predict sea-level rise, and assess key wetlands to protect/create in light of the analysis.

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: NRCS

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 2011

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, 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. Both parents incubate eggs and brood young, and fledglings remain with their parents for several months.

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.

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 sugarcane 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: On the basis of biannual waterbird counts conducted by the Division of Forestry and Wildlife, the population is estimated at between 1,100 and 2,100 birds, with an increasing trend.

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, and sugar settling basins), brackish water habitats (coastal ponds, silted fish ponds, 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 with others remain unprotected. 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.

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:

- <u>Habitat loss</u>. 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.
- <u>Introduced and native predators</u>. 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*).
- <u>Altered hydrology</u>. Altering wetland habitats for flood control or to allow them to serve as municipal water sources makes them generally unsuitable for aeʻo.

- 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 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.

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.

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 to predict sea-level rise, and assess key wetlands to protect/create in light of the analysis.

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. U.S. Fish and Wildlife Service, Portland, OR.


Photo: David Leonard, USFWS

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

SPECIES INFORMATION: The mōlī or Laysan albatross is a large, abundant seabird (Family: Diomedeidae) whose breeding range is centered in Hawaiʻi. 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 kaʻupu or black-footed albatross (*P. nigripes*). In Hawaiʻi, 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 kaʻupu, and nest varies from a scrape to a ring-like structure comprising sand, vegetation, and debris. In Hawaiʻi, 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 61 years old.

DISTRIBUTION: Nests throughout the Northwestern Hawaiian Islands (NWHI) and on the Main Hawaiian Islands (MHI) of Kauaʻi and Oʻahu and Lehua Island off Niʻihau. Outside of Hawaiʻi, 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 islands such as Nihoa and Lehua. A majority of the world's mōlī nest within the Hawaiian Islands National Wildlife Refuge (NWR) and Midway Atoll 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*).
- 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 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.

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 Kauaʻi, 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. Establish a breeding colony at James Campbell NWR in Oʻahu, by translocating chicks hatched from the U.S. Navy Pacific Missile Range Facility.
- 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.

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.

References:

Hawaiʻi Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawaiʻi, Center for Conservation Research and Training. Honolulu, Hawaiʻi.

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, Hawaiʻi.

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.

Photo: David Leonard, USFWS

Seabirds

Kaʻupu 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 2005

SPECIES INFORMATION: The kaʻupu or black-footed albatross is the smallest albatross (Family: Diomedeidae) in Hawaiʻi. 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, kaʻupu 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. Kaʻupu 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 Niʻihau in the Main Hawaiian Islands (MHI). Outside of Hawaiʻi, 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 kaʻupu. 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.

CONSERVATION ACTIONS: Actions specific to conservation of kaʻupu 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.

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, Hawaiʻi.

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 – Vulnerable

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 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 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, Hawaiʻi.


Photo: C. S. N. Bailey, NPS

ʻUaʻu or Hawaiian petrel

Pterodroma sandwichensis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Indigenous
NatureServe Heritage Rank G2/T2 –
Species Globally Imperiled/Subspecies Locally Imperiled
IUCN Red List Ranking – Vulnerable
Regional Seabird Conservation Plan – USFWS 2005

SPECIES INFORMATION: The ʻuaʻu or Hawaiian petrel is a medium-sized, nocturnal gadfly petrel (Family: Procellariidae) endemic to Hawaiʻi. 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 ʻW-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, ʻuaʻu 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 Hawaiʻi, they feed primarily on squid, but also on fish, especially goatfish and lantern fish, and crustaceans. ʻUaʻu 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, Hawaiʻi, Kauaʻi, Lānaʻi, and possibly on Molokaʻi. Subfossil evidence indicates that prior to the arrival of Polynesians, ʻuaʻu was common throughout the MHI. At sea, they occur throughout the central tropical and subtropical Pacific Ocean.

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, Hawaiʻi; around 1,600 pairs occur on Kauaʻi; several thousand birds occur on Lānaʻi; and potentially around 50 pairs nest on Molokaʻi.

LOCATION AND CONDITION OF KEY HABITAT: Nests in a variety of remote, inland habitats. On the islands of Hawaiʻi 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 Kauaʻi and Lānaʻi, and West Maui colonies occur in lower-elevation forests dominated by ʻōhiʻa (*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.
- 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.

CONSERVATION ACTIONS: Past actions directed at ʻaʻo (Newell's shearwater [*Puffinus auricularis*]) have often benefited ʻuaʻu populations. These actions include the rescue and rehabilitation of downed fledglings by the Save Our Shearwaters (SOS) program and efforts to shade and curtail resort and event lighting and streetlights. Current and future conservation efforts on Kauaʻi to benefit 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 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 Lānaʻi, Hawaiʻi, Maui, and Kauaʻi and perform surveys on Molokaʻi, Lānaʻi, and Kahoʻolawe to assess ʻuaʻu presence on these islands.
- Continue to identify fallout areas and minimize effects of powerlines and artificial lights.
- Continue to support the SOS program, 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, 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, locate colonies, investigate behavior, determine geographic variability in threats, and evaluate the effectiveness of conservation measures.
- 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.

References:

Hawaiʻi Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawaiʻi, Center for Conservation Research and Training. Honolulu, Hawaiʻi.

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).

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, Hawaiʻi.


Photo: Rachel Seabury, USFWS

Bonin Petrel

Pterodroma hypoleuca

SPECIES STATUS:
State recognized as Indigenous
North American Waterbird Conservation Plan – Moderate concern
Regional Seabird Conservation Plan - USFWS 2005

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 Hawaiʻi (i.e., ʻuaʻu 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 Hawaiʻi, eggs are laid in mid January and chicks fledge by June. Competes with larger ʻuaʻu 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. Outside of Hawaiʻi, 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 Hawaiʻi and Japan.

ABUNDANCE: In the Hawaiian Archipelago, population 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 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 Hawaiʻi 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.

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 post rat eradication.

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.

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: DOFAW

ʻOu 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

SPECIES INFORMATION: The ʻou 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. ʻOu (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. ʻOu (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 Hawaiʻi, 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: ʻOu (Bulwer's petrel) breed throughout the NWHI and on offshore islets of the MHI, including Hulu, Kaeoi, Kāohikaipu, Kapapa, Kaʻula, Lehua, Mānana, Mokeʻehia, Mōkōlea Rock, Moku Lua, Moku Manu, Mokuhoʻoniki, Molokini, and Popoiʻa. Outside of Hawaiʻi, ʻou (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 Hawaiʻi, population 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, ʻou (Bulwer's petrel) were abundant. The worldwide population is unknown.

LOCATION AND CONDITION OF KEY HABITAT: **Terrestrial:** ʻOu (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 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.
- 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.

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.

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: Forest and Kim Starr, USFWS

ʻUaʻu kani or Wedge-tailed shearwater

Puffinus pacificus

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 ʻuaʻu 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. ʻUaʻu 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. 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 will sitting on the water; often follows fishing vessels. In Hawaiʻi, diet primarily consists of larval goatfish, flyingfish, squirrelfish, and flying squid. Like most seabirds ʻuaʻu 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 Hawaiʻi, 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). Outside of Hawaiʻi, 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 Hawaiʻi, population 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 Kaʻula (1,500-2,500 pairs). Smaller populations occur on Moku Manu, Mokuʻauia, Kāpapa, Molokini, Mōkapu Peninsula, Kaʻena Point Natural Area Reserve on Oʻahu, and Kīlauea Point National Wildlife Refuge on Kauaʻi. 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, 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*).
- 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.
- Overfishing. Because ʻuaʻu kani rely on predatory fish to drive prey to the surface, overfishing may be affecting Hawaiian populations.
- Contaminants. Mercury, lead, and organochlorines have been detected in Hawaiian birds.
- Disease. Pox-like lesions have been observed on birds breeding on Maui and Molokaʻi.

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) program, particularly its public 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.

References:

Hawaiʻi Natural Heritage Program [Hawaiʻi Biodiversity and Mapping Program]. 2004. Natural diversity database. University of Hawaiʻi, 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: Forest and Kim Starr, USFWS

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

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 Hawaiʻi, 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., Kaʻula, Lehua, Moku Manu). Outside of Hawaiʻi, Christmas shearwaters nest on islands throughout the central and eastern Pacific. Non-breeding distribution includes the eastern Pacific Ocean.

ABUNDANCE: In Hawaiʻi, 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.

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.

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: Brenda Zaun, USFWS

ʻAʻo or Newell's shearwater

Puffinus auricularis 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 2005

SPECIES INFORMATION: The ʻaʻo 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. ʻAʻo 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. ʻAʻo 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: ʻAʻo nest on Kauaʻi, Hawaiʻi, Molokaʻi, and Lehua, and may also nest on Oʻahu, Maui, and Lānaʻi, but not confirmed. Nesting colonies do not occur outside of Hawaiʻi. 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 ʻaʻo, and the species was thought to be extinct by 1908. The species was rediscovered at sea in 1947 and breeding birds were found on Kauaʻi 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 by approximately 75 percent from 1993 to 2008, 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.
- 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.

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.

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.

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, Hawaiʻi.

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, Hawaiʻi.


Photo: Steve McConnell

ʻAkēʻakē or Band-rumped storm-petrel

Oceanodroma castro

SPECIES STATUS:
Federal Candidate for Listing
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 Maui (in Haleakalā National Park) and the island of Hawaiʻi (in Hawaiʻi Volcanoes National Park) at elevations greater than 1,200 meters (3,900 feet), 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*).
- 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 predator and ungulate eradication or control.

CONSERVATION ACTIONS: Past actions directed at ʻaʻo 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 to benefit the ʻakēʻakē, ʻaʻo, 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 potential sites for the establishment of new breeding colonies.
- Continue efforts to eradicate and control predators and ungulates, particularly on Lehua where birds have been recently observed.
- Continue to identify fallout areas and minimize effects of powerlines and artificial lights.
- Continue to support the SOS program, particularly the public outreach about light fallout and its rescue and rehabilitation program. Consider establishing similar programs on other islands where appropriate.

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) 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.

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.


Photo: Ian Jones, USFWS

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

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 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). 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:
- <u>Introduced predators</u>. 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.

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.

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.

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: Eric VanderWerf

Koaʻe 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 koaʻe kea or white-tailed tropicbird is a showy, white seabird (Family: Phaethontidae), related to boobies and frigatebirds. Six koaʻe kea (white-tailed tropicbird) subspecies are recognized; only one (*P. l. dorothea*) breeds in Hawaiʻi. 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. Koaʻe kea (white-tailed tropicbird) usually forage alone, but occasional with conspecifics, most often far from land; often will follow ships. Koaʻe 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 koaʻe ula or red-tailed tropicbird (*P. rubricauda*). Koaʻe 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 Hawaiʻi, 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: Koaʻe 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 Kauaʻi; Pelekunu Valley, Waikolu, and windward sea cliffs on Molokaʻi; Kaholo Pali, Maunalei Gulch, Hauola Gulch on Lānaʻi ; Kīlauea Crater and windward coast on the island of Hawaiʻi, and the offshore islet Mokoliʻi. A few pairs nest on southeastern Oʻahu. Outside of Hawaiʻi, koaʻe 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 Hawaiʻi, population 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: Koaʻe kea (white-tailed tropicbird) breeds mainly on oceanic islands. Frequently nests in inaccessible crevices or ledges on cliff walls, outside of Hawaiʻi 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.) 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 koaʻe 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: 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 koaʻe 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 survey protocol to assess population status and monitor trends.

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

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

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, mostly on offshore islets, but possibly on Niʻihau, Kaʻula, Lānaʻi, 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 Hawaiʻi, population 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: Koaʻe ʻula (red-tailed tropicbird) breed mainly on oceanic islands and coral atolls with shrubs, including beach magnolia (*Scaevola sericea*) and beach heliotrope (*Tournefortia argentea*). Koaʻe ʻula (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.) and feral cats (*Felis silvestris*). All sites in NWHI are free of rats and cats.

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 koaʻe ʻula (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.

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 koaʻe ʻula (red-tailed tropicbird) include the following:

- Conduct long-term demographic studies 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.

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.


Photo: Holly Freifeld, USFWS

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
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 one (*S. l. plotus*) is 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), 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.


Photo: Jack Jeffery

ʻĀ or Red-Footed Booby
Sula sula

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. 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 Hawaiʻi, 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: ʻĀ (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*) 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 ʻā (red-footed booby) should include the following:

- Eradication and control of introduced predators and rabbits (*Oryctolagus cuniculus*) at current and potential breeding colonies (e.g., on Lehua).
- Eradication of invasive species that may alter ʻā (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 ʻā (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

ʻIwa 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

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 (*Puffinus pacificus*), 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 Hawaiʻi, 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 'iwa (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

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

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: Forest and Kim Starr, USFWS

ʻEwaʻewa 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 ʻewaʻewa 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 ʻewaʻewa (sooty tern) subspecies are recognized, and one (*S. f. oahuensis)* breeds in Hawaiʻi. 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*). ʻEwaʻewa (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 Hawaiʻi, ʻewaʻewa (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 Hawaiʻi, 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: ʻEwaʻewa (sooty tern) breed throughout the NWHI and on Moku Manu off of the island of Oʻahu. Outside of Hawaiʻi, ʻewaʻewa (sooty tern) breed on most islands throughout the world's tropical oceans. Outside the breeding season, ʻewaʻewa (sooty tern) are highly pelagic.

ABUNDANCE: In Hawaiʻi, 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: ʻEwaʻewa (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. ʻIwa or great frigatebirds (*Fregata minor*), cattle egrets (*Bubulcus ibis*), ʻakekeke or ruddy turnstones, (*Arenaria interpres*) ʻaukuʻu or black-crowned night herons (*Nycticorax nycticorax*), Laysan (*Telespiza cantans*) and Nihoa (*T. ultima*) finches will depredate eggs and chicks.
- Overfishing. Because ʻewaʻewa (sooty terns) rely on predatory fish to drive prey to the surface, overfishing may eventually affect Hawaiian populations.
- Oil pollution. ʻEwaʻewa (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 ʻewa ʻewa (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 ʻewaʻewa (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 ʻewaʻewa (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.

Photo: Forest and Kim Starr, USFWS

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 Hawaiʻi. 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 Hawaiʻi, 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 Hawaiʻi, 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 Hawaiʻi, 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 Hawaiʻi, population estimated at 112,000 breeding pairs with the largest populations occurring on Nihoa (35,000 pairs) and Kaʻula (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 Hawaiʻi, 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.
- 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.


Photo: USFWS

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

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 Hawaiʻi: *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 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 Hawaiʻi, 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 and offshore islets of MHI. Outside of Hawaiʻi, 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 Hawaiʻi, 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 Hawaiʻi, 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. ‘Iwa or great frigatebirds (*Fregata minor*), Laysan Finches (*Telespiza cantans*), and shorebirds will depredate eggs and chicks.
- 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: Fefer, USFWS

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

SPECIES 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:

- <u>Introduced predators</u>. 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.

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: David Leonard, USFWS

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 Hawaiʻi, 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 Hawaiʻi, 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 Oʻahu. Outside of Hawaiʻi, 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 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 Oʻahu, the number of pairs has increased from one to greater than 250 between 1961 and 2005. 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.), 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.

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).

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.

References:

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.

American Wigeon

Anas americana

SPECIES STATUS:
State recognized as Indigenous

Photo: Eric VanderWerf

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 Hawaiʻi, 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 Hawaiʻi, State Waterbird counts of American wigeons from 1986 to 2003 have averaged 19.5 ± 8.4 (SE) 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 Hawaiʻi, wigeons winter at Kanahā Pond State Wildlife Sanctuary and Kealia Pond National Wildlife Refuge on Maui, and near Waipiʻo on Oʻahu. 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 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: 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 available from website:
http://www.birds.cornell.edu/programs/AllAboutBirds/BirdGuide/Northern_Shoveler.html

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 Hawaiʻi, 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 1986 to 2003 averaged 296 ± 30.4 (SE) birds. There is some evidence of a downward trend of about ten birds per year over that period.

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 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: 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: 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 Hawaiʻi, 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 1986 to 2003 provide an average of 190 ± 29 (SE) 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 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: 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 across the Pacific with reference to the Hawaiian Islands. Studies in Avian Biology No. 22: 124-132.


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 Hawaiʻi, 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, Hawaiʻi State waterbird surveys of lesser scaups from 1986 to 2003 have averaged 55.7 ± 20.4 (SE) 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 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: 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.


Photo: DOFAW

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 Hawaiʻi 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. Hawaiʻi 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 Hawaiʻi to Japan. In Hawaiʻi, 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 Oʻahu population was estimated at about 15,000. From 1986 to 2004, the average number of kōlea in Hawaiʻi State waterbird surveys has been about 950 ± 170 (SE) 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 Hawaiʻi 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 Hawaiʻi, 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 Hawaiʻi, 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 Hawaiʻi, kōlea come into contact with herbicides and pesticides that may be harmful. Aircraft strikes at Līhuʻe (Kauaʻi) and Kahului (Maui) airports occur occasionally 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 Hawaiʻi 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 Hawaiʻi, 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: Eric VanderWerf

Migratory Birds

ʻŪlili or Wandering Tattler

Heteroscelus incanus

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan—Moderate concern

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 1986 through 2004 yield an average summer count for the MHI of 81 ± 8.7 (SE) and a winter MHI count of 74 ± 6.5 (SE). 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

Kioea or Bristle-thighed Curlew

Numenius tahitiensis

SPECIES STATUS:
State recognized as Indigenous
IUCN Red List Ranking-Vulnerable

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 6.3 ± 1.5 (SE) birds in the MHI in summer, and 9.7 ± 3.9 (SE) 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 Hawaiʻi 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.


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, 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 60percent (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 1986 to 2004, based on State waterbird surveys, was 512 ± 101 (SE), while during breeding season counts averaged 458 ± 62 (SE). 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 ʻakekeke 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 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 ʻakekeke 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 postfledging-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 available from website:
http://animaldiversity.ummz.umich.edu/site/accounts/pictures/Calidris_alba.html

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 Hawaiʻi 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 Hawaiʻi, based on State waterbird surveys from 1986 through 2003 yield an average summer count for the MHI of 138 ± 36 (SE), and a winter MHI count of 272 ± 32.6 (SE). 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 Hawaiʻi include loss and degradation of habitat and avian disease.

CONSERVATION ACTIONS: To protect the ability of wintering hunakai 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 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.

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—Critically 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. A small population of Nihoa millerbirds was translocated from Nihoa Island to Laysan Island, which has a land area of approximately 411 hectares (1,016 acres) and appears to be increasing steadily.

ABUNDANCE: The most recent population estimate on Nihoa Island was approximately 650 birds in 2009. In 2011 and 2012, 50 millerbirds (24 and 26, respectively) were translocated to Laysan Island. By September 2014, the population was estimated at approximately 164 birds.

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, 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.

MONITORING: Continue transect 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:

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, Hawaiʻi.

Northwestern Hawaiian Islands Passerines

Photo: Kate Willis, USFWS

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 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 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) has conducted transect surveys at Laysan Island during most years in 1966–2012. Based on these surveys, the average population size has been estimated as 10,000 birds. The 1998 population size estimates for the Laysan, Southeast, and Grass populations were 9,911, 350, and 30, respectively, which are within the typical range of variation observed since the 1960s.

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. 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.

MONITORING: Continue current program of transect counts 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.
- Assess which management options (e.g., additional translocations, or supplementation of small populations with birds from Laysan, or both) would be most beneficial in terms of extinction risk reduction.

References:

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. 2014. Laysan Finch (*Telespiza cantans*) 5-Year Review, Short Form Summary. U.S. Fish and Wildlife Service, Honolulu, Hawai'i.

Northwestern Hawaiian Islands Passerines

Photo: Craig Rowland, USFWS

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
Northwestern Hawaiian Islands Passerines Recovery Plan—USFWS 1984

SPECIES INFORMATION: The Nihoa finch 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 is 2,800 birds based on surveys conducted in 2007.

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.

MONITORING: Continue current program of transect counts 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.

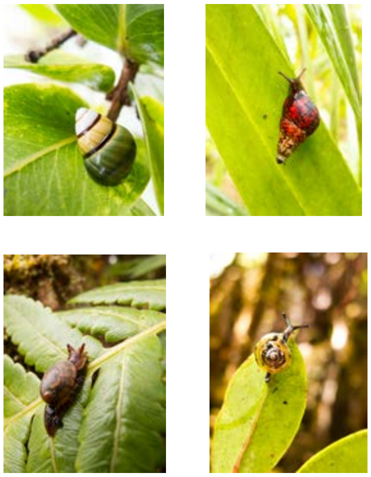
References:

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, Hawaiʻi.

Terrestrial Invertebrates



Upper left: *Achatinella byronii*, Upper right: *Laminella sanguinea*, Lower left: *Succinea* sp. Lower right: *Philonesia* sp. Photos by: D. R. Sischo

Land snails

Orders Stylommatophora, Archaeogastropoda

ORDERS INCLUDE:
44 Achatinelline species Federally/State Listed as Endangered
13 Native Families
51 Native Genera
767+ Native Species
767+ Endemic Species

GENERAL INFORMATION: The Hawaiian Islands hosted one of the most spectacular evolutionary radiations of land snails known to science with 98 percent of the 767 nomenclaturally 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. There are 60 described species in the family Helicarionidae, 56 in Pupillidae, 42 in Succineidae, 14 in Helicinidae, ten in Zonitidae, ten in Ellobiidae (native but mostly not endemic), two in Hydrocenidae, and one in Punctidae. The systematics of the amastrids, achatinellids, helicarionids, pupillids, helicinids, and zonitids was revised in the first half of the 20th century, but these taxonomies are currently under revision using modern molecular genetic techniques combined with morphological analyses. 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 to 90 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* (see species profiles), 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: 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 land snails should include:

- Systematic surveys to determine the geographic ranges of all extant species.
- Systematic surveys of all extant populations to determine abundance and threats.
- Systematic surveys to locate unknown populations.
- Conservation of remaining native forests from further loss and/or degradation.
- Localized predator control.
- Establish populations in habitat protected by predator-proof fencing.
- Captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of populations.

MONITORING: Implement scientifically robust monitoring of priority species and populations to assess trends and respond with appropriate conservation measures.

RESEARCH PRIORITIES:

- Conduct life history studies to quantify growth, population size, age distribution, and habitat needs.
- Develop and refine survey protocols to facilitate the collection of useful population data.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

Cowie RH, Evenhuis NL, Christensen CC. 1995. Catalog of the Land and Freshwater Molluscs of the Hawaiian Islands. Leiden (Netherlands): Backhuys Publishers.

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.

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

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Photo: W. P. Mull; *Achatinella* spp.

Oʻahu Tree Snails

Achatinella spp.

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 for the Oʻahu Tree Snails of the Genus *Achatinella* – USFWS 1992

SPECIES INFORMATION: The entire genus *Achatinella* consisting of 41 species of small, colorful tree snails (Family: Achatinellidae), is endemic to Oʻahu; 22 species are believed to be extinct and 18 are near extinction. Although varied in color patterns and shapes, all are approximately two centimeters (.75 inch) in length, and most have smooth, glossy oblong or ovate shells that are decorated with various colors. Based on their occurrence in Native Hawaiian stories and their use in leis, Oʻahu tree snails must have been very abundant when Polynesians arrived in Hawaiʻi. Oʻahu tree snails are nocturnal and graze on fungus that grows on the leaves of native plants. Although native snails are sometimes found on non-native plants it is not known if the fungus on these introduced species is sufficient to support healthy populations. Adult snails are hermaphroditic and can live for many years, although growth rates and fecundity are very low. For example, *A. mustelina* does not become sexually mature for three to five years, may live for over ten years, and only produces four to seven offspring per year. Young are born alive.

DISTRIBUTION: Currently, Oʻahu tree snails are restricted to remnant native forest on the highest ridges of the Koʻolau and Waiʻanae ranges on the island of Oʻahu. Historically, the genus was widely distributed from near sea level along the windward coast to the central plains and throughout the Koʻolau and Waiʻanae mountains.

ABUNDANCE: Unknown. A lack of systematic, island-wide surveys impedes any effort to estimate the population sizes of most of the remaining species. However, a loss of 75 to 95 percent of native habitats supports a conclusion that the remaining populations are restricted and small. Two species, *A. mustelina* and *A. sowerbyana*, are believed to be the most abundant of the extant species. Population estimates for *A. mustelina* are just under 1,000 individuals.

LOCATION AND CONDITION OF KEY HABITAT: All *Achatinella* are arboreal, living in trees and bushes where they feed on fungi on the leaves and trunks. Oʻahu tree snails occur in a variety of habitats including dry, mesic, and wet forests and shrublands. Condition of occupied habitat varies considerably. Currently, lands managed by the State of Hawaiʻi, the U.S. Military, and The Nature Conservancy support populations of Oʻahu tree snails.

THREATS: Historically, the loss of native forest habitat and the introduction of rats (*Rattus exulans*) likely affected snail populations; the impact of collecting for leis and other ornaments on snail populations is unknown but likely contributed to some declines. In the recent past, the introduction of additional rat species, over-collection, and the introduction of the carnivorous snail *Euglandina rosea* have resulted in declines in the genus. Ironically, *E. rosea* was introduced to control the giant African snail (*Achatina fulica*) a non-native, agricultural pest. Current threats include the continued degradation of habitat by non-native, invasive vegetation, especially strawberry guava (*Psidium cattleianum*), Christmas berry (*Schinus terebinthifolius*), silk oak (*Grevillea banksii*), shrub verbena (*Lantana camara*), and Koster's curse (*Clidemia hirta*). Pigs (*Sus scrofa*) also degrade habitat and predation by rats and introduced snails continues to be a problem. Low reproductive rates and limited dispersal abilities increase the vulnerability of this genus.

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. A captive breeding program at the University of Hawaiʻi at Mānoa supports at least two species, *A. apexfulva* and *A. fuscobasis*, that are extinct in the wild. This facility has been successful in breeding snails. The U.S. Army is actively managing populations of *A. mustelina* under a Biological Opinion regarding continued military training issued by the USFWS. In addition to common statewide and island conservation actions, specific management directed toward Oʻahu tree snails should include:

- Protection of all existing habitat and restoration and management of potentially suitable but degraded habitat, including rat and *E. rosea* control.
- Continuation of captive propagation and the initiation of a program to re-introduce snails to restored habitats.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue surveys of populations and their distribution in known and potential habitats.
- Continue surveys of predator populations and non-native vegetation.

RESEARCH PRIORITIES:

- Conduct life history studies to quantify growth, population size, age distribution, and habitat needs.
- Develop and refine survey protocols to facilitate the collection of useful population data.

References:

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.

Photo: *Achatinella* apexfulva

O'ahu tree snails

Achatinella apexfulva

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

Achatinella apexfulva was the first Hawaiian tree snail species described by Western science. In 1786 Captain George Dixon (English Royal Navy Officer and commander of the Queen Charlotte), while anchored off the coast of O'ahu, was given a lei made entirely of *A. apexfulva* shells. This lei, brought to England, was the sample from which the genus was described. This species is endemic to the northern Ko'olau mountains of O'ahu where it was once widespread in mid-upper elevation habitat. Currently no wild snails are known to exist, and as of May 12, 2015, only one adult snail was left in the University of Hawai'i's tree-snail captive rearing facility.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli, or singing snails, of Hawai'i.

DISTRIBUTION: Presumed extinct in the wild. Present only in captive propagation.

ABUNDANCE: Fewer than five snails.

LOCATION AND CONDITION OF KEY HABITAT: Prior to extirpation snails occurred in mesic to wet forest habitat of the northern Ko'olau mountains of O'ahu.

THREATS: The small founder population of *Achatinella apexfulva,* currently in captive propagation, is at risk of extinction.

If unknown wild populations still persist they are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea,* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase their vulnerability to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Should populations be discovered, conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING: Continue propagation efforts for captive population, and implement scientifically robust monitoring of populations, should they be found, to assess trends and threats.

RESEARCH PRIORITIES:

- Develop cryo-storage techniques, to take advantage of future cloning opportunities.
- Improve captive rearing techniques.

References:

Alison Kay. 1963. *Achatinella apexfulva*: A beginning and an end. Hawaiian Shell News. Vol XI, No. 7, 3.

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.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D. R. Sischo; *Achatinella bulimoides*

O‘ahu tree snails

Achatinella bulimoides

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella bulimoides* is endemic to the windward and leeward slopes of the northern Ko‘olau Mountains of O‘ahu. With a large historical range extending from Kawainui Gulch to south Kaukonahua, *A. bulimoides* in recent times was thought to be extinct, until one population was located in 2004 on a windward slope of Punalu‘u Valley. Since 2004 two more small populations have been located, all occurring on the windward slopes of Punalu‘u Valley.

Members of the genus *Achatinella* are all endemic to the island of O‘ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five 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. Having beautiful shells, Hawai‘i’s tree snails have been described as the “jewels of the forest” and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention k ahuli, or singing snails, of Hawai‘i.

DISTRIBUTION: The current known distribution of this species is restricted to three populations in a single valley on the windward side of the Ko`olau mountains above 610 meters (2,000 feet) elevation. This species is represented in captive propagation.

ABUNDANCE: The three wild populations total fewer than 30 known snails. Fewer than six snails are present in the captive population.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to wet forests along the windward slopes of the Ko‘olau mountains, at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon..

Photo: D. R. Sischo; *Achatinella byronii*

O'ahu tree snails

Achatinella byronii/ decepiens

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella byronii* and *Achatinella decipiens* were historically considered to be two distinct species, and by some subspecies. Based on current genetic and morphological data, the distinctions between the two species do not hold up. For conservation purposes *A. byronii* and *A. decipiens* are managed as a single species. *A. byronii/decipiens* is endemic to the northern Ko'olau Mountains of O'ahu where it is currently one of the most abundant of the extant *Achatinella* species. *A. byronii/decipiens* is distinguishable from other *Achatinella* species by unique irregular wrinkles on the body whorl of most shells.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli, or singing snails of Hawai'i.

DISTRIBUTION: This species is restricted to the northern Ko'olau Mountains with five populations at elevations above 610 meters (2,000 feet). One population is kept in captive propagation.

ABUNDANCE: Not widely distributed but locally abundant, wild populations total almost 1000 snails. There are four snails in captivity.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to wet forests along the windward slopes of the Ko'olau Mountains, at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase their vulnerability to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D. R. Sischo; *Achatinella concavospira*

O'ahu Tree Snails
Achatinella concavospira

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic
IUCN Red List Ranking – Critically endangered

SPECIES INFORMATION: *Achatinella concavospira* is endemic the Central and Southern Wai'anae Mountains of O'ahu. Currently it is one of only two remaining *Achatinella* species from the region. Historically, populations were known from locations throughout the present-day Honouliuli State Forest Reserve. While *A. concavospira* individuals have similar shell coloring to some morphs of *A. mustelina* (also from the Wai'anae Mountains), genetic studies have indicated that *A. concavospira* is more closely related to *A. apexfulva* from the Ko'olau Mountains.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaii's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawai'i.

DISTRIBUTION: Central and southern Wai`anae Mountains above 610 meters (2,000 feet). t elevation.

ABUNDANCE: One population of over 100 individuals protected by a predator-proof exclosure, and fewer than 100 total snails in seven small populations outside the predator-proof exclosure.

LOCATION AND CONDITION OF KEY HABITAT: This species is restricted to pockets of remaining native mesic forest habitat in the upper elevations of the Wai'anae Mountains.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, habitat fragmentation, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross-reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: J. Prior; *Achatinella fulgens*

Terrestrial Invertebrates

O'ahu tree snails

Achatinella fulgens

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella fulgens* is endemic to the southern Ko'olau Mountains of O'ahu, with a historical range extending from Wa'ahila Ridge to Niu Valley. In recent times, *A. fulgens* has experienced drastic range reductions with only one known population left. Interestingly, remaining *A. fulgnes* occur exclusively on the trunks and branches of invasive guava trees. Also worth noting is that this remaining population occurs at approximately 400 meters (1300 feet), the lowest of any extant *Achatinella* species.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7–20.4 millimeters (0.7–0.8 inches) and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawai'i.

DISTRIBUTION: This species remains in only one valley in the southern Ko'olau Mountains. Elevation is approximately 400 meters. Present in captive propagation.

ABUNDANCE: The wild population has fewer than ten known snails and the captive population has one snail.

LOCATION AND CONDITION OF KEY HABITAT: The remaining snails are living on the trunks of mature guava trees in a gulch on private land. It is unlikely that non-native guava trees are ideal habitat, but this is the remaining habitat that exists within their.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: W. P. Mull; *Achatinella* spp.

O‘ahu tree snails

Achatinella fuscobasis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella fuscobasis* was historically abundant in summit areas on the leeward slopes of the southern Ko‘olau Mountains of O‘ahu. In recent times, *A. fuscobasis* has experienced drastic population declines and range reductions.

Members of the genus *Achatinella* are all endemic to the island of O‘ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawai‘i.

DISTRIBUTION: Though formerly abundant in the southern Ko‘olau mountains, this species has nearly vanished from the wild. One population remains in a single valley above 610 meters (2,000 feet). This species is kept in captive propagation.

ABUNDANCE: One wild population is known. The captive population totals around 100 snails.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species consists of native dominated wet-forest habitat in protected summit areas of the Ko‘olau Mountains.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.

- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D. R. Sischo; *Achatinella lila*

O'ahu tree snails

Achatinella lila

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella lia* used to be one of the more abundant species in the northern Ko'olau Mountains of O'ahu, however recent extirpations have restricted *A. lila* to only two locations on the windward slopes of a single valley. Fortunately, this species has survived relatively well in captive propagation.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 – 20.4 mm and give live birth of 3-5 offspring per year. Members of the genus typically live upwards of 10 years and are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaii's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention Kahuli or singing snails of Hawai'i.

DISTRIBUTION: This species is restricted to two locations in the Northern Ko'olau Mountains above 610 meters (2,000 feet) elevation. This species is kept in captive propagation and is planned for relocation to a predator-proof exclosure on the Ko'olau summit.

ABUNDANCE: The two wild populations total around 100 snails. There are 200 snails in captive propagation.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to discrete areas along the slopes and summit of the Ko'olau Mountains at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.

- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D.R. Sischo; *Achatinella livida*

O'ahu tree snails

Achatinella livida

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella livida* is endemic to the northern Ko'olau Mountains of O'ahu, where this species has experienced massive range reductions and local extirpations. Currently, *A. livida* is only known from five discrete sites along the summit. *A. livida* is now the northernmost occurring *Achatinella* spp. in the Ko'olau Mountains.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawai'i.

DISTRIBUTION: This species is the northernmost *Achatinella* species known in the Ko`olau Mountains and is limited to five sites. This species is kept in captive propagation.

ABUNDANCE: There are fewer than 100 individuals remaining in four wild populations. There is one snail in captivity.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to discrete areas along the windward slopes and summit of the Ko'olau Mountains at elevations above 610 meters (2,000 feet).

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.

- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D.R. Sischo; *Achatinella mustelina*

Oʻahu tree snails

Achatinella mustelina

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella mustelina* is endemic to the Waiʻanae Mountains of Oʻahu and is currently one of the most widespread and abundant members of its genus. Populations now mostly inhabit discrete patches of mesic and wet forest habitat above 610 meters (2,000 feet). Because this species is so widespread, it has been divided into six Evolutionary Significant Units (ESU). ESUs are managed as distinct populations for conservation and management purposes. Though the species is widespread as a whole, the individual ESUs vary in their rarity.

Members of the genus *Achatinella* are all endemic to the island of Oʻahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawaiʻi.

DISTRIBUTION: Waiʻanae Mountains above 610 meters (2,000 feet) elevation. The comparatively wide geographical range of this species is divided into six Evolutionarily Significant Units (ESUs) to protect the remaining genetic diversity. Once contiguous across the mountain range, this species is now restricted to fragmented populations within the ESUs.

ABUNDANCE: This species is represented in four predator-proof exclosures, captive propagation and 110 wild populations.

LOCATION AND CONDITION OF KEY HABITAT: This species occupies remnant native mesic and wet forest habitat above 610 meters throughout the Wai`anae Mountains.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.

Photo:. J. Lau; *Achatinella pupukanioe*

Oʻahu tree snails

Achatinella pupukanioe

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella pupukanioe* is endemic to the central and southern Koʻolau Mountains of Oʻahu. This species was last seen in 1980 and was presumed extinct until a small population of seven individuals was located near the summit of the central Koʻolau Mountains.

Members of the genus *Achatinella* are all endemic to the island of Oʻahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawaiʻi

DISTRIBUTION: Formerly known from the leeward summits of the central and southern Koʻolau Mountains, this species remains only near the summit of one ridge in the northern Koʻolaus.

ABUNDANCE: The only known wild population has 7 snails.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to one ridge, in wet forest, on the leeward side of the Koʻolau Mountains above 610 meters (2,000 feet).

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.

- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson’s chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O’ahu Tree Snails of the genus *Achatinella*. Portland, Oregon..


Photo: D. R. Sischo; *Achatinella sowerbyana*

O'ahu tree snails

Achatinella sowerbyana

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Achatinella sowerbyana* is endemic to the northern Ko`olau Mountains, where it is one of the most abundant extant *Achatinella* species. Populations are typically restricted to small patches of wet forest habitat in summit regions.

Members of the genus *Achatinella* are all endemic to the island of O'ahu. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of ten years. They are 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. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawai'i.

DISTRIBUTION: This species is somewhat broadly distributed in the Northern Ko`olau Mountains at elevations exceeding 610 meters (2,000 feet).

ABUNDANCE: Of the 15 wild populations that are monitored, three populations exceed 100 snails each. The known abundance of wild snails is approximately 500 individuals and there may still be discrete small populations that have not been located.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to discrete valleys along the windward slopes and summit areas in wet forest of the Ko`olau Mountains, at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D. R. Sischo; A*mastra cylindrica*

Terrestrial Invertebrates

Oʻahu terrestrial snails

Amastra cylindrica

SPECIES STATUS:
State recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Amastra cylindrica* is endemic to the Waiʻanae Mountains of O`ahu and although it is not federally listed as endangered, is one of the rarest mollusks in the world. Currently, this species entire known range is restricted to habitat within a small hanging valley. Unfortunately, this small patch of forest is under constant threat from invasive weeds and snail predators. *A. cylindrica* is ground-dwelling and feeds on decaying leaf material.

DISTRIBUTION: One population in Mikilua Gulch on the Lualualei Naval Reserve in the southern Wai`anae Mountains, above 610 meters (2,000 feet). One population is kept in captive propagation

ABUNDANCE: There are fewer than 12 snails in the wild population and over 500 snails in captive propagation.

LOCATION AND CONDITION OF KEY HABITAT: The remaining wild snail site is small (approximately 10x10 meters), and consists of four large trees (*Pisonia umbellifera*) with a substrate of rocky talus.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp*.)*, *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.


Photo: D. R. Sischo; *Amastra spirizona*

O'ahu terrestrial snails

Amastra spirizona

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Amastra spirizona* is endemic to mesic and wet forest habitat in the Wai`anae Mountains of O'ahu. Although it is not federally listed as endangered, this species is extremely rare. Currently, only two wild populations are known to exist. Where it occurs, *A. sprizona* can be found on the ground and in the trees where it feeds on dead and decaying leaf material.

DISTRIBUTION: This species is only found above 610 meters (2,000 feet) in two valleys in the northern and central Wai`anae Mountains. This species is kept in captive propagation.

ABUNDANCE: There are two wild populations of less than 50 snails and one captive population of less than five snails.

LOCATION AND CONDITION OF KEY HABITAT: This species currently occupies habitat dominated by *Freycinetia arborea* (i`e i`e) and *Asplenium* sp. (birdsnest ferns) along rocky talus outcroppings on shaded hillside in discreet locations in the Wai`anae Mountains.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.*)*, *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.

- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

Photo: D. R. Sischo; *Auriculella pulchra*

O‘ahu tree snails

Auriculella pulchra

SPECIES STATUS:
State Recognized as Endemic

SPECIES INFORMATION: *Auriculella pulchra* is a small tree snail in the subfamily Auriculellinae, endemic to the central and northern Ko‘olau Mountains of O‘ahu, where it was once widespread and locally abundant. This species was thought to be extinct until a small population was discovered in 2014 along the summit of Poamoho. *Auriculella* species are similar to other tree snails within the family Achatinellidae, in that they are arboreal and feed on fungus and algae that grow on leaf surfaces.

DISTRIBUTION: This species is restricted to an unknown number of discreet populations on the windward facing cliffs of the Ko‘olau Mountains above 610 meters (2,000 feet) elevation.

ABUNDANCE: Unknown. At least one population of over 30 individuals.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this species is limited to discrete areas along the windward slopes of the Ko`olau Mountains in wet forest at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson’s chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.

- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

Yeung NW, Chung, D, Sischo, DR, Hayes, KA. 2015. Rediscovery and Expansion of an extinct Hawaiian species: *Auriculella pulchra* Pease, 1868 (Gastropoda: Pulmonata: Achatinellidae) in review.

Photo: K. A Hayes & N. W. Yeung; *Cookeconcha hystricella*

Oʻahu tree snails

Cookeconcha hystricella

SPECIES STATUS:
State Recognized as Endemic

SPECIES INFORMATION: *Cookeconcha hystricella* is in the Endodontidae family, and is endemic to the island of Oʻahu. Although it is not federally listed as endangered, this species is extremely rare and now only occurs at one known location. In fact, this is the only species known from the entire family to still occur in the main Hawaiian Islands. Little is known of the biology and life history of this elusive species.

DISTRIBUTION: Range restricted to elevations above 610 meters (2,000 feet) in the Waiʻanae Mountains.

ABUNDANCE: Present in discrete locations but abundance data not available.

LOCATION AND CONDITION OF KEY HABITAT: This species is currently restricted to small, fragmented locations in the southern Wai`anae Mountains in mesic forest at elevations above 610 meters.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.

- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.
- Research basic life history and ecology.

References:

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, Hawaiʻi.

Photo: D. R. Sischo; *Kaala subrutila*

O'ahu terrestrial snails

Kaala subrutila

SPECIES STATUS:
State Recognized as Endemic

SPECIES INFORMATION: *Kaala subrutila* is a species in the family Helicarionidae and is the only species described from this genus. *K. subrutila* is endemic to bog habitat on the summit of Mount Ka'ala above 900 meters (3,000 feet), on the island of O'ahu. Little is known of this snail other than that it is predominantly ground dwelling. Due to its very small native range, and the presence of invasive predators, *K. subrutila* is highly vulnerable to extinction.

DISTRIBUTION: Restricted to the highest point of the Wai`anae Mountains on Mount Ka`ala, above 900 meters elevation.

ABUNDANCE: Little is known regarding the abundance of the Ka`ala snail.

LOCATION AND CONDITION OF KEY HABITAT: Mount Ka'ala is the highest point on O'ahu (1,227 meters (4,025 feet) elevation) and home to this rare ground-dwelling snail.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea, Oxychilus alliarius* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.

- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.
- Research basic life history and ecology.

References:

Curry, PA and NW Yeung. 2013. Predation on endemic Hawaiian land snails by the invasive snail *Oxychilus alliarius*. Biodiversity and Conservation 22:3165-3169.

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, Hawaiʻi.


Photo: K. A Hayes & N. W. Yeung; *Laminella aspersa*

Maui terrestrial snails

Laminella aspera

SPECIES STATUS:
State Recognized as Endemic

SPECIES INFORMATION: *Laminella aspersa* is endemic to mesic and wet forest habitats of East Maui. Although it is not federally listed as endangered, this species is extremely rare. Thought to be extinct, the only known population was discovered in 2014. Where it occurs, *L. aspersa* can be found on the ground and in trees where it feeds on dead and decaying leaf material.

DISTRIBUTION: Recently known only from one location on East Maui.

ABUNDANCE: Data not available

LOCATION AND CONDITION OF KEY HABITAT: Data not available.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high winds, fires, and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

Photo: D. R. Sischo; *Laminella sanguinea*

O'ahu terrestrial snails

Laminella sanguinea

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Laminella sanguinea* is in the family Amastridae. This species is endemic to mesic forest in the Wai'anae Mountains of O'ahu. Although it is not federally listed as endangered, this species is extremely rare. Where it occurs, *L. sanguinea* can be found on the ground and itrees where it feeds on dead and decaying leaf material.

DISTRIBUTION: This species is endemic to the Wai'anae Mountains and the current range extends from Mt. Ka'ala in the north to Palikea in the south above 610 meters (2,000 feet) elevation. One population is kept in captive propagation.

ABUNDANCE: Two small populations of less than 20 snails are protected by predator-proof exclosures. Three wild populations total fewer than ten snails. There are fewer than 20 snails in captive propagation.

LOCATION AND CONDITION OF KEY HABITAT: This species currently occupies habitat dominated by *Freycinetia arborea* (i`e i`e) along rocky areas on shaded hillside in two locations in the Wai`anae Mountains.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O'ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.


Photo: D. R. Sischo; *Newcombia cumingii*

Maui tree snails

Newcombia cumingii

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Newcombia cumingii* is in the family Achatinellidae, subfamily Achatinellinae. This species is endemic to the island of Maui, where it is now only known to occur at two locations in the West Maui Mountains. Unlike other members of the subfamily, these tree-snails have highly textured, elongated shells making them very cryptic.

Members of the genus *Newcombia* are endemic to the islands of Molokaʻi, Lanaʻi, and Maui and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7–20.4 millimeters (0.7–0.8 inches) and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years and are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches and trunks of host trees.

DISTRIBUTION: Found only in discrete areas of West Maui.

ABUNDANCE: Fewer than 30 individuals were counted in the wild.

LOCATION AND CONDITION OF KEY HABITAT: One population exists in fragmented mesic habitat, while the other in intact mesic habitat, on West Maui.

THREATS: Wild populations are susceptible to predation by rats, cannibal snails (*Euglandina rosea*), and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of cannibal snails and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosures.

- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui. Federal Register 78:32015-32065.

Photo: D. R. Sischo; *Partulina mighelsiana*

Moloka`i tree snails

Partulina mighelsiana

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina mighelsiana* is endemic to the eastern mountains of Molokaʻi. Although not federally listed, this species is rare and now only exists in small isolated fragments of its former range.

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years. They are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails of Hawaiʻi.

DISTRIBUTION: Formerly widespread, this species is now restricted to upper elevation habitat (above 610 meters (2,000 feet)) in the eastern mountains of Molokaʻi.

ABUNDANCE: Last surveyed in the early 2000s, wild specimens did not exceed 100 snails.

LOCATION AND CONDITION OF KEY HABITAT: Mesic and wet forest habitat in the eastern mountains of Molokaʻi. Habitat is largely intact.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.), *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.

- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.


Photo: D. R. Sischo; *Partulina proxima*

Moloka`i tree snails
Partulina proxima

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina proxima* is endemic to the eastern mountains of Molokaʻi. Although not federally listed, this species is rare and now only exists in small isolated fragments of its former range. The only known populations now exist entirely within The Nature Conservancy's Kamakou Preserve.

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years. They are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli or singing snails, of Hawaiʻi.

DISTRIBUTION: This species remains in discrete upper elevation habitat (above 610 meters (2,000 feet)) in the eastern mountains of Molokaʻi. Remaining populations are known to occur in native wet forest habitat within the Nature Conservancy's Kamakou Preserve.

ABUNDANCE: No recent abundance information is available.

LOCATION AND CONDITION OF KEY HABITAT: Remaining populations are known to occur in native wet forest habitat within The Nature Conservancy's Kamakou Preserve.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.*)*, *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation, and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:
- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:
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, Hawaiʻi.

Photo: D. R. Sischo; *Partulina redfieldi*

Terrestrial Invertebrates

Moloka`i tree snails

Partulina redfieldi

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina redfiedli* is endemic to the eastern mountains of Molokaʻi. Although not federally listed, this species is rare and now only exists in small isolated fragments of its former range.

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years. They are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli, or singing snails, of Hawaiʻi.

DISTRIBUTION: This species is restricted to isolated areas of upper elevation forest (above 610 meters (2,000 feet)) on Moloka`i.

ABUNDANCE: Surveys from 2010 found three distinct populations of this species with number of snails nearing 200 individuals.

LOCATION AND CONDITION OF KEY HABITAT: Limited to fragmented, native-dominated habitat in the Kamakou Preserve on Molokaʻi.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.*)*, *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires, and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.

- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

Photo: D. R. Sischo; *Parulina tessellata*

Moloka`i tree snails

Partulina tessellata

SPECIES STATUS:
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina tessellate* is endemic to the eastern mountains of Molokaʻi. Although not federally listed, this species is rare and now only exists in small isolated fragments of its former range.

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7 to 20.4 millimeters and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years. They are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention kahuli, or singing snails, of Hawaiʻi.

DISTRIBUTION: Likely remaining in discrete locations of appropriate habitat on northeastern Molokaʻi but current distribution is unknown.

ABUNDANCE: Data deficient.

LOCATION AND CONDITION OF KEY HABITAT: Data deficient.

THREATS: Wild populations are susceptible to predation by rats (*Rattus* spp.*)*, *Euglandina rosea* and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:
- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of *Euglandina rosea* and Jackson's chameleons.

- Establish populations within protected habitat of predator-proof exclosure structures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.

U.S. Fish and Wildlife Service. 1992. Recovery plan for the O’ahu Tree Snails of the genus *Achatinella*. Portland, Oregon.

Photo: D. R. Sischo; *Partulina semicarinata*

Lanaʻi tree snails

Partulina semicarinata

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina semicarinata* is one of only two remaining *Partulina* species endemic to the island of Lana'i. Remaining populations exist exclusively in the upper elevations summit habitat above 600 meters (2,000 feet). This species can be distinguished from other *Partulina* species by a distinctive keel that runs along the last whorl.

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7–20.4 millimeters (0.7–0.8 inches) and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years and are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention Kahuli or singing snails of Hawaiʻi.

DISTRIBUTION: This species is currently only found at two locations along the Munro trail at elevations above 600 meters. This species is currently in the captive propagation facility on Oahu.

ABUNDANCE: Current extensive surveys for this species located fewer than 20 individuals. There is one individual in the captive propagation lab.

LOCATION AND CONDITION OF KEY HABITAT: This species is restricted to fragmented populations in habitat dominated by native vegetation at elevations on Lana`i above 600 meters.

THREATS: Wild populations are susceptible to predation by rats, cannibal snails (*Euglandina rosea*), and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of cannibal snails and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui. Federal Register 78:32015-32065.

Photo: D. R. Sischo; *Partulina variabilis*

Lanaʻi tree snails

Partulina variabilis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
IUCN Red List Ranking – Critically Endangered

SPECIES INFORMATION: *Partulina variabilis* is one of only two remaining *Partulina* species endemic to the island of Lanaʻi. Remaining populations exist exclusively in the upper elevations summit habitat above 600 meters (2,000 feet).

Members of the genus *Partulina* are endemic to the islands of Molokaʻi, Lanaʻi, Maui and Hawaiʻi and share many life history characteristics with the federally listed genus *Achatinella*. These large arboreal snails range in size from 16.7–20.4 millimeters (0.7–0.8 inches) and give live birth to three to five offspring per year. Members of the genus typically live upwards of 10 years and are nocturnal, feeding on algae, bacteria and fungus that grow on the surface of leaves, branches and trunks of host trees. Having beautiful shells, Hawaiʻi's tree snails have been described as the "jewels of the forest" and are well known in the islands. Hawaiian folklore often depicts the snails as being able to sing, in fact many pieces of traditional Hawaiian poetry mention Kahuli or singing snails of Hawaiʻi.

DISTRIBUTION: This species is currently found at several locations along the Munro Trail at elevations above 600 meters. This species is currently in the captive propagation facility on Oahu.

ABUNDANCE: Current extensive surveys for this species located fewer than 75 individuals. There are 21 snails in the captive propagation lab.

LOCATION AND CONDITION OF KEY HABITAT: This species is restricted to fragmented populations in native-dominated habitat at elevations on Lanaʻi above 600 meters.

THREATS: Wild populations are susceptible to predation by rats, cannibal snails (*Euglandina rosea*), and chameleons (*Chamaeleo jacksonii*). Low reproductive rates, predation and limited dispersal abilities all increase the vulnerability of populations to demographic and environmental stochasticity such as inbreeding, loss of genetic diversity, hurricanes, high-winds, fires and drought.

CONSERVATION ACTIONS:

- Survey historical range for undiscovered populations.
- Conduct stop-gap predator control as soon as possible, including rat trapping and the manual removal of cannibal snails and Jackson's chameleons.
- Establish populations within protected habitat of predator-proof exclosures.
- Pursue captive rearing to temporary hold individuals for safe keeping or produce offspring for reestablishment or augmentation of wild populations.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats.
- Cross reference monitoring data with a detection probability index to more accurately measure population size.
- 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.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Develop effective predator control strategies.

References:

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, Hawaiʻi.

U.S. Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for 38 Species on Molokai, Lanai, and Maui. Federal Register 78:32015-32065.

Photo not available

Mites (and Ticks)

Order Acari

ORDER INCLUDES:
58 Native Families
102 Native Genera
164 Native Species
153 Endemic Species

GENERAL INFORMATION: Mites are the most diverse and abundant arachnid, and except for ticks, 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 prey on or are parasites of animals, while others feed on plants, fungus, decaying organic matter, excrement, or carrion. Many mites are considered to be pests, while some are considered useful for biocontrol of other pests. All ticks are external parasites of vertebrates, feeding on blood. Ticks transmit the widest variety of pathogens of any blood-sucking arthropod, including bacteria, rickettsiae, protozoa, and viruses. The order Acari is poorly known in Hawaiʻi.

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.

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.

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.

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.

Photo: Bill Mull; *Theridion grallator* or Happy-face spider

Terrestrial Invertebrates

Spiders

Order Araneae

ORDER INCLUDES:
Kauaʻi Cave Wolf Spider, Federally Endangered
16 Native Families
36+ Native Genera
132+ Native Species
128+ Endemic Species

GENERAL INFORMATION: Spiders have four pairs of legs and no antennae, and they are predaceous. Worldwide there are over 75,000 species. Hawaiʻi has at least 132 native species which are believed to have originated from 34 founder species. Most Hawaiian spiders are believed to have dispersed to 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* and *Theridion* (Theridiidae), and *Mecaphesa* and *Misumenops* (Thomisidae). However, many more species remain to be described, particularly in the genera *Tetragnatha* and *Argyrodes*, and perhaps also in *Cyclosa*, *Havaika*, and *Theridion*. Common and widespread native species include *Tetragnatha quasimodo*, *Misumenops anguliventris*, *M. facundus*, and *Pagiopalus* spp. The happy-face spider (pictured above) also 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 50 or so species in the genus *Tetragnatha* (long-jawed spiders), occur on all of the MHI and are found in most habitats. The constituent species encompasses a huge 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. Due to the fact that most species are nocturnal, Hawaiian native spiders remain poorly known.

DISTRIBUTION: Spiders are known from all of the MHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys hampers population estimates. However, the loss of native habitats likely means that species within the order are declining. Of the known species, *Adelocosa anops* (limited to a single cave on Kauaʻi) and *Doryonychus raptor* (largely restricted to low elevation habitats on Kauaʻi) appear to be the most threatened.

LOCATION AND CONDITION OF KEY HABITAT: Spiders occur in all habitats in Hawaiʻi including caves, lava flows, forests, and shrublands. Key habitat requirements are poorly known.

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 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 spiders should include:

- Forest restoration. Spider populations have responded positively to reforestation efforts at Auwahi on East Maui.
- Control of invasive non-native invertebrates.
- Conduct surveys to determine the distribution and abundance of known spiders and to document and identify new species.
- 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 (*Argyrodes* and *Theridion*), Araneidae (*Cyclosa*), Linyphiidae, Philodromidae, Oonopidae, Salticidae (*Havaika*), Thomisidae, Tetragnathidae (*Tetragnatha*).
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

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, 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 Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Oxford GS, Gillespie RG. 2001 Portraits of evolution: studies of coloration in Hawaiian spiders. BioScience 51:521-528.

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.

False scorpions

Order Pseudoscorpionida

ORDER INCLUDES:
7 Native Families
8 Native Genera
15 Native Species
15 Endemic Species

GENERAL INFORMATION: False scorpions are small predatory arachnids that prey on other arthropods. Unlike scorpions, false scorpions do not have a stinging tail. Fertilization is either external or internal. Most females construct a brood nest. The order is poorly known in Hawaiʻi.

DISTRIBUTION: False scorpions are known from Kauaʻi, Maui, Oʻahu, the island of Hawaiʻi 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: False scorpions prefer habitats that provide cracks, nooks, or crevices in which they can retreat. In Hawaiʻi, 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 false scorpions should include:
- Conduct surveys to determine the distribution and abundance of known false scorpions 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.

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.

Weygoldt P. 1969. The biology of pseudoscorpions. Cambridge, (MA): Harvard University Press. 145 pp.


Photo: Gordon Smith, USFWS

Terrestrial Invertebrates

Kauaʻi Cave Arthropods

Adelocosa anops
(Kauaʻi Cave Wolf Spider),
Spelaeorchestia koloana
(Kauaʻi Cave Amphipod)

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
NatureServe Heritage Rank G1 - Critically imperiled
Draft Recovery Plan for the Kauaʻi Cave Arthropods: the Kauaʻi Cave Wolf Spider *Adelocosa anops*) and the Kauaʻi Cave Amphipod (*Spelaeorchestia koloana*) – USFWS 2004
Final Rule: Designation of Critical Habitat for the Kauaʻi Cave Wolf Spider and Kauaʻi Cave Amphipod Critical Habitat – USFWS 2003

SPECIES INFORMATION: Both the Kauaʻi cave wolf spider and the Kauaʻi cave amphipod were discovered in 1971, and both are known from less than a dozen caves on the island of Kauaʻi. Although a few wolf spider species (Family: Lycosidae) have reduced eyes, the Kauaʻi 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 Kauaʻi cave wolf spider is a predator and actively stalks its prey using its sense of touch or chemoreceptors. The species likely feeds on the Kauaʻi cave amphipod and non-native arthropods. Unlike other wolf spiders, the fecundity of the Kauaʻi cave wolf spider is low.

Compared to other amphipods (Family: Talitridae), the Kauaʻi cave amphipod has unusual morphological attributes which justifies its placement in the monotypic genus *Spelaeorchestia*. Like the Kauaʻi cave wolf spider, the Kauaʻi 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 Kauaʻi. Both are restricted to caves found in a 10.5 square kilometer (four square mile) lava flow. The Kauaʻi cave wolf spider has been documented in six caves, but only regularly observed in one. The Kauaʻi 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 lave 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 Kauaʻi cave wolf spider and Kauaʻi 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 increases 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, the use of pesticides, and the use of biocontrol agents 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 Kauaʻi 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 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. 2004. 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*). Portland, (OR): U.S. Fish and Wildlife Service. 55 pp.

Photo not available

Bristlethighs

Order Archaeognatha

ORDER INCLUDES:
1 Native Family
1 Native Genus
5 Native Species
5 Endemic Species

GENERAL INFORMATION: Bristletails are primitive insects. They feed on algae, lichen, plant material, and possibly on dead arthropods. Fertilization is external and may involve courtship. Compared to other invertebrate orders found in Hawaiʻi, Archaeognatha is represented by very few native species. The order is poorly known in Hawaiʻi.

DISTRIBUTION: Bristletails are known from all MHI except Kahoʻolawe and Niʻihau.

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: 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.

References:
Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaiʻi Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Young FN, Kritksy G. 2002. A survey of entomology. Lincoln, (NE): Writers Club Press. 308 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2. Honolulu: University of Hawaiʻi Press. 475 pp.

Zimmerman EC. 2001. Insects of Hawaiʻi: Volume 1 Introduction. Honolulu: University of Hawaiʻi Press.

Beetles

Order Coleoptera

Photo: James Liebherr, *Blackburnia* spp. Photo: *Rhyncogonus* spp.

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 Hawaiʻi, 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 fungus, some specialize on particular plant parts and others are detritivores. Diversity within most families is generally highest on Maui, Oʻahu, and Kauaʻi. The most specious families include: Carabidae (5 genera/239 spp.), Curculionidae (10 genera/169 spp.), Aglycyderidae (*Proterhinus*/158 spp.), Anobiidae (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 Aglycyderidae and Staphylinidae; substantial research has not been conducted on either family in over 100 years. As an example of the diversity of Hawaii'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 forest. 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 Hawaiʻi, 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*), and by 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 that species within the order are declining. Based on extensive collecting effort 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 ʻōhiʻa (*Metrosideros polymorpha*) forests has declined precipitously. These habitats are often those most heavily impacted by alien predaceous, social Hymenoptera (e.g., ants and vespid wasps), 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 group 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 predaceous ants (Formicidae) and wasps (Vespidae) as well as non-native competitors such as non-native sowbugs (Isopoda) and the black twig borer (*Xylosandrus compactus*; Scolytidae; Coleoptera) 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).
- 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 koa forests on Oʻahu, Maui, Molokaʻi, and the island of Hawaiʻi.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Clydemia*, *Tibouchina*, *Alsophila*, and *Passiflora*.
- 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 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.
- Initiate studies to determine the effects of biocontrol organisms on beetle populations.

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 Hawaiʻi: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Springtails
Order Collembola

ORDER INCLUDES:
5 Native Families
32 Native Genera
95 Native Species
95 Endemic Species

GENERAL INFORMATION: Springtails are primitive, wingless insects. Springtails can be carnivores, scavengers, or fungivores; some also feed on dead (i.e., detritivores) and living plant material (i.e., herbivores). They go through a slight metamorphosis and usually grow to less than five millimeters (0.2 inches). Ants and spiders are known to prey on springtails. The order is poorly known in Hawaiʻi.

DISTRIBUTION: Springtails are known from all MHI except Kahoʻolawe and Niʻihau.

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: Because they are hydrophiles (i.e., water lovers) springtails are most often found in damp habitats. 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 cold desert-like habitat at the summit of Mauna Kea.

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.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Young FN, Kritksy G. 2002. A survey of entomology. Lincoln, (NE): Writers Club Press. 308 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.

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 are able to 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 (i.e., anamorphic growth). 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 Hawaiʻi. *A. maritima* and *Euborellia eteronoma* are widespread and populations appear stable. *A. perkinsi*, known only from Kauaʻi, has apparently declined. *A. howarthi* is restricted to caves on Hawaiʻi 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 Oʻahu, one was endemic to Maui, and one was known from the island of Hawaiʻi. Earwigs are not considered pests in Hawaiʻi, 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.

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. Honolulu (HI): Biological Survey, Bishop Museum.

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 Hawai'i Press.

Campsicnemus penicillatus. Photo: Karl Magnacca

True flies

Order Diptera

ORDER INCLUDES:
27 Native Families
87 Native Genera
2,000+ Native Species
2,000+ 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 Hawaiʻi, making the Hawaiian fauna globally significant. The most speciose genera include *Campsicnemus*, *Drosophila*, *Scaptomyza*, and *Lispocephala*. Species in the genus *Drosophila* are perhaps the best-known 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 Hawaiʻi.

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 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 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 status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.

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).

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Montgomery, S. Personal communication.

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.

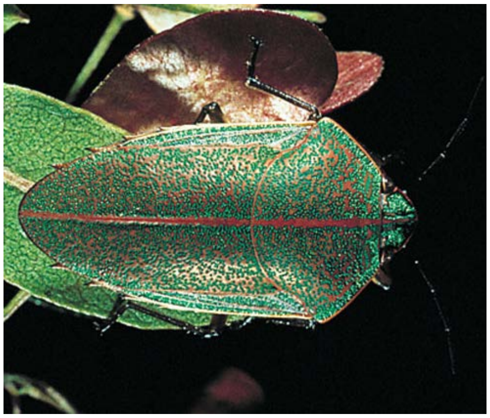


Photo: W. P. Mull; *Coleotichus blackburniae; Koa bug*

Terrestrial Invertebrates

True bugs

Order Heteroptera

ORDER INCLUDES:
12 Native Families
39 Native Genera
418 Native Species
415 Endemic Species

GENERAL INFORMATION: Heteroptera is a large and diverse order that includes terrestrial and aquatic species. Most species are small and feed on plants; however, some are predaceous and others are scavengers. Members of the order also are known as true bugs, and the most familiar members of the order are assassin bugs (Reduviidae), stink bugs (Pentatomidae), and water bugs (Belostomatidae). 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. Of the 415 endemic species, 39 have not been collected in over 50 years. As an example of the diversity of Hawaii's true bugs, three genera are briefly outlined below. Most species in the genus *Nesiomiris* (Miridae) 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, Reynoldsia, Tetraplasandra, Munroidendron,* and *Ilex*. All species in the genus *Orthotylus* (Miridae) are all endemic to single islands. The 63 native species described are known from all the MHI. Overall, species within the genus feed on a wide variety of native host plants, although most individual species depend on a single host plant or several closely related species, with plants in Rubiaceae being particularly important. All but one of the 40 described native species in the genus *Sarona* (Miridae) are endemic to single islands, and most depend on a single host plant, often in the genus *Melicope*.

DISTRIBUTION: True bugs are known from all the MHI.

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 with 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 and caves.

THREATS:

- Loss or degradation of habitat, especially dry lowland habitats and coastal zones.
- Loss of host-specific plants.
- Insufficient information for species assessments.
- Predation and parasitism by invasive non-native insects including ants (Formicidae), the southern green stinkbug (*Nezara viridula*), parasitoid flies (Diptera) and wasps (Hymenoptera), and generalist egg predators.
- Displacement by non-native congeners (e.g., invasive members of the family Lygaeidae).

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.
- Outplanting of native plants, especially those that are hosts to declining heteropteran 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.
- 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.
- Initiate efforts to relocate 39 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. Honolulu (HI): Biological Survey, Bishop Museum.

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. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Photo not available

Aphids, Hoppers, Whiteflies, Mealybugs, Scale Insects

Order Homoptera

ORDER INCLUDES:
6 Native Families
38 Native Genera
393 Native Species
393 Endemic Species

GENERAL INFORMATION: Homoptera is a large and diverse order, particularly rich in Hawai'i. All members of the order 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 Hawaii's leaf and tree hoppers, three endemic species are outlined. The endemic genus *Nesophrosyne* (Family: Cicadellidae) is comprised of 62 described species and subspecies. All are likely endemic to individual islands, and most species depend on a narrow range of host plants. Eighty-two described species and subspecies comprise the endemic genus *Nesosydne* (Family: Delphacidae). All are likely endemic to individual islands, and most species depend on a narrow range of host plants. The endemic genus *Oliarus* (Family: Cixiidae) is comprised of 82 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 and are found in caves.

DISTRIBUTION: Members of the order Homoptera are found on all the MHI.

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. The most abundant species appear to be found in the genus *Nesophrosyne* and their tolerance to non-native ants (Formicidae) likely explains their abundance.

LOCATION AND CONDITION OF KEY HABITAT: True bugs are a very ecologically diverse group and occur in most terrestrial habitats. 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 non-native ants.
- Non-native parasitoid wasps (Vespidae) may adversely affect some species in the family Coccoidea.
- Biocontrol agents to control the non-native two-spotted leafhopper (*Sophonia rufofascia*) and glassy winged sharpshooter (*Homalodisca coagulate*) have the potential to adversely affect native members of the family Cicadellidae.

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 homoptera should include:

- Conduct surveys to determine distribution and abundance of known homoptera and to document and identify new species.
- Outplanting of native host plants that support rare Homoptera.
- 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 biocontrol organisms on species in the family Cicadelliade.
- The genus *Nesophrosyne* (Cicadellidae), which is comprised of many undescribed species that depend on rare native host plants, should be reviewed and revised as appropriate.

References:

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, HI: University of Hawaiʻi Press.

Osborn, H. 1935. Cicadellidae of Hawaii. Bernice P. Bishop Museum Bulletin 134: 1–62.

Nishida GM editor. 2002. Hawaiian Terrestrial Arthropod Checklist, 4th edition. Honolulu, HI: Hawaiʻi Biological Survey, Bishop Museum.

Zimmerman EC. 2001. Insects of Hawaiʻi: Volume 1 Introduction. Honolulu, HI: University of Hawaiʻi Press.

Terrestrial Invertebrates

Bees and wasps

Order Hymenoptera

ORDER INCLUDES:
17 Native Families
60 Native Genera
650+ Native Species
650+ 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, comprises non-social bees and wasps and does not include any native ants. The most speciose genus is *Sierola* (Bethylidae) with 180 described and an estimated 400–500 total species. Several species in each of the genera *Hylaeus* (Colletidae), *Ectemnius* (Sphecidae), and *Nesodynerus* (Vespidae), including *H. chlorostictus*, *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 played an important role in keeping other insects, particularly herbaceous species, in check, and in pollinating plants. 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 prey on scale insects (Homoptera); species in the family Eucoilidae lay their eggs on fly (Diptera) pupae, and species in the families Vespidae and Bethylidae prey on Lepidoptera caterpillars. As an example of the diversity of Hawaii's hymenopterans, two genera are briefly outlined. The 63 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 recovery of native plants. Wasps in the genus *Sierola* are found throughout the Indo-Pacific region, but over 90 percent of the known species are endemic to Hawai'i. They are small, black wasps found primarily in wet and mesic forest. Fullway (1920) described 171 species, with 119 from O'ahu and 44 from the island of Hawai'i. Possibly hundreds of species remain to be described, and it is not uncommon to find greater 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.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative survey.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawaiʻi Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. University of Hawaiʻi Press, Honolulu.

Fullaway DT. New species of *Sierola* with explanatory notes. Bishop Museum Occasional Papers 7(7):57-159.

Howarth FG, and Mull WP. 1992. Hawaiian insects and their Kin. University of Hawaiʻi Press, Honolulu.

Nishida GM, editor. 2002. Hawaiian Terrestrial Arthropod Checklist, 4th edition. Biological Survey, Bishop Museum, Honolulu, Hawaiʻi.

Takumi RL. 1999. A Systematic Review of the Ectemnius (Hymenoptera: Sphecidae) of Hawaiʻi, University of California Press, Berkeley.

Zimmerman EC. 2001. Insects of Hawaiʻi: Volume 1 Introduction. University of Hawaiʻi Press, Honolulu.

Photo: Jim Denny; *Udara Blackburn;* Blackburn's Blue

Moths and Butterflies

Order Lepidoptera

ORDER INCLUDES:
Blackburn's Sphinx Moth -
Federally listed as Endangered
State listed as Endangered
18 Native Families
60 Native Genera
957 Native Species
600+ Endemic Species

GENERAL INFORMATION: The beauty and popularity of many species of butterflies and moths makes Lepidoptera perhaps the best known insect order. Hawaiʻi supports 955 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 Hawaii's state insect. This disparity in numbers is likely the result of the fact that moths are typically generalists, while most butterflies are dependent on specific host plants. Native moths are very small, with most only having a wingspan of one centimeter (.39 inches) or less, and most are poorly known. Approximately 350 species of native moths are in the genus *Hyposmocoma*, and twice as many are likely undescribed. The species comprising *Hyposmocoma* are the second most diverse animal genus in Hawaiʻi (flies in the genus *Drosophila* being the most diverse). 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. In 2005, however, a new species (*H. molluscivora*) was discovered on Maui, the larva of which feeds on snails. Less than one percent of the world's known moths and butterflies are carnivorous.

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.

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 native host plants.

- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Linepithema humile*), 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 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.
- Systematic review of the order.

References:

Explore Biodiversity. Major orders of the insecta. Lepidoptera: butterflies and moths. Available at: http://www.explorebiodiversity.com/Hawaii/BiodiversityForgotten/Wildlife/Inverts/Insects/Lepidoptera.htm.

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.

Rubinoff D. University of Hawai'i. Personal communication. 2005.

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.

Photo not available

Lacewings and Antlions

Order Neuroptera

ORDER INCLUDES:
4 Native Families
5 Native Genera
50 Native Species
50 Endemic Species

GENERAL INFORMATION: Lacewings and antlions are predaceous, feeding on other insects. Most adult species have four large, net-veined, colorful wings. Despite this, most are poor fliers; a few species are flightless (e.g., *Pseudopsectra lobipennis* and *Nesothauma haleakalae*). The largest number of Hawaiian endemic species is found in the genera *Anomalochrysa* and *Micromus*.

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.

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.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Anax strenuus. Photo: Karl Magnacca.

Terrestrial Invertebrates

Damselflies and dragonflies

Order Odonata

ORDER INCLUDES:
3 Native Families
4 Native Genera
29 Native Species
27 Endemic Species

GENERAL INFORMATION: Dragonflies are an ancient insect group that coexisted with dinosaurs, and are part of an easily recognized and well-known insect order (Odonata). All members of the order are predaceous, have large compound eyes, two pairs of large membranous wings, and a long, thin abdomen. No dragonfly or damselfly stings and all have an aquatic larval form (naiad). The order consists of two suborders, one contains the damselflies and the other the dragonflies. Damselflies are weak fliers, and at rest most hold their wings together above the body. Dragonflies are strong fliers, and at rest hold their wings spread. 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. *M. oahuense* is one of the few truly terrestrial damselflies in the world. Also notable is the endemic dragonfly, *Anax strenuus*. It is the largest Hawaiian native insect with a wingspan of 15 centimeters (6 inches). Five endemic damselflies (*Megalagrion leptodemas*, *M. nesiotes*, *M. nigrohamatum nigrolineatum*, *M. oceanicum*, and *M. pacificum*) are federally listed as endangered, and another (*M. xanthomelas*) is a candidate for listing.

DISTRIBUTION: Dragonflies and damselflies are known from all the Main Hawaiian Islands except for Kaho‘olawe.

ABUNDANCE: Unknown. The loss of native habitats likely means that many species within the order are declining.

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 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.
- Assess potential haplotype differences among island populations of widespread species to determine the importance of protecting populations on individual islands.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

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).

Nishida GM, editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

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.

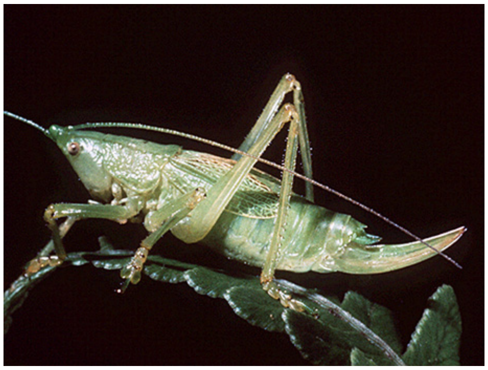


Photo: Bishop Museum; *Banza nitida*

Terrestrial Invertebrates

Crickets and Katydids

Order Orthoptera

ORDER INCLUDES:
2 Native Families
10 Native Genera
260 Native Species
259 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 being colored to match their background. The number of endemic Hawaiian crickets is twice the number of species that can be found in the entire continental United States. The largest number of endemic species is found in the genus *Trigonidium*.

DISTRIBUTION: Crickets and katydids are known from all the MHI except for Kaho'olawe. 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: Crickets and katydids occur in a wide range of habitats including dry and wet forests.

THREATS:

- Loss or degradation of habitat.
- Non-native invasive parasitoid 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:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- 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. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Photo not available

Lice

Order Phthiraptera

ORDER INCLUDES:
2 Native Families
25 Native Genera
57 Native Species
5 Endemic Species

GENERAL INFORMATION: Lice are wingless 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 Hawaiʻi.

DISTRIBUTION: Lice are known from the island of Hawaiʻi, Maui, and Oʻahu, 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.

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.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.

Photo not available

Bark lice and Psocids

Order Psocoptera

ORDER INCLUDES:
5 Native Families
6 Native Genera
93 Native Species
90 Endemic Species

GENERAL INFORMATION: Most bark lice and psocids are scavengers or feed on lichen found on woody vegetation. Bark lice and psocids are an important food source for native birds and other insect-eaters. The largest number of endemic species occurs within the genera *Ptycta*, *Palistreptus*, and *Kilauella,* respectively.

DISTRIBUTION: Bark lice and psocids are known from all the MHI except for Niʻihau.

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.

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.

References:
Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaiʻi 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.

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 endemic species, *Parapsyllus laysanensis*, is known in Hawaiʻi and is a seabird parasite. This order is poorly known in Hawaiʻi.

DISTRIBUTION: Hawaii's one 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 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 *P. laysanensis* should include:
- Conduct surveys to determine distribution of known *P. laysanensis* populations 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 the endemic species.

References:
Davies RG. 1988. Outlines of entomology. New York, (NY): Chapman and Hall. 408 pp.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaiʻi 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.

Photo not available

Thrips

Order Thysanoptera

ORDER INCLUDES:
2 Native Families
9 Native Genera
29 Native Species
29 Endemic Species

GENERAL INFORMATION: Thrips are herbivorous, fungivorous, or predaceous, preying on insects and mites, although most are herbivore sap-suckers. Some species are capable of producing young without the contribution of sperm (i.e., parthenogenic). Metamorphosis is intermediate and thrips rarely grow to be more than four millimeters (0.2 inches). Thrips are gregarious and are usually found in large colonies. This order is poorly known in Hawaiʻi.

DISTRIBUTION: Thrips are known from all the MHI except for Niʻihau.

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: Thrips occur in a variety of habitats ranging from dry, lowland areas to wet, high-elevation forests. Fungivores and predaceous thrips are more likely to occur in wetter habitats. Individuals are often found in trash, under bark, and other well-protected locations.

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 thrips should include:
- Conduct surveys to determine the distribution and abundance of known thrips 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.

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.

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.

Drosophila conspicua. Photo: Karl Magnacca.

Terrestrial Invertebrates

Pomace flies

Drosophilidae (Diptera)

Family Includes:
12 Genera
2 Native Genera
12 Introduced Genera
598 Species
566 Endemic Species
32 Introduced Species

GENERAL INFORMATION: The family Drosophilidae contains roughly 4,000 described species, approximately 25 percent of which are endemic to the Hawaiian Islands (Markow and O'Grady 2006). This large radiation accounts for 10 percent of all Hawaiian insects and is the best-studied native Hawaiian lineage. Extensive investigations into the taxonomy, genetics, ecology, and evolutionary biology of Hawaiian Drosophilidae have been made over the past 50 years (Hardy 1965; Spieth 1980).

The Hawaiian Drosophilidae is the oldest lineage of native plants or animals known and is estimated to have colonized the Hawaiian islands about 25 million years ago (Russo et al. 1995). Soon after arriving in the Hawaiian islands, this lineage split into two distinct genera, *Drosophila* and *Scaptomyza* (O'Grady and DeSalle 2008; O'Grady et al. 2011; Lapoint et al. 2013), each of which has diversified extensively in Hawaiʻi.

The Hawaiian Drosophila is divided into the picture wing, modified mouthpart, antopocerus, modified tarsus, ateledrosophila, nudidrosophila, haleakalae, and rustica species groups (O'Grady et al. 2010). Most species are saprophagous and feed on yeasts and fungi present in decaying plant material (Ort et al. 2012). Hawaiian Drosophila have evolved a close association with approximately 40 percent of the native Hawaiian plant families, particularly Campanulaceae and Araliaceae, and rely on these hosts to complete their life cycles (Magnacca et al. 2008). Drosophila have specialized in two major ways, with species groups showing preference for a specific plant part (e.g., leaves, fruit, flowers, stems, bark, sap flux) of that host plant, and individual species being specific to a given native plant family. This subdivision of available resources is one potential explanation for the large numbers of Hawaiian Drosophila species. In addition to fine-scale ecological specialization, most Hawaiian Drosophila species also exhibit some degree of sexual dimorphism. Males often use specialized structures, including legs, antennae, mouthparts, and wings in elaborate courtship displays.

The genus *Scaptomyza* is the sister group to the Hawaiian *Drosophila* and were the result of the same original colonization event. *Scaptomyza* is divided into 21 subgenera; ten are endemic to Hawaiʻi and the remainder are derived from several lineages that escaped from Hawaiʻi and diversified on the mainland and other island groups (O'Grady and DeSalle 2008; Lapoint et al. 2013). While most members of Scaptomyza are classified as saprophages and have developed close associations with native plant families (Magnacca et al. 2008), there are also some unique taxa that have adapted to be parasites of endemic spiders (subgenus Titanochaeta) or herbivores on living plant tissue (subgenera Scaptomyza and Parascaptomyza).

Leblanc et al. (2009) reported on 32 Drosophilidae species introduced to Hawaiʻi through human activity. They listed 12 genera (*Amiota, Cacoxenus, Chymomyza, Dettopsomyia, Drosophila, Hirtodrosophila, Leucophenga, Mycodrosophila, Scaptodrosophila, Scaptomyza, Stegana, Zaprionus*) with non-native species, including mainland relatives of *Drosophila* and *Scaptomyza*. The impact of many of these non-native species is unknown. Only one species, *Drosophila suzukii* (spotted wing Drosophila) is known to be an agricultural pest of fruit trees, strawberries, and cane fruits.

DISTRIBUTION: Drosophilidae are ubiquitous in Hawaiian ecosystems. Native species of *Drosophila* and *Scaptomyza* were historically found almost anywhere there are native plants, from close to sea level to above the tree line on the highest volcanoes. The introduction of ants and other alien insects has resulted in considerable range contraction, especially at lower elevations; they are now found primarily in mesic to wet forest between 460 and 1,830 meters (1,500 and 6,000 feet). Introduced taxa are generally found in association with humans or with the fruits of non-native plants and only a few species are regularly encountered in intact native rainforest or mesic forest habitats.

ABUNDANCE: Population sizes differ by species and range from common (hundreds of thousands of breeding individuals) to extremely rare. A total of 15 species of Hawaiian Drosophila are currently listed as endangered (treated separately), and at least another 16 species in the picture wing group have not been seen in 40 years, despite regular surveys across the islands. However, five that had been in the latter category have been rediscovered since 2013. Some species show seasonal abundance that may be linked to resource availability (e.g., decomposing leaves), while others undergo unpredictable localized booms due to rare but large breeding resources (e.g., a treefall and associated rotting bark).

LOCATION AND CONDITION OF KEY HABITAT: Species diversity is highest in native-dominated rainforest and mesic forest habitats throughout the Main Hawaiian Islands.

THREATS:

- <u>Habitat loss and degradation.</u> Habitat is lost to fire, conversion for agriculture, logging, and grazing, and disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- <u>Predation.</u> Introduced insect species, particularly *Vespula* wasps and ants, prey on these flies.
- <u>Competition.</u> Introduced saprophagous insects, especially crane flies (Limoniidae: *Libnotes* spp.) and stilt-legged flies (Neriidae), compete with Drosophilidae.

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 Drosophilidae 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 status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.

References:

Hardy DE. 1965. Diptera: Cyclorrhapha. II, Series Schizophora, Section Acalypterae I. Family Drosophilidae. *In* Insects of Hawaii 12.

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

Leblanc L, O'Grady PM, Rubinoff D, and Montgomery SL. 2009. New Immigrant Drosophilidae in Hawaii, and a Checklist of the Established Immigrant Species.

Magnacca KN, Foote D, and O'Grady PM. 2008. A Review of the Endemic Hawaiian Drosophilidae and Their Host Plants. Zootaxa 1728:1-58.

Markow T, and O'Grady PM. 2006. Drosophila: A Guide to Species Identification and Use. Academic Press, London, United Kingdom.

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.

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.

Russo CMA, Takezaki N, Nei M. 1995. Molecular phylogeny and divergence times of Drosophilid species. Molecular Biology and Evolution. 12:391-404.

Spieth HT. 1981. History of the Hawaiian *Drosophila* project. Drosophila Information Service. 56: 6-14.


Drosophila digressa. Photo: Karl Magnacca.

Picture wing Drosophila

Drosophila digressa

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

GENERAL INFORMATION: *Drosophila digressa* Hardy & Kaneshiro, 1968 is a medium-sized picture wing fly endemic to Hawaiʻi Island. It is a member of the *lanaiensis* species subgroup, which consists of five species, all of them rare. All members of the 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 Hawaiʻi. The species occurs in mesic to wet forest where its host plants are found. Although always uncommon and sporadic, it was historically found from 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 ʻŌlaʻa in Hawaiʻi Volcanoes National Park. Recent collections and observations have come only from Manukā and ʻŌlaʻa; 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 ʻŌlaʻa site appear to be low but consistent, while *D. digressa* is 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. ʻŌlaʻa 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.

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 primaeva, externally identical sister species of *D. sharpi*. Photo: Karl Magnacca.

Sharp's Drosophila

Drosophila sharpi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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. 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* is 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, Hawaiʻi.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaiʻi. 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 kikiko, Kauai sister species of *D. aglaia*, nearly identical in appearance. Photo: Karl Magnacca.

Picture wing Drosophila

Drosophila aglaia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 Waiʻanae range of Oʻahu, occurring in diverse mesic forest gulches. Although always uncommon, it was historically found widely throughout the range on the eastern and northern slopes. It is the namesake of the *aglaia* species subgroup, which consists of six species, all of them extremely rare. It is nearly identical to the recently-discovered *D. kikiko* of Kauaʻi (pictured above), differing only in minor details of the coloration of the side of the thorax and the front leg hairs of the male. Notably, the host plants are unknown for all members of the subgroup except one, which means the host of *D. aglaia* cannot be inferred with any certainty. This uncertainty regarding their precise habitat makes surveys specifically targeting *D. aglaia* difficult.

DISTRIBUTION: Known only from the Waianae range of Oʻahu, where it has historically been found at six sites from Mokulēʻia, west of Kaʻala, to Puʻu Palikea at the southern end. The most recent record was in 1997 at Puʻu Palikea, but intensive surveys 2013–2015 have failed to recover it there. At other historic sites, it has not been seen since 1971. There are no records from the leeward side, including Waiʻanae and Makaha valleys, but these 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 *Urera glabra* (as *U. 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 (Puʻu 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, Hawaiʻi.

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.

Photo not available

Picture wing Drosophila

Drosophila differens

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 beautiful of the native pomace flies. This group is distinctive by its extra crossvein in the wing in all 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.

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. *Drosophila differens* is reported to breed in *Clermontia*, which continues to occur in the area it had been found, though it is relatively uncommon. However, the other lobeliad genera *Cyanea* and *Trematolobelia* also occur in the area, the latter abundantly in places, and it is likely that *D. differens* breeds in these as well.

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, Hawaiʻi.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaiʻi. 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 hemipeza. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing Drosophila

Drosophila hemipeza

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 beautiful of the native pomace flies. This group is distinctive for having an extra crossvein in the wing in all 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* (which is 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. The species is endemic to Oʻahu, occurring from diverse mesic forest to 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 *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, 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, Makaha Valley, ʻĒkahanui, Kaluaʻā Gulch, and several sites in the vicinity of Puʻu Palikea. 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.

ABUNDANCE: Unknown. During two years of ongoing monthly monitoring from 2013–2014, 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 such as 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.

Picture wing Drosophila

Drosophila heteroneura

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic
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 beautiful of the native pomace flies. This group is distinctive for having an extra crossvein in the wing in all except the Kauaʻi representatives. The species is endemic to Hawaiʻi, occurring in montane mesic to wet forest, where it is sympatric with *D. silvestris* except in Kohala. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads. *Drosophila heteroneura* closely resembles the other species of the subgroup, *D. differens* of Molokaʻi, *D. planitibia* of Maui, and *D. silvestris* of Hawaiʻi. It differs differs strikingly from all of these in having the head broad, particularly in the males which possess a distinct "hammerhead". However, 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 it being used extensively in genetics research.

DISTRIBUTION: *Drosophila heteroneura* 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 is sometimes moderately abundant. However, access is extremely limited and much of the area has not been surveyed in many years.

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*), which is 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.

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. Photo: Karl Magnacca.

Picture wing Drosophila
Drosophila montgomeryi

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 on 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 except for the Oʻahu *Pisonia* breeder *D. ambochila*. *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 for 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.

ABUNDANCE: This species is still found in nearly its full historic range as well as some additional sites. However, it is apparently no longer 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. Two years of ongoing monthly monitoring from 2013–2014 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 reported to breed in *Urera kaalae*, and is presumed to breed in *U. glabra* since it occurs at sites where only that 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 actually be clones; since it is dioeceous, this may result in all plants in the area being one sex. 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.

Picture wing Drosophila

Drosophila mulli

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Threatened
State Recognized as Endemic
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 Hawaiʻi, occurring in lowland to montane wet forest. The breeding host of *D. mulli* is unclear. It is closely associated with the native *Pritchardia* palms – adults have been found almost exclusively by collecting them from the undersides of *P. beccariana* leaves, and pupal cases presumed to be those of *D. mulli* have been found suspended from the leaves. However, it has never been reared and the breeding location is unknown. No other *Drosophila* are associated with palms.

DISTRIBUTION: *Drosophila mulli* is known from three sites between 2500 and 3200 feet elevation: ʻŌlaʻa 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 Hawaiʻi, 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.

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 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.

Picture wing Drosophila
Drosophila musaphilia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 (1966–75) 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 like even some other endangered 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.

Photo not available

Picture wing Drosophila

Drosophila neoclavisetae

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 is not known for certain, but almost all other members of the *adiastola* group, including its close relatives, breed in rotting bark of lobeliads, primarily *Clermontia*.

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 40 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 it had 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 Puu 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, Hawaiʻi.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaiʻi. 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.

Picture wing Drosophila

Drosophila obatai

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic
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 *Chrysodracon* 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 1970–71. 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 Puleʻē 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 2013–2014 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 *Chrysodracon*, 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 *Chrysodracon* (=*Pleomele*). The species was not recorded in fly rearing records, but it is known to breed in at least *C. halapepe* since it occurs at sites where only that species is present. *Chrysodracon forbesii* is presumed to be a host as well, since it is extremely similar and the two species grade into each other morphologically, but *D. obatai* has not been definitively associated with it. Both species 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 actually be clones. Manuwai and Puleʻē 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 *Chrysodracon*.
- Outplant *Chrysodracon* 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 *Chrysodracon* 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, Hawaiʻi.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaiʻi. 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, Hawaiʻi.

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.

Picture wing Drosophila

Drosophila ochrobasis

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 Hawaiʻi, 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 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* historically known from many collections at six sites between 1966 and 1975, from the Saddle Road kīpuka, Kaʻū Forest Reserve, Hualālai, and Kohala. However, sometime after this 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 that time 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 substenoptera. Photo: Karl Magnacca.

Picture wing Drosophila

Drosophila substenoptera

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 beautiful of the native pomace flies. This group is distinctive for having an extra crossvein in the wing in all 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, except at the last, it is only ever 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 two years of ongoing monthly monitoring from 2013–2014, 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 such as 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 Peʻahināiʻa rather than the stunted, boggy forest found at the summits of both Kaʻala 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:

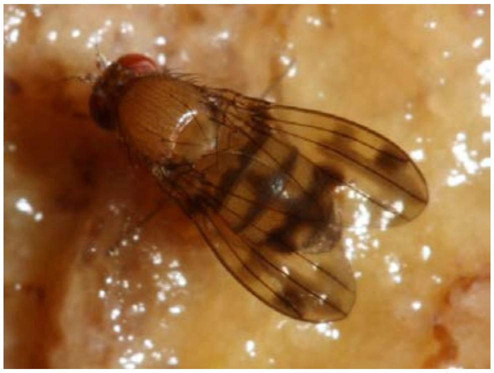
Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaiʻi.

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, Hawaiʻi.

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. Photo: Karl Magnacca.

Picture wing Drosophila

Drosophila tarphytrichia

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic
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 groups 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 found widely 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 Waianae 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 2013–2015 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 uncommon but not extremely 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 (2013–15), and all have been *D. hexachaetae*.

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 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, Hawaiʻi.

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 Hawaiʻi. 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.


Hylaeus anthracinus. Photo: Karl Magnacca.

Yellow-faced bee

Hylaeus anthracinus

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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 visted 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 (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 the 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 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 largest population on Oʻahu, at Kaʻena Point, has virtually disappeared since 2011 for unknown reasons.

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 that they are unlikely to disperse 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 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 *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.

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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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 assimulans. Photo: John Kenolio.

Yellow-faced bee
Hylaeus assimulans

SPECIES STATUS:
Federal Candidate for Listing
State recognized as Endemic

GENERAL INFORMATION: *Hylaeus assimulans* (Perkins, 1899) is a large bee found on Oʻahu and Maui Nui. It lives primarily in coastal areas, often extending up into lowland dry forest. 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*), which it is closely associated with and visits more often than other species. Other important plants visted 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 records for Molokaʻi. 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 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. Current populations of *Hylaeus assimulans* are widely scattered, so that they are unlikely to disperse on their own to sites where vegetation restoration is carried out. ʻIlima is one of relatively few native plants that can resprout 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 *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.

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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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.

Yellow-faced bee

Hylaeus facilis

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, native bees are often found in marginal habitat. Nevertheless, some suitable areas appear to exist, but are located where *H. facilis* is not present. In some of these, other native *Hylaeus* that were historically collected in company with it are still present. Thus, *H. facilis* may have specialized habitat requirements that are currently unknown.

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 *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.
- 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 Hawaii Press, Honolulu.

Magnacca KN. 2007. Conservation status of the endemic bees of Hawaii, *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.

Yellow-faced bee

Hylaeus kuakea

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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.

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, 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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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.

Yellow-faced bee

Hylaeus longiceps

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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, but much of the coast is unexplored. Two sites are known for Oʻahu, Kaʻena Point and Kahuku Point, but *Hylaeus* have all but disappeared from the former since 2011, and at the latter they have not been seen since the arrival in 2013 of an alien yellow-faced bee from India, *Hylaeus strenuus*.

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 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 made 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, so that they are unlikely to disperse 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 O'ahu. It has already been detected on Kaua'i and will likely spread to the other islands as well.

THREATS:

- <u>Habitat loss and degradation.</u> Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- <u>Competition and predation.</u> Non-native Hymenoptera, including bees (particularly *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- <u>Stochastic events.</u> 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.

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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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.

Yellow-faced bee

Hylaeus mana

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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 any signs of ecological specialization. It was only discovered in 2002, and little 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 south to Mānana in the north, it is restricted to the narrow zone around 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 most 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.

THREATS:

- <u>Habitat loss and degradation.</u> Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- <u>Competition and predation.</u> Non-native Hymenoptera, including bees, ants (primarily *Anoplolepis gracilipes* and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- <u>Stochastic events.</u> 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.

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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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.


Hylaeus hilaris. Photo: Karl Magnacca.

Yellow-faced bee
Hylaeus hilaris

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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 candidate 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 that they are unlikely to disperse 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:
- <u>Habitat loss and degradation.</u> Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- <u>Competition and predation.</u> Non-native Hymenoptera, including bees (particularly *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 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.

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.
- 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 Hawaii Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawaii, *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.


Photo: James Bruch, KIRC

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 Hawaii'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 solanacious plants such as commercial tobacco (*Nicotiana tabacum*), tree tobacco (*N. glauca)*, eggplant (*Pseudomonas solanacearum*), tomato (*Lycopersicon esculentum*), and Jimson weed (*Datura stramonium*). Adults have been observed feeding on the nectar of koaliawa (*Ipomea indica)*. Other likely adult nectar sources include other species of *Ipomea*, maiapilo (*Capparis sandwichiana)*, and ʻilieʻe (*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 at 56 days, but pupae may aestivate (i.e., period of dormancy 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, the species was rediscovered on East Maui. Additional populations recently have been found on Kahoʻolawe and the island of Hawaiʻi. 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 is had been recorded. Currently, the largest populations reside on Maui and Hawaiʻi. 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 Hawaii'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 sandwiceneses*), ʻohe (*Reynoldsia sandwicensis*), hao (*Raovolfia sandwicensis*), ʻālaʻa (*Pouteria sandwicensis*), āulu (*Pisonia sandwicensis* and its varieties), ʻaʻaliʻi (*Dodonaea viscose*), naio (*Myoporum sandwicense*), and wiliwili (*Erythrina sandwicensis*). The populations on Maui and Hawaiʻi are primarily associated with ʻaiea (*Nothocestrum* spp.) trees. Perhaps the largest stand of ʻaiea trees in the State are located on Maui in the Kanaio Natural Area Reserve. Other large stands are found on Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, and the island of Hawaiʻi. On Molokaʻi, potential moth habitat consists of mixed-species mesic and dry forests with both native and non-native plants (see below). On Kahoʻolawe, caterpillars currently feed on the non-native tree tobacco, as do populations on Maui and the island of Hawaiʻi. Although the species will feed on non-native plants, primary constituent elements of critical habitat as designated by the USFWS 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 ʻilieʻe. These species are likely superior to non-natives in that they are more persistent, especially during drought conditions. In 2003, 40,420 hectares (99,433 acres) of critical habitat was designated by the USFWS on the islands of Hawaiʻi, Maui, Molokaʻi, and Kahoʻolawe.

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. Current threats include non-native ants, especially the big-headed ant (*Linepithema humile*) and several species of parasitic flies and wasps. Although little documentation exists of direct predation, native insects have been eliminated in areas where big-headed ants occur, and several alien wasp species have been reported parasitizing species closely related to Blackburn's sphinx moth. All species of *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 Hawaiʻi, and the potential host plant, *N. peltatum* on Kauaʻi, are federally listed as endangered. Finally, 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. For example, 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 the following:

- Restoration of habitat (e.g. dry and mesic shrub land and forests) and increased protection of currently occupied habitats, especially those supporting host plants.
- Support cultivation and restoration of *Nothocestrum* species.
- Restore *Nothocestrum* on Kahoʻolawe 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 and 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, Hawai'i.


Megalagrion nigrohamatum nigrolineatum. Photo: Dan Polhemus, USFWS.

Blackline Hawaiian damselfly

Megalagrion nigrohamatum nigrolineatum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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 region, on both the windward and leeward sides. Seventeen 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 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 cannot survive where introduced fish and frogs are present. 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. 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.
- 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, Hawaiʻi.

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.

Flying earwig Hawaiian damselfly

Megalagrion nesiotes

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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 forest, 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 Hawaiʻi, mostly below 914 meters (3,000 feet) elevation. The last collections from Hawaiʻi 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.

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, Hawaiʻi.

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 oceanicum. Photo: Dan Polhemus, USFWS.

Oceanic Hawaiian damselfly

Megalagrion oceanicum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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 in the vicinity of fast-moving stream sections that serve as breeding sites; they are strong fliers and may also be found in adjacent forest.

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 region. Twelve populations are currently known.

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, Hawaiʻi.

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.

Pacific Hawaiian damselfly

Megalagrion pacificum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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 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:
- <u>Habitat loss and degradation.</u> Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- <u>Predation.</u> 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, Hawaiʻi.

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 leptodemas. Photo: Dan Polhemus, USFWS.

Crimson Hawaiian damselfly

Megalagrion leptodemas

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
State Recognized as Endemic

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, the small size and shy habits make them inconspicuous when flying about. Adults are found along stream corridors in the vicinity of standing pools or slow-moving stream sections that serve as breeding sites, usually not straying far from the stream. It is considered 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 Maakua.

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. 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.
- 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, Hawaiʻi.

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 xanthomelas. Photo: Karl Magnacca.

Terrestrial Invertebrates

Orangeblack Hawaiian damselfly

Megalagrion xanthomelas

SPECIES STATUS:
Federal Candidate for Listing
State Recognized as Endemic

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 in the vicinity of 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, including Niʻihau, except for Kahoʻolawe. However, it has apparently been extirpated from Kauaʻi and Maui (the Niʻihau population is unknown). On Oʻahu it was formerly widespread, including in basal spring wetlands around Pearl Harbor and in the vicinity of Honolulu, but the alteration of wetlands and near-ubiquitous presence of alien fish and frogs has reduced them to a single small population on the grounds of Tripler Army Medical Center. Lānaʻi has a few locations, but the largest population appears to be in artificial ponds at Koele Lodge. Molokaʻi and Hawaiʻi have several significant populations, dwelling in both streams and anchialine ponds near the coast.

ABUNDANCE: Unknown. The Molokaʻi and Hawaiʻi populations are relatively large, though the anchialine ponds on the Kona coast of Hawaiʻi are under threat from development, pollution, and introduction of fish. The Oʻahu 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* is able to 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.
- 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, Hawaiʻi.

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.

Procanace acuminata. Photo: Hawaii Biological Survey.

Terrestrial Invertebrates

Beach flies

Procanace (Diptera: Canacidae)

Genus Includes:
10 Species
9 Endemic Species
1 Introduced 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 species in Hawaiʻi, eight of which are endemic. These species can be found in a range of habitats, from the coastal aquatic environments to high-elevation freshwater streams (Hardy and Delfinado 1980; O'Grady and Pak 2015). The endemic Hawaiian *Procanace* are notable within the genus and the family for their adaptation to freshwater, rather than saltwater, habitats.

DISTRIBUTION: Species are found on the Main and several Northwestern Hawaiian Islands (MHI and NWHI) (Hardy and Delfinado 1980; O'Grady and Pak 2015). Endemic members of the genus *Procanace* are found in freshwater stream habitats throughout the islands. Hawaiʻi is the only place on earth where canacid flies have successfully colonized freshwater habitats. The Alakaʻi Swamp region of Kauaʻi, where five of the eight endemic species can be found, is especially diverse.

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 coastal strand and freshwater stream habitats throughout the MHI and NWHI.

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 Hawaii.

References:

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.

Hardy, DE and Delfinado, MD. 1980. Diptera: Cyclorhhapha III. Insects of Hawaii 13: 1-451.

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

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.

Photo not available

Pillbugs, Sowbugs, Woodlice, Isopods

Order Isopoda (Terrestrial)

ORDER INCLUDES:
5 Native Families
10 Native Genera
19 Native Species
18 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 that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial members of this order occupy a wide range of habitats ranging from marine and freshwater habitats to terrestrial habitats. Pillbugs and sowbugs are terrestrial. Isopods occur in 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.

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.

Brusca R. 1997. Tree of life project [Internet]. Available at: http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida.

Photo not available

Centipedes

Orders Geophilomorpha, Lithobimorpha

ORDERS INCLUDE:
5 Native Families
10 Native Genera
12 Native Species
11 Endemic Species

GENERAL INFORMATION: Centipedes have elongated and segmented bodies. Worldwide, there are five divergent orders of centipedes; only two occur in Hawaiʻi (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 Hawaiʻi.

DISTRIBUTION: Centipedes are known from Kauaʻi, Oʻahu, Molokaʻi, Maui, and the island of Hawaiʻi 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 most Hawaiian habitats.

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.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaiʻi 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). Available at: http://www.emporia.edu/ksn/v45n3-march1999/intro.htm.

Millipedes

Orders Polyxenida, Spirostreptida

ORDER INCLUDES:
2 Native Families
2 Native Genera
16 Native Species
16 Endemic Species

GENERAL INFORMATION: Most millipedes 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 lack poisonous fangs and do not bite, but will emit poisonous or foul-smelling substances to deter predators. Of the 15 orders of millipedes found worldwide, only two are found in Hawaiʻi, and both are poorly known.

DISTRIBUTION: Millipedes are known from all the MHI except for the islands of Hawaiʻi and Niʻihau.

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.

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). Available at: http://www.emporia.edu/ksn/v45n3-march1999/intro.htm.


Courtesy Annette Tagawa

Freshwater Fishes

ʻOʻopu nākea

Awaous guamensis

SPECIES STATUS:
IUCN Red List – Data Deficient

SPECIES INFORMATION: The indigenous ʻoʻopu nākea (*Awaous guamensisi)* is the largest of Hawaii's indigenous 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. ʻOʻopu 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 ʻoʻopu nākea are relatively good climbers and swimmers, and post-larvae use tidal inundation to move upstream. The ʻoʻopu nākea will often burrow under rocks leaving only its eyes showing.

DISTRIBUTION: Historically, ʻoʻopu nākea were found on all the Main Hawaiian Islands. Today, they are found in streams on the island of Hawaiʻi, Kauaʻi, Molokaʻi, Maui, and Oʻahu. ʻOʻopu 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: Abundant on Kauaʻi. Populations reduced on Oʻahu.

LOCATION AND CONDITION OF KEY HABITAT: ʻOʻopu 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 Oʻahu, 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, and the introduction of exotic species and parasites. 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:

- Establish survey schedule to determine population size and distribution;

- Monitor number of returning hinana;
- Monitor number of fish taken in recreational fishing each year.

RESEARCH PRIORITIES:

- Determine effects of pollution on populations;
- 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;
- Research effect of fishing on total population size and distribution.

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.

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; Hawaiʻi. State of Hawaiʻi, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

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.

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.

Murphy, Cheryl A. Personal communication.

Yamamoto, M, Tagawa A. 2000. Hawaiʻi's native and exotic freshwater animals. Honolulu, HI: Mutual Publishing. 200 pp.

ʻOʻopu ʻakupa or Sandwich Island sleeper

Eleotris sandwicensis

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: ʻOʻopu ʻakupa or Sandwich Island sleeper (*Eleotris sandwicensis)* is Hawaii's only endemic eleotrid. Adult ʻoʻopu ʻakupa 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 Hawaii'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. ʻOʻopu ʻakupa 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: Historically, ʻoʻopu ʻakupa 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 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 Oʻahu. One study shows that ʻoʻopu ʻakupa are present in Pelekunu stream but rare in Waikolu stream, both on Molokaʻi. ʻOʻopu ʻakupa populations are stable in both altered and unaltered streams.

LOCATION AND CONDITION OF KEY HABITAT: ʻOʻopu ʻakupa are found only in estuaries and the lower reaches of streams. 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 results from water diversion, stream channelization, and dams. 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 such as 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:

- Establish survey schedule to determine population size and distribution;
- Monitor number of returning hinana;

- Monitor number of fish taken in recreational fishing each year.

RESEARCH PRIORITIES:

- Determine effects of pollution on population;
- 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;
- Initiate research to study source-sink population structure;
- Research impacts and methodologies to deal with alien species;
- Research effect of fishing on total population size and distribution.

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.

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.

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.

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

ʻOʻopu ʻalamoʻo

Lentipes concolor

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: The endemic ʻoʻopuʻ alamoʻo (*Lentipes concolor*) can be distinguished from Hawaii's other endemic gobies by their extraordinary abilities to climb vertical waterfalls. Male ʻoʻopuʻ alamoʻo 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. ʻOʻopuʻ alamoʻo 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. ʻOʻopuʻ alamoʻo 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. ʻOʻopuʻ alamoʻo 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: ʻOʻopuʻ alamoʻo has been found in streams on all main islands historically. They are currently found in streams on the island of Hawaiʻi, Kauaʻi, Maui, Molokaʻi, and in seven streams on Oʻahu. Although, not as common, it is very likely that ʻoʻopuʻ alamoʻo exist in more streams on Oʻahu, 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, ʻoʻopuʻ alamoʻo 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 Hawaiʻi. 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: Abundance throughout the islands is unknown; however, populations are decreasing on Oʻahu and Maui.

LOCATION AND CONDITION OF KEY HABITAT: ʻOʻopuʻ alamoʻo do best in unobstructed, cool, fast-moving streams. They spend the majority of their life in freshwater in the upper reaches of streams. ʻOʻopuʻ alamoʻo are very well suited to the naturally variable characteristics of Hawaii's streams. However, where natural stream habitat has been altered, including decreases in forest cover, ʻoʻopuʻ alamoʻo populations have decreased. The majority of already degraded key habitat is located on Oʻoʻopuʻ alamoʻo ahu, 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 ʻoʻopuʻ alamoʻo 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, and the introduction of exotic species and parasites. 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 ʻoʻopuʻ alamoʻo; 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 ʻoʻopuʻ alamoʻo. 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:
- Establish survey schedule to determine population size and distribution;
- Monitor number of returning hinana.

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.

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.

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 Hawaiʻoʻopuʻ alamoʻo i, Department of Land and Natural Resources, Division of Aquatic Resources. 159 pp.

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.

McRae MG. Louisiana State University. Personal communication.

Way CM et al. 1998. Reproductive Biology of the Endemic Goby, *Lentipes concolor*, from Malamakaʻoʻopuʻ alamoʻo ole Stream, Maui and Waikolu Stream, Molokaʻoʻopuʻ alamoʻo 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.

Freshwater Fishes

ʻOʻopu nōpili

Sicyopterus stimpsoni

SPECIES STATUS:
IUCN Red List – Near Threatened
Endemic

SPECIES INFORMATION: Both male and female ʻoʻopu nōpili (*Sicyopterus stimpsoni*) 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 ʻoʻopu 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 ʻoʻopu 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 ʻoʻopu 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: Historically, ʻoʻopu 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 Oʻahu 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. ʻOʻopu nōpili develop aggressive signaling colors at different rates. Those that develop them early establish territories first. These ʻoʻopu nōpili displace other non-colored ʻoʻopu nōpili further upstream. Post-larvae are found in oceanic waters, but little is known of its oceanic distribution.

ABUNDANCE: Abundant where present on all main islands except for Oʻahu where its numbers are greatly reduced from historical times.

LOCATION ANDCONDITION 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, and the introduction of exotic species and parasites. 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:

- Establish survey schedule to determine population size and distribution;
- Monitor number of returning hinana.

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.

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.

Hobson Keith. Canadian Wildlife Service. Personal communication.

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.

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

ʻOʻopu naniha

Stenogobius hawaiiensis

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: ʻOʻopu naniha (*Stenogobius hawaiiensis*) 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: 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.

ABUNDANCE: 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 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, and dams. 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:

- Establish survey schedule to determine population size and distribution;
- Monitor number of returning hinana.

RESEARCH PRIORITIES:

- Research conservation-relevant biology and ecology;
- Better understand the role of estuaries in species ecology;
- Determine effects of pollution on population;
- 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, specifically how this goby is able to have high numbers in altered streams;
- Research effect of fishing on total population size and distribution.

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.

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.

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.

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.

Mountain shrimp
ʻŌpaekalaʻole
Atyoida bisulcata

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

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 schedule 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.

Hawaiian prawn
ʻŌpae ʻoehaʻa
Macrobrachium grandimanus

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

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: ʻŌpae ʻoehaʻa (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 schedule 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

Snails

Pīpīwai or *Clithon cariosus*
Hihiwai or Pipipi or *Clithon neglectus*
Neritilia hawaiiensis

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

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 move upstream to 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. *N. hawaiiensis* is more exclusively found in anchialine ponds.

ABUNDANCE: Unknown. There are no formal quantitative surveys for these species.

LOCATION AND CONDITION OF KEY HABITAT: Pīpīwai occur in the lower reaches of streams and extend more into estuaries. Unknown for the other species. Habitat condition has been degraded in many streams 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 clean estuaries with significant pollution;

- Continue on-going partnerships focused on environmental education and conservation;
- Restore habitat.

MONITORING:
- Establish survey schedule to determine population size and distribution.

RESEARCH PRIORITIES:
- Improve understanding of the life history, biology, and ecology of these snails.

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.

Photo not available

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 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.

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.

Newcomb's snail

Erinna newcombi

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Threatened
State Recognized as Endemic
IUCN Red List Ranking – Vulnerable

SPECIES INFORMATION: *Erinna newcombi* is a freshwater aquatic snail in the family Lymnaeidae. This species is endemic to Kauaʻi Island and inhabits the pristine upper reaches of small streams and springs. This aquatic snail requires cool, clean, moderate- to fast-flowing water and appears to exist only in water systems that are perennial in nature, even through severe drought conditions. The ecology and life history of this species poorly understood but likely is similar to other lymnaeid species. Lymnaeids in general eat algae, and lay egg clusters that they attach to submerged rocks and or vegetation. Larvae do not disperse widely, and the entire lifecycle of the snail is likely tied to single stream systems.

DISTRIBUTION: Occurs in ten small stream and spring sites located in six watersheds in the upper reaches of Kauaʻi.

ABUNDANCE: Estimated at 6,000 to 7,000 individuals.

LOCATION AND CONDITION OF KEY HABITAT: Pristine upper reaches of ten small streams and springs, including Kalalau Stream, Lumahaʻi River, Hanalei River, Kealia Stream, Makaleha Stream, and the north fork of the Wailua River.

THREATS:
- Anthropogenic and natural changes. Changes to hydrolytic systems on Kauaʻi threaten this species.
- Predation. This snail is threatened by predation by the invasive snail Euglandina rosea, predation on the eggs and adults by two invasive species of sciomyzid flies and two species of marsh flies, and potentially predation by introduced fish and frogs.

CONSERVATION ACTIONS: Specific actions should include the following:
- Establish baseline monitoring data on known populations.
- Survey for other extant populations.
- Ensure adequate stream and spring flows.
- Stabilize and increase populations through habitat protection and predator control.

MONITORING:
- Establish monitoring of populations.

RESEARCH PRIORITIES:

- Elucidate population biology and life history.
- Investigate predator control strategies.
- Investigate captive rearing methods.

References:

U.S Fish and Wildlife Service. 2006. Recovery Plan for the Newcomb's Snail (*Erinna newcombi*). Portland, Oregon.

U.S. Fish and Wildlife Service. 2007. Newcomb's Snail (*Erinna newcombi*). 5-year Review: Summary and Evaluation. Honolulu, Hawai'i.

Photo not available

Freshwater Invertebrates

Aquatic Limpet

Ferrissia sharpi

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

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 schedule 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 vespertina

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

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 Oʻahu.

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 schedule 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.

Photo not available

Freshwater Invertebrates

Flatworm

Oahuhawaiiana kazukolinda

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Little is known about this species biology. It is a planarian flatworm.

DISTRIBUTION: The species was described from samples collected in Manoa, Oʻahu stream. They reproduce by producing a cocoon that has about four developing young.

ABUNDANCE: Unknown. No formal monitoring occurs.

LOCATION AND CONDITION OF KEY HABITAT: Manoa Stream, unkown habitat preferences.

THREATS: None identified.

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:

- 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 potential habitat.

MONITORING:

- Establish survey schedule 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:

Kawakatsu M, Mitchell R. 1984. *Oahuhawaiiana kazukolinda*, a new genus, new species turbellaria (Tricladia, Maricola): a new freshwater planarian from Honolulu Island [sic] Hawaii USA. Zoological Science (Tokyo) 1(3):487-500.

Anchialine Pond Shrimps

Antecaridina lauensis
Calliasmata pholidota
ʻŌpae ʻula or *Halocaridina rubra*
Halocaridina palahemo
Metabetaeus lohena
Procaris hawaiana
Palaemonella burnsi
Vetericaris chaceoru


Metabetaeus lohena
Courtesy Karl Magnacca

SPECIES STATUS:
All Federally Listed as Candidates except *Halocaridina*
All State Listed as Candidates except *Halocaridina*
IUCN Red List - Not considered
All Endemic except *Antecaridina*, *Calliasmata*, *Metabeteus*

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*, and *M. lohena* are endemic to Hawaii. 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 all larger (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* has been seen feeding on shrimp. All have red color and reduced appendages. 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. Lifespan of ʻōpae ʻula is long, up to 20 years 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* is blind. *A. lauensis,* ʻōpae ʻula and *M. lohena* occur in salinities of two to 36 ppt. The rarer species are all 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 separate species but part of a genetically diverse cryptic species complex.

DISTRIBUTION: Historic distribution includes 600 to 700 anchailine pools on Oʻahu, Maui, Molokaʻi, and the island of Hawaiʻi and an unknown underground distribution. Currently they occur in fewer anchialine ponds on Maui and Hawaiʻi, and ʻōpae ʻula occurs 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 of the species (*V. chaceorum* and *H. palahemo*) only occur in a single pool each (on Hawaiʻi). Only ʻōpae ʻula and *M. lohena* have a widespread distribution. The other four species occur in no more than four pools each. Six of these eight species can be found in both the Ahihi-Kinaʻu (Maui) and Manuka (Hawaiʻi) Natural Area Reserves (NARs). Some species occur in Wainapanapa Maui; the Waikoloa Anchialine Pond Preserve in North Kona, Hawaiʻi, the Ka Lae area near South Point Hawaiʻi on Department of Hawaiian Home Lands property, and in the Kaloko-Honokohau National Historic Park and Hawaii Volcanoes National Park, all on Hawaiʻi. ʻŌpae ʻula is known from Barbers Point, Flat Island, Waianae, and an aquaculture facility in Kahuku, all on Oʻahu.

ABUNDANCE: Abundance of anchialine shrimps in the Waikolao 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. *H. palahemo* has not been seen in recent surveys. 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 suffered from introduced fishes.

LOCATION AND CONDITION OF KEY HABITAT: Anchialine pond shrimp are found in underground (hypogeal) salt waters and in anchialine ponds, which are found in geologically young lava fields near the coast. The lava in these areas has 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 shrimp 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 industry and was colonized by ʻōpae ʻula that turn 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 very unclear the extent to which anchialine ponds are necessary for the survival of ʻōpae ʻula. The ponds may be a source of increased primary productivity to the anchialine shrimp and associated community as the underground habitat is likely low in productivity without these connections.

THREATS:

- Habitat destruction has reduced available habitat for anchialine pond shrimps. 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 Waikaloa to assess the impacts of development there;

- A number of introduced species may compete with them for food or prey on them. Introduced fishes (Tilapia, koi, mosquitofish and guppies) and Tahitian prawns are a major predatory threat and alter the habitat use of remaining shrimp. Over 90 percent of the anchialine ponds in the Kona coast of Hawaiʻi are contaminated with non-native species. The presence of introduced fishes leads the shrimps to retreat into crevices in the substrate. As a result the ponds become overgrown with algae, leading to greatly accelerated debris accumulation and decay of the ponds, suggesting ʻōpae ʻula is 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;
- Maintain healthy populations with appropriate fishing regulations and education;
- Closure and rerouting of a portion of the road adjacent to 49 pools in Manuka NAR has been proposed.

MONITORING:

- Continue surveys of population and distribution in known and likely habitats;
- Develop quantitative survey methods.

RESEARCH PRIORITIES:

- Improve understanding of life history of anchialine pond shrimps including the importance of ponds vs. underground habitats to the existence and size of shrimp populations;
- 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:

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 Hawaiʻi 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 Hawaiʻi Volcanoes National Park from Wahaʻula to Kaʻaha, Puna and Kaʻu, Hawaiʻi. 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.

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


Parhyale hawaiensis
Courtesy Alivia Price, Nipam Patel

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 Hawaiʻi, though specific research on these species ecology is rare. *G. amikai* has been found in an artificial pond on Kahoʻolawe. *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 Hawaiʻi. *R. lokoa* and *P. paakai* have the most widespread distribution on the island of Hawaiʻi.

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 filled or 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:

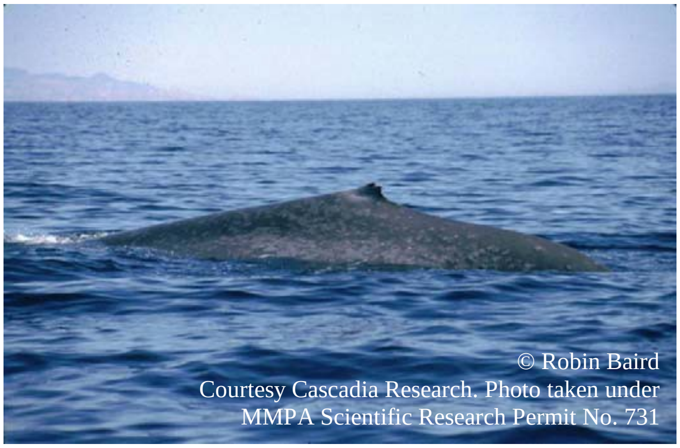
- Improve understanding of life history and biology of anchialine pond amphipods and the role of interstitial underground waters;
- Understand the ecological importance of interactions with introduced competitors and predators;
- Research the life history of introduced competitors and predators to develop 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 brackish lava 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.



Other baleen whales

Balaenoptera acutorostrata (LC)
Balaenoptera borealis (FE, EN)
Balaenoptera edeni (DD)
Balaenoptera musculus (FE, EN)
Balaenoptera physalus (FE, SE, EN)
Eubalaena japonica (FE, EN)

SPECIES STATUS:
Four Federally Listed Endangered (FE)
One State Listed as Endangered (SE)
IUCN Red List - Various (see abbreviations below)
IUCN Data Deficient (DD)
IUCN Endangered (EN)
IUCN Least Concern (LC)

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, and fin whales feed on large schools of fish and krill, whereas blue whales and North Pacific right whales feed exclusively on plankton. 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 Hawaiʻi that is non-migratory and they are most often sighted northwest of the Main Hawaiian Islands (MHI). The others feed at higher latitudes and migrate to Hawaiʻi seasonally.

BUNDANCE: Abundance estimates in the Hawaiian Islands Exclusive Economic Zone are as follows: sei whale 178, Bryde's whale 633, fin whale 58, and blue whale 81. There are no estimates for minke or 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.
- arine 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.
- 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.

- **ONSERVATION ACTIONS:** ctions specific to baleen whales should include the following:Continue to reduce vessel strikes and entanglement.
- Reduce marine debris and pollutants in the marine environment.
- Collaborate with the National Oceanic and Atmospheric Administration (NOAA) on enforcement of the Marine Mammal Protection Act to prevent marine mammal harassment and disturbance.
- Incorporate baleen whales and other marine mammals in Hawaiian Islands Humpback Whale National Marine Sanctuary management.

ONITORING:

- CMonitor abundance and distribution of baleen whales in Hawaiian waters.
- Monitor mortality and injury from entanglement and boat strikes.

RESEARCH PRIORITIES:

- REvaluate impacts of plastics and marine debris on baleen whales.
- SExamine impacts of underwater noise and sonar transmissions on baleen whales.

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, 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. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

McDermid KJ, McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

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.

Other Toothed Whales


Peponocephala electra
Courtesy Keoki Stender

Feresa attenuata (DD)
Grampus griseus (LC)
Indopacetus pacificus (DD)
Kogia breviceps (DD)
Kogia sima (DD)
Lagenodelphis hosei (LC)
Mesoplodon densirostris (DD)
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 Data Deficient (DD)
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),* nai'a or 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 whales have 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 naiʻa. 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 naiʻa 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 all 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 3,433, Risso's dolphin 5,207, Longman's beaked whale 4,571, Fraser's dolphin 10,226, Blainville's beaked whale 2,338, killer whale 101, melon-headed whale 447, sperm whales 3,354, striped dolphin 20,650, naiʻa 6,288, and Cuvier's beaked whale 1,941. There are no current abundance estimates for pygmy and dwarf sperm whales. 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. Cuvier's and Blainville's beaked whales and killer whales are 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: Actions specific to toothed whales should include the following:

- Continue to reduce vessel strikes and entanglement.
- Reduce marine debris and pollutants in the marine environment.
- Incorporate toothed whales and other marine mammals in Hawaiian Islands Humpback Whale National Marine Sanctuary management.
- Collaborate with local conservation organizations on cetacean conservation, education, and marine debris clean-up.

MONITORING:

- Monitor abundance and distribution of toothed whales in Hawaiian waters.
- Monitor mortality and injury from entanglement and boat strikes.

RESEARCH PRIORITIES:

- Continue research on stock structure, habitat, and ecology.
- Evaluate impacts and toxicity of small plastic pellet debris on toothed whales.
- Examine impacts of vessel noise and sonar transmissions on toothed whales.

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 Hawaiʻi. Aquatic Mammals 28(3): 294-297.

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 Hawaiʻi. Maui: Hawaii: Pacific Whale Foundation.

Marine Mammals

Short-finned pilot whale

Globicephala macrorhynchus

SPECIES STATUS:

IUCN Red List - Lower Risk/Conservation Dependent

SPECIES INFORMATION: Short-finned pilot whales (*Globicephala macrorhynchus*) feed primarily on squid, but they may also feed on octopus and fish, all from moderately deep water. When they are swimming and probably 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 2002 NOAA Stock Assessment Report estimates short-finned pilot whale abundance at 1,700, but this number underestimates the total population because it does not include the Northwestern Hawaiian Islands and only includes short-finned pilot whales within 25 nautical miles offshore. Barlow (2003), however, estimates population abundance for the entire Hawaiian Exclusive Economic Zone at 8,800.

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;

- Man-made noise is a threat that results from high vessel traffic and military vessels that use Hawaiian waters for operations involving sonar and explosions. This man-made noise can interfere with acoustic signals critical to reproduction and feeding. Man-made noises also have been shown to cause disturbance responses from far away, hearing loss, and physical harm;
- Interactions with whale watching tours may impact these whales; however, these are few tours focusing on this 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:

- Establish a systematic fisheries monitoring system for interactions with short-finned pilot whales;
- Continue working to decrease marine debris;
- Work with partners to decrease pollutants and chemicals in the marine environment;
- Continue to collaborate with NOAA on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance;
- Continue collaboration with NOAA, agency partners and stakeholders in the process of considering species for inclusion in the HIHWNMS;
- Work with and assist local conservation organizations on cetacean conservation, education, and marine debris clean-up.

MONITORING:

- Survey nearshore habitat for detailed population size and distribution;
- Monitor the number of short-finned pilot whales entangled or otherwise impacted by marine debris and taken as fisheries bycatch.

RESEARCH PRIORITIES:

- Continue researching habitat use, feeding behaviors, and other biological information;
- Improve understanding of impacts from tourism related activities on short-finned pilot whales;
- Collaborate with NOAA to understand interactions with nearshore fisheries;
- Research impacts and toxicity of small plastic pellet debris on marine mammals;
- Initiate studies to determine threats and minimize their impacts.

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 R

Harrison 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.

McDermid K J McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

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.


Courtesy HIHWNMS. Photo taken under NOAA Fisheries Permit No. 782-1438

Marine Mammals

Humpback whale or Koholā

Megaptera novaeangliae

SPECIES STATUS:
Federally Listed as Endangered,
Proposed for Delisting
State Listed as Endangered
State recognized as Indigenous
IUCN Red List – Least Concern

SPECIES INFORMATION: Kohola̅, 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 is thought to occur in Hawaiian waters. Life span is about 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 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 10,000 whales, increasing at a rate of 5.5–6 percent annually.

LOCATION AND CONDITION OF KEY HABITAT: Kohalā prefer warm shallow waters for calving, commonly near offshore reefs, islands, or continental shores. Feeding grounds are in cold, productive, shallow waters.

THREATS:

- Whaling. Kohalā were historically threatened by commercial and aboriginal whaling, although a prohibition on commercial whaling by the International Whaling Commission has greatly reduced this threat.
- Harassment, boat strikes, and entanglement. Whale-watching boats have resulted in harassment and disturbance to kohalā. Ships colliding with kohalā and entanglement in fishing gear are significant causes of injury and mortality. 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 (Sanctuary),

which has reduced the threat of boat strikes. A Cetacean Take Reduction Plan implemented in the North Pacific in 1997 has reduced entanglements with fishing gear.

- 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.

CONSERVATION ACTIONS: Actions specific to conservation of kohalā should include the following:

- Continue to reduce boat strikes and entanglement.
- Reduce marine debris and pollutants in the marine environment.
- Collaborate with the National Oceanic and Atmospheric Administration (NOAA) on enforcement of the Marine Mammal Protection Act to prevent harassment and disturbance.
- Continue federal-State partnerships for kohalā conservation, most visibly in the form of management, education, and research within the Sanctuary.

MONITORING: Monitor abundance and distribution of kohalā.

RESEARCH PRIORITIES:

- Evaluate interactions with nearshore fisheries.
- Evaluate impacts of plastics and marine debris on marine mammals.
- Continue to evaluate the health of the population in the Sanctuary.

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.

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

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.

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).

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 – Critically Endangered

SPECIES INFORMATION: Īlio-holo-i-ka-uaua, or Hawaiian monk seals, are benthic feeders and feed on reef fishes, octopus, squid, and lobsters over many substrates up to depths of 305 meters (1,000 feet). Juveniles feed on a higher proportion of nocturnal fish species. Food seems to be a limiting factor for population growth. They are usually solitary, except on preferred beaches when they occur in close proximity and interact. Mating occurs in the spring and early summer. Gestation is approximately one year. Pupping occurs in late winter and spring. Weaning lasts five to six weeks, in late spring, and pups and mothers stay ashore until pups are weaned. Foster parenting occurs. Most females breed every other year, but about one-third breed in consecutive years. 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. These are the only endangered marine mammal that occurs exclusively within the United States.

DISTRIBUTION: Occurs in all of the Hawaiian Islands, including a small population in the Main Hawaiian Islands (MHI), although the majority of the population and pupping occurs in the Northwestern Hawaiian Islands (NWHI).

ABUNDANCE: The total population is estimated at 1,200 individuals, most of which occur in the NWHI, with a decreasing population trend. About 150 of these seals occur in the MHI, where the population is increasing.

LOCATION AND CONDITION OF KEY HABITAT: Feeding occurs within the atoll lagoon systems and on the reef slope within 200 kilometers (124 miles) of islands or atoll systems. They also forage on the submarine ridges connecting the atoll systems and on the seamounts around the NWHI. Terrestrial habitat is used about one-third of the time and includes haul-out areas for pupping, nursing, and resting, primarily on sandy beaches, but virtually all substrates are used. Beach vegetation is used for protection from wind and rain. Critical habitat has been designated under the Endangered Species Act as all waters out to 20 fathoms of depth and beaches (including sand spits and islets) and beach vegetation to its deepest inland extent around the six known breeding sites plus Maro Reef, Gardner Pinnacle, Necker, and Nihoa Islands. In addition, there is proposed critical habitat that would extend the current designation in the NWHI out to the 500-meter depth contour plus Sand Island at Midway Islands, as well as six new areas in the MHI (Kaula Island, Niʻihau, Kauaʻi, Oʻahu, Maui Nui, and Hawaiʻi) from 5 meters inland to the 500-meter depth contour.

THREATS:

- Human disturbance. Capture by humans and disturbance by military activities in the NWHI were once major threats. Disturbance of mothers with pups on popular beaches in the MHI is an ongoing threat.
- 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 has decreased entanglement.
- 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.
- 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.
- Small population size and low genetic diversity exacerbate the other threats.

CONSERVATION ACTIONS: Actions specific to īlio-holo-i-ka-uaua should include the following:

- Continue to reduce fishery interactions and remove marine debris.
- Continue restoration and conservation of habitat and prey base.
- Remove sharks that cause significant predation of pups.
- Continue efforts to reduce potential introduction and exposure to infectious diseases.
- Expand and coordinate education and outreach programs.
- Conduct as-needed c aptive feeding and release of juveniles, and translocation of problem males and pups from low-survival areas to bolster other subpopulations.
- Maintain extensive field presence in NWHI to monitor and manage the seal population.

MONITORING: Conduct population monitoring, pup tagging, and adult identification program.

RESEARCH PRIORITIES:

- Examine causes of low juvenile survival.
- Continue habitat use and diet studies.

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.

IUCN Red List of Threatened Species. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

National Marine Fisheries Service. 1988. Critical habitat, Hawaiian monk seal; Endangered Species Act. Federal Register 53(102):18988-18996.

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. 2007. Hawaiian Monk Seal (*Monachus schauinslandi*). 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Honolulu, Hawaiʻi.

National Marine Fisheries Service. 2011. Endangered and threatened wildlife and plants: proposed rulemaking to revise critical habitat for Hawaiian monk seals. Federal Register 76(106):32026-32063.

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).

Marine Mammals

False killer whale

Pseudorca crassidens

SPECIES STATUS:
Federally Listed as Endangered – Main Hawaiian Insular Stock
State Listed as Endangered
IUCN Red List – Data Deficient

SPECIES INFORMATION: False killer whales are found at the broadest range of depths of all cetaceans in Hawaiʻi. In Hawaiʻi, they feed primarily on mahi mahi and yellowfin tuna, and food sharing is known to occur. To increase success of finding prey, they travel in a broad band up to several kilometers wide. They have low reproduction rates with calving intervals of approximately seven years. Gestation ranges from 14 to 16 months and lactation for one and half to two years. Life span is about 60 years. They are gregarious and form strong social bonds, and are usually found in subgroups of 10 to 20 that belong to larger groups of 40 or more individuals. They also occur with other cetaceans, most notably the bottlenose dolphin. False killer whales in Hawaiʻi are reproductively and genetically isolated from other populations in the Pacific.

DISTRIBUTION: Three stocks occur in the Hawaiian Islands, with partially overlapping ranges: the Main Hawaiian Insular stock (federally listed as endangered) is found within 140 kilometers of the Main Hawaiian Islands (MHI), the Hawaiʻi Pelagic stock in waters greater than 40 kilometers from the MHI, and the Northwestern Hawaiian Insular stock within 93 kilometers of the Northwestern Hawaiian Islands (NWHI) and Kauaʻi. The species also occurs in tropical and temperate waters worldwide.

ABUNDANCE: Abundance estimates are as follows: for the Main Hawaiian Insular stock, 150 whales with a declining population trend, for the Hawaiʻi Pelagic stock, 1,500 whales with an unknown trend, and for the Northwestern Hawaiian Insular stock, 500 whales with an unknown trend.

LOCATION AND CONDITION OF KEY HABITAT: Shallow inshore and deep oceanic waters around Hawaiʻi.

THREATS:

- Fisheries interactions. Injury and mortality can be caused by hooking and entanglement of whales in fishing gear. False killer whales are known to steal yellowfin tuna and mahi mahi off trolling lines, which may have resulted in intentional shooting of the whales by fishers. To reduce mortality and injury in Hawaiian longline fisheries, a Take Reduction Plan became effective in 2012. The plan describes gear requirements, time-area closures, and improved responses to hooked and entangled false killer whales.
- 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 from ingestion.

- 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.
- Climate change. Rising ocean temperatures and ocean acidification from climate change could result in lower ocean productivity and decreased food availability.

CONSERVATION ACTIONS: Actions specific to false killer whales should include the following:

- Reduce marine debris and pollutants in the marine environment.
- Continue to reduce vessel strikes and entanglement.
- Continue to collaborate with the National Oceanic and Atmospheric Administration (NOAA) on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance.
- Incorporate false killer whales and other marine mammals in Hawaiian Islands Humpback Whale National Marine Sanctuary management.
- Collaborate with local conservation organizations working on cetacean conservation and education.

MONITORING:

- Monitor abundance and distribution of false killer whales in Hawaiian waters.
- Continue monitoring entanglement and fisheries bycatch.

RESEARCH PRIORITIES:

- Evaluate habitat use, feeding behaviors, and other biological information.
- Evaluate impacts of plastics and marine debris on marine mammals.
- Evaluate impacts of whale-watching and other tourist activities on false killer whales.

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, 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. 2015. Version 2014.3. www.iucnredlist.org. (Accessed May 2015).

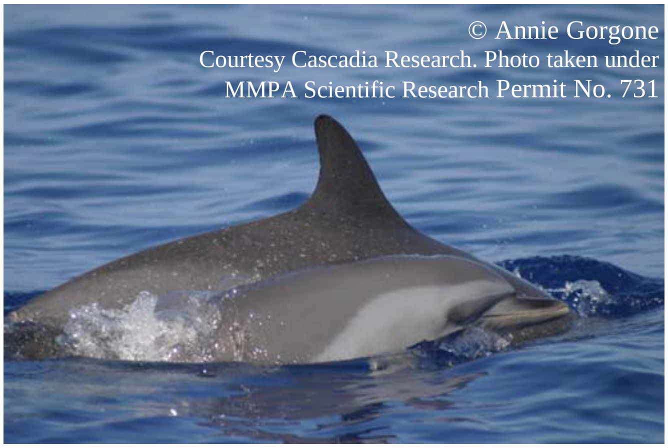
McDermid KJ, and McMullen TL. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian Archipelago. Marine Pollution Bulletin 48: 790-794.

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.

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.

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

Naiʻa or Spotted dolphin

Stenella attenuata

SPECIES STATUS:
IUCN Red List - Lower Risk/ Conservation Dependent

SPECIES INFORMATION: Naiʻa or the spotted dolphin (*Stenella attenuata*) found in Hawaiian waters is considered one of three subspecies of *Stenella attenuata*. The diet of spotted dolphins in Hawaiʻi has been studied very little, but it appears that they feed primarily on mesopelagic cephalopods and fish. A recent study shows 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. 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.

DISTRIBUTION: They are found throughout the Hawaiian Islands, often off leeward coasts. They have small home ranges and may not move between islands.

ABUNDANCE: The 2002 NOAA Stock Assessment estimates spotted dolphins abundance at approximately 2,900, but this number underestimates the total population because it does not include the Northwestern Hawaiian Islands and only includes dolphins within 25 nautical miles offshore. Barlow (2003) estimated population abundance for the entire Hawaiʻi Exclusive Economic Zone at approximately 10,300. It is important to note that within Hawaiʻi there may be distinct spotted dolphins populations that do not intermingle. There is no data to determine a clear trend in abundance.

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 Hawaiʻi, Kauaʻi, Lānaʻi, and Niʻihau. At night they move further off shore 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. More studies need to be conducted to quantify this threat;
- 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:

- Establish a systematic fisheries monitoring system for interactions with spotted dolphins;
- Continue working to decrease marine debris;
- Continue to collaborate with NOAA on enforcement of the Marine Mammal Protection Act as it relates to preventing marine mammal harassment and disturbance;
- Continue collaboration with NOAA, agency partners and stakeholders in the process of considering species for inclusion in the HIHWNMS;
- Work with partners to decrease pollutants and chemicals in the marine environment;
- Work with and assist local conservation organizations working on cetacean conservation, education and marine debris clean-up;
- Continue collaboration with NOAA on education and outreach activities, such as the "Ocean Etiquette" program, to promote dolphin-friendly ecotourism activities.

MONITORING:

- Survey nearshore habitat for detailed population size and distribution;
- Monitor the number of pantropical spotted dolphins entangled or otherwise impacted by marine debris and taken as fishery bycatch.

RESEARCH PRIORITIES:

- Continue researching habitat use, feeding behaviors, and other biological information;
- Initiate studies to determine further threats and minimize their impacts;
- Collaborate with NOAA to understand interactions with nearshore fisheries;
- Improve understanding of impacts from tourism related activities on spotted dolphins;
- Research impacts and toxicity of small plastic pellet debris on marine mammals;
- Study impacts of noise from marine vessels on spotted dolphins.

References:

Baird, Robin. Cascadia Research Collective. Personal Communication.

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.

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

Naiʻa or Spinner dolphin

Stenella longirostris

SPECIES STATUS:
IUCN Red List - Lower Risk/ Conservation Dependent

SPECIES INFORMATION: Naiʻa 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, 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. Recent research shows that this food source is close to shore early in the night so the spinner dolphins follow them inshore for awhile. During the day, they expend less energy resting or socializing in nearshore, shallow waters such as bays and lagoons surrounded by reef. 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 ten and a half 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 Hawaiʻi. Today, spinner dolphins are still located throughout the entire Hawaiian Archipelago. These dolphins travel along the coast of each island. A large "resident" population occurs off the coast of Kona on the island of Hawaiʻi and asmaller group off Kahena on the east side. On Oʻahu, dolphins are found off the west coast of Waiʻanae, but they also travel between Waiʻanae and the southern shores. On Lānaʻi, 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 2002 NOAA Stock Assessment Report estimates the Kona population at approximately 2,300 and total population abundance in Hawaiʻi at approximately 3,200. The total population abundance estimate underestimates the total population size because it does not include the Northwestern Hawaiian Islands and only includes dolphins within 25 nautical miles offshore of the Main Hawaiian Islands. Barlow (2003) estimates spinner dolphin abundance throughout Hawaii's Exclusive Economic Zone at approximately 2,800. Ostman Lind et al. (2004) crudely estimate about 1,000 individuals in the population off Kona. There is no known data on whether the population is increasing or decreasing.

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 run off, 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. Additionally, a high speed ferry that will travel through the Main Hawaiian Islands may be approved in the near future;
- Habitat degradation from coastal development and run-off is also a threat particular to spinner dolphins as they primarily 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 statewide and island conservation actions, specific actions include:

- Continue collaboration with NOAA on education and outreach activities, such as the "Ocean Etiquette" program, to promote dolphin-friendly ecotourism activities;

- Continue to collaborate with NOAA on enforcement of the Marine Mammal Protection Act as it relates to preventing dolphin harassment and disturbance;
- Continue collaboration with NOAA, agency partners and stakeholders in the process of considering new species or areas for inclusion in the HIHWNMS;
- Continue working to decrease marine debris;
- Work to decrease pollutants and chemicals in the marine environment;
- Work with and assist local conservation organizations working on cetacean conservation, education, and marine debris clean-up;
- Support other public outreach and education efforts focusing on the effects of fisheries bycatch, marine debris, pollutants, and noise on spinner dolphins.

MONITORING:
- Continue surveys of population and distribution in known and potential habitats, along impacted coasts to determine the level of impact and project future trends;
- Monitor the number of spinner dolphins entangled or otherwise impacted by marine debris or taken as fishery bycatch to determine if education efforts are successful.

RESEARCH PRIORITIES:
- Improve understanding of impacts from tourism related activities on spinner dolphins in Hawaiʻi;
- Collaborate with NOAA to understand interactions with nearshore fisheries;
- Determine correlations between marine debris accumulations with shipping lanes and currents to better target efforts;
- Research impacts and toxicity of small plastic pellet debris on marine mammals;
- Study impacts of noise from ships on spinner dolphins.

References:

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 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.

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.

For photo see:

http://www.nmfs.noaa.gov/prot_res/species/turtles/loggerhead.html

Loggerhead sea turtle

Caretta caretta

SPECIES STATUS:
Federally Listed as Threatened
State Listed as Threatened
IUCN Red list – Endangered

SPECIES INFORMATION: 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 population size in the North Pacific is unknown but is likely declining. The nesting population in Japan has declined significantly in recent decades.

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 Hawaiʻi.

THREATS:

- <u>Fisheries bycatch</u>. 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.
- <u>Habitat loss and degradation</u>. Nesting beaches (all of which are outside Hawaiʻi) 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.
- <u>Harvest of eggs and adults</u>. Harvest occurs on beaches in many countries, although conservation efforts have reduced this threat.
- <u>Marine debris</u>. Entanglement by, or ingestion of, marine debris is a source of mortality.

CONSERVATION ACTIONS: Actions specific to loggerhead sea turtles should include the following:

- Cooperate with jurisdictions where nesting occurs to restore nesting habitat and reduce take of eggs and females.
- Reduce marine debris in 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.

MONITORING: Continue to monitor turtles harmed or killed by marine debris and fisheries bycatch.

RESEARCH PRIORITIES: Determine distribution, abundance, and status of post-hatchlings, juveniles, and adults in the marine environment.

References:

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.

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.


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 – Endangered

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 exhibit 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: 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 habitat 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. 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. 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 on 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.
- Marine debris. Entanglement by, or ingestion of, marine debris is a source of mortality.
- Climate change. 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 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.

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:

- Examine the environmental factors associated with FP.
- Evaluate effects of tourist activities on turtles.
- Determine distribution, abundance, and status of post-hatchlings, juveniles, and adults in the marine environment.

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 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.

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.

Meadows DW. 2004. Behavior of green sea turtles in the presence and absence of recreational snorkellers. Marine Turtle Newsletter 103: 1-4.

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.

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.

Leatherback sea turtle

Dermochelys coriacea

For photo see:

http://www.nmfs.noaa.gov/prot_res/species/turtles/leatherback.html

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
IUCN Red list – Vulnerable

SPECIES INFORMATION: 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 turtle in which adults are also pelagic and carnivorous, feeding on jellyfishes, 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 Hawaiʻi-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. 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 Hawaiʻi. In the Pacific Ocean, the annual number of breeding females is around 3,000 with declining nesting population trends noted at most breeding locations.

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 Hawaiʻi 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 Hawaiʻi) 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.

CONSERVATION ACTIONS: Actions specific to leatherback sea turtles should include the following:

- Cooperate with jurisdictions where nesting occurs to restore nesting habitat and reduce 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.

MONITORING: Continue to monitor turtles harmed or killed by marine debris and fisheries bycatch.

RESEARCH PRIORITIES: Determine distribution, abundance, and status of post-hatchlings, juveniles, and adults in the marine environment, especially in their foraging grounds.

References:

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.

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.

Marine Reptiles

Hawksbill sea turtle

Eretmochelys imbricata

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered
IUCN Red list – Critically Endangered

SPECIES INFORMATION: 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 Hawaiʻi 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 Hawaiʻi. 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 less than 20 breeding females annually. Population trends are unknown but may be stable on the island of Hawaiʻi. Worldwide, the breeding population is estimated at 22,000 to 29,000 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 on 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 sources of mortality.
- Climate change. 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.

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 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.

MONITORING:

- Continue to monitor nesting sites.
- Continue to monitor abundance and distribution.
- Continue to monitor turtles harmed or killed by marine debris and from fisheries bycatch.

RESEARCH PRIORITIES: Determine distribution, abundance, and status of post-hatchlings, juveniles, and adults in the marine environment.

References:

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 Hawaiʻi. 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, Hawaiʻi 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.

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.

Marine Reptiles

Olive ridley sea turtle

Lepidochelys olivacea

SPECIES STATUS: Federally Listed as Threatened State Listed as Threatened IUCN Red list – Vulnerable

SPECIES INFORMATION: 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 Hawaiʻi-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, Hawaiʻi represents a point of convergence for these source areas.

DISTRIBUTION: Worldwide, the species occurs in subtropical and tropical waters of the Pacific Ocean. Generally only seen in deep oceanic waters around Hawaiʻi. Nesting has been recorded only once in Hawaiʻi, on Maui in 1985.

ABUNDANCE: There is no clear trend in abundance.

LOCATION AND CONDITION OF KEY HABITAT: Most often found in shallow water around reefs, bays, and inlets. Most nesting occurs on continental beaches. 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 Hawaiʻi) 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.

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 take of eggs and females.
- Reduce marine debris in 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.

MONITORING:

- Continue to monitor nesting sites.
- Continue to monitor turtles harmed or killed by marine debris and from fisheries bycatch.

RESEARCH PRIORITIES:

- Determine distribution, abundance, and status of post-hatchlings, juveniles, and adults in the marine environment.

References:

Gulko D, Eckert K. 2003. Sea Turtles: An Ecological Guide. Honolulu, HI: Mutual Publishing.

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.

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 take 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.

Marine Reptiles

Yellow-bellied sea snake

Pelamis platurus

SPECIES STATUS:
State recognized as indigenous
IUCN Red List – Not Considered

SPECIES INFORMATION: This sea snake is pelagic and feeds on small fishes and eels. 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 venemous, but have a small mouth and fangs and are generally un-aggressive unless harassed.

DISTRIBUTION: They occur in tropical and subtropical areas of the Indian and Pacific Oceans. Specific distribution in Hawai'i is poorly known.

ABUNDANCE: No estimates or surveys of abundance exist because they are pelagic and rare.

LOCATION AND CONDITION OF KEY HABITAT: Occur in water from 22 to 30 degrees C and 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:
- Boat strikes;
- Fishery bycatch.

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:
- Restoration of habitat;
- Maintain healthy populations with adequate fishery regulation.

MONITORING:
- Initiate surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES: None identified.

References:
Gulko D, Eckert K. 2003. Sea turtles: an ecological guide. Honolulu, HI: Mutual Publishing. 128 pp.

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).


Manta
Courtesy NMFS

Marine Fishes

Sharks and Rays

Great white shark
Niuhi
Carcharodon carcharias

Whale shark
Lele waʻa
Rhincodon typus

Manta ray
Hāhālua
Manta alfredi or *Manta birostris*

SPECIES STATUS:
IUCN Red List – sharks are Vulnerable, Manta ray is Data Deficient
None Endemic

SPECIES INFORMATION: Great whites (niuhi) are predators on large fishes, marine mammals, and some sea turtles and larger invertebrates. Whale sharks filter feed on planktonic schooling fishes, squids, and crustacean larvae and adults. Manta rays are planktonic filter feeders in coastal waters. These species have slow growth rates and low fecundity that limit their recovery from threats. The sharks travel widely and may only be occasional visitors to Hawaiʻi. Recent tagging of great white sharks off California found that many took unexpectedly large migrations into the Central Pacific Ocean, including one individual that made it all the way to Hawaiʻi for a few months. Manta taxonomy is confused so it cannot be determined whether our species is alfredi or birostris at this time.

DISTRIBUTION: All species are likely to occur throughout the Hawaiian Islands but great whites (niuhi) have been noted in the main islands through Laysan Island, and whale sharks have been recorded throughout the main islands.

ABUNDANCE: There are no systematic survey efforts for these species.

LOCATION AND CONDITION OF KEY HABITAT: All species can be found in shallow water depths. A tagged great white shark spent most of its time in very deep water however. All are wide ranging. Manta rays can be predictably found off parts of the west coast of the island of Hawaiʻi.

THREATS:

- These species are threatened by fisheries bycatch and directed catch in other parts of the world for food, medicinal and other commercial uses;
- Tourism to see manta rays occurs on the Kona Coast of the island of Hawaiʻi. Tourism for great white and whale sharks occurs elsewhere but their presence here is too unpredictable to make tourism feasible.

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. These sharks are listed in Appendix II of the Convention on International Trade in Endangered Species (CITES). In addition to common statewide 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:

Crow GL, Crites J. 2002. Sharks and rays of Hawaii. Honolulu, HI: Mutual Publishing. 203 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).

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.

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: 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* (no common name), *Scolecenchelys phuioilo* (no common name), *Acromycter alcocki* (no common name), *Bathycongrus aequorea* (no common name), and *Gorgasia hawaiiensis* (Hawaiian garden eel, puhi).

DISTRIBUTION: The many-vertebrate moray has been found off Oʻahu only. Steindachner's moray has been found from Oʻahu through the Northwestern Hawaiian Islands (NWHI). Fowler's snake eel occurs off Maui, Lānaʻi, and Oʻahu. *Ophichthus kunaloa* is found from the island of Hawaiʻi to Oʻahu. *Scolecenchelys puhioilo* is known from only two specimens from Oʻahu and Maro Reef. *Acromycter alcocki* has been collected from Maui to Oʻahu. *Bathycongrus* occurs from the island of Hawaiʻi to Kauaʻi and maybe further northwest. Hawaiian garden eels occur from the island of Hawaiʻi to Oʻahu. 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 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:
- Puhi-kauila (dragon eel) and Hawaiian garden eels are prized by aquarists;
- Hawaiian garden eels may be threatened by habitat alteration.

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:
- Restoration of habitat;
- Maintain healthy populations with appropriate fishing regulations 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;
- 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: Hawaiʻi Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawaiʻi Division of

Aquatic Resources.

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

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.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Fishes

Active Reef Fishes

Chaetodon tinkeri
Courtesy Keoki Stender

Chaetodontidae

Chaetodon fremblii
Chaetodon tinkeri
Prognathodes sp.

Pomacanthidae

Apolemichthys arcuatus
Centropyge fisheri
Centropyge loricula
Genicanthus personatus

Pomacentridae

Chromis hanui
Chromis ovalis
Chromis struhsakeri
Plectroglyphidodon sindonis

Geniacanthus personatus male
Courtesy Keoki Stender

Priacanthidae

Priacanthus meeki

Cheilodactylidae

Cheilodactylus vittatus

Ammodytidae

Ammodytoides pylei
Lepidammodytes macrophthalamus

Monacanthidae

Cantherhines verecundus

Thamnaconus garretti

Ostraciidae

Ostracion whitleyi

Tetraodontidae

Torquigener randalli

SPECIES STATUS:
IUCN Red List – Not considered
All Endemic except *Chaetodon tinkeri*, *Apolemichthys*, *Centropyge loricula,* and *Ostracion*

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:
- These species are almost all prized by aquarists except for Hawaiian rock damselfish, ʻāweoweo, and Hawaiian morwong, and the ammodytids. Masked angelfish in particular command a very high price;
- ʻĀweoweo is fished recreationally and commercially.

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:
- Restoration of habitat;
- Maintain healthy populations with appropriate fishing regulations 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 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: Hawaiʻi Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawaiʻi Division of Aquatic Resources.

Hoover 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).

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.

Liopropoma aurora
Courtesy Keoki Stender

Marine Fishes

Sex Changing Reef Fishes

Serranidae

Liopropoma aurora
Pseudanthias thompsoni
Pseudogramma polyacanthum hawaiiensis

Anampses chrysocephalus male
Courtesy Keoki Stender

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: 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: Hawaiian anthias have been reported from Molokaʻi throughout the rest of the chain to the northwest. Palespotted podge has been found from the island of Hawaiʻi to Oʻahu. The sand wrasse has only been found off Oʻahu. Lae-nihi have only been found from the island of Hawaiʻi to Necker Island. 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.

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:

- 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.

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:

- Maintain healthy populations with appropriate fishing regulations 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;
- Support aquacultural research to 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.

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

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.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

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

Tripterygiidae
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: 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, pao'o), *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: *Enchelyurus* occurs from O'ahu to Lisianski. *Entomacrodus strasburgi* occurs from Moloka'i to O'ahu. Zebra blennies occur from Hawai'i Island to Lisianski. The scale- eating blenny occurs from the island of Hawai'i 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 O'ahu. The longtail dragonet is found from Maui to Pearl and Hermes Atoll. *Draculo* has been found from Moloka'i to Kaua'i. *Synchiropus hawaiiensis* has been found from Maui to Moloka'i. *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 O'ahu. The ribbon goby is found off Lāna'i and Moloka'i. *Oxyurichthys lonchotus* has been collected from Hawai'i Island to O'ahu. Hawaiian orbicular velvetfish have been found from O'ahu through Midway Atoll. *Scorpaenopsis altirostris* is found from the island of Hawai'i to Moloka'i. *Scorpaenopsis pluralis* is known only from the holotype from near Laysan. *Synodus falcatus* has been found from Moloka'i through Laysan Island. *Synodus janus* is only known from the holotype collected off the island of Hawai'i. 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 (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). 'Upāpalu (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:

- 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:

- Maintain healthy populations with appropriate fishing regulations 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;
- 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: Hawaiʻi Division of Aquatic Resources. 21 pp.

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawaiʻi 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.

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.

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

Bottomfishes

Ulua aukea or Giant ulua
Caranx ignobilis

Black ulua
Caranx lugubris

Butaguchi or Thick or Pig ulua
Pseudocaranx dentex

Kahala or Amberjack
Seriola dumerii

Giant grouper
Epinephelus lanceolatus

Hāpuʻu or Hawaiian grouper
Epinephelus quernus

Lehi
Aphareus rutilans

Uku or Jobfish
Aprion virescens

Ulaʻula or Ehu
Etelis carbunculus

Ulaʻula koaʻe or

Onaga

Etelis coruscans

Goldflag jobfish

Pristipomoides auricilla

Opakapaka

Pristipomoides filamentosus

Kalekale

Pristipomoides seiboldii

Ukikiki or Gindai

Pristipomoides zonatus

SPECIES STATUS:
IUCN Red List – Vulnerable (giant grouper)
Near Threatened (Hawaiian grouper)
Others Not considered

SPECIES INFORMATION: Ulua aukea, black ulua, butaguchi, and kahala are jacks (Lutjanidae); the giant grouper and hāpuʻu are sea basses (Serranidae); and onaga, ehu, kalekale, opakapaka, gindai, goldflag jobfish, lehi, and uku are snappers (Lutjanidae). All of these bottomfishes are included in the Western Pacific Regional Fisheries Management Council's (WPRFMC) Bottomfish and Seamount Fisheries Management Plan. This plan also includes the snapper *Lutjanus kasmira* or taʻape; however, this is an introduced species in Hawaiʻi and thus is not included in our Species of Greatest Conservation Need list. All jacks are agile, strong swimming predators. The ulua aukea is a "near-apex" predator that feeds on a large array of prey including parrotfishes, ʻōpelu, wrasses, big eyes, eels, cephalopods, and crustaceans. They primarily feed nocturnally, but may also feed to a lesser extent during the day. Black ulua feed primarily on fish, while kahala feed on octopus and other bottom dwelling prey in the Northwestern Hawaiian Islands and feed within the water column in the Main Hawaiian Islands. Groupers are ambush predators of other fishes and crustaceans. Snappers also are carnivorous and their diets consist primarily of fishes, crustaceans and cephalopods. Some species such as the kalekale, opakapaka, and onaga have a broader diet. Onaga feed close to the bottom and are morning feeders as are the ehu. Opakapaka are nocturnal feeders and uku are daytime feeders. Most bottomfishes are slow-growing and long-lived; however, the jacks are relatively fast growing. Female ulua aukea and kahala are reproductive at four years of age. Male and female ulua aukea spawn in pairs. Spawning occurs during new and full moon periods, and peaks in summer from May to August. Kahala spawn from February to June. More than one clutch may be produced in a year for both ulua aukea and kahala. Ulua aukea eggs hatch 24 to 48 hours after spawning and larvae are pelagic. Juvenile ulua aukea can recruit into estuaries and can be found in areas with salinities as low as 1.5 parts per thousand. Groupers are often protogynous hermaphrodites, starting life as female and changing sex to male later in life. For most snappers, maximum spawning occurs during the summer months and peaks from July to August. Opakapaka, onaga, uhu and uku, however, may spawn "serially" over an extended time period. Ehu have the shortest and most defined spawning period lasting from July to September. Snapper eggs are small and pelagic, hatching 17 to 36 hours after spawning. Larvae are estimated to remain in pelagic waters from 25 to 47 days. These species range in size from the kalekale that reaches a maximum of 55 centimeters (two feet) to the giant grouper that can reach 2.7 meters (nine feet).

DISTRIBUTION: All species can be found throughout the State, although they are currently much rarer, especially the giant grouper. Ulua aukea are more abundant and larger in the Northwestern Hawaiian Islands (NWHI). Butaguchi are also more common in the NWHI.

ABUNDANCE: Ulua are looked for in surveys of coral reef fishes in the Main and Northwestern Hawaiian Islands, both by the National Oceanic and Atmospheric Administration (NOAA) and the Division of Aquatic Resources (DAR). Commercial landings have varied over the past few years for ulua aukea and black ulua, but show no overall decrease, though longer-term declines have occurred. From 1999 to 2003, ulua aukea landings range from a low of approximately 2,700 kilograms (6,000 pounds) in 2000 to a high of 5,000 kilograms (11,000 pounds) in 2003. black ulua landings range from a low of approximately 120 kilograms (260 pounds) in 1998 to a high of 680 kilograms (1,500 pounds) in 2003. Butaguchi landings are highly variable but average around 13,600 kilograms (30,000 pounds) per year with no declining trend. Kahala commercial landings also have varied but have shown a decrease from 2000 to 2003 with landings of approximately 6,600 kilograms (14,500 pounds) and 2,540 kilograms (5,600 pounds), respectively.

Groupers also are looked for in surveys of coral reef fishes in the MHI and NWHI, both by NOAA and DAR. A recent survey in shallow reefs of the main islands found no individuals of either grouper species. Commercial landings in recent years have been about 18,000 kilograms (40,000 pounds) a year for the hāpuʻu. Overall landings in the past few years are lower in the main islands and the Hoomalu zone. Catch Per Unit Effort (CPUE) has been decreasing for the past 40 years in the main islands. Size of fish caught in the main islands is 30 to 40 percent less than those caught in the NWHI.

Commercial landings in recent years have been about 2,270 kilograms (5,000 pounds) a year for gindai. Uku landings have varied from approximately 53,500 kilograms (118,000 pounds) in 1998 to 50,800 kilograms (112,000 pounds) in 2001 to 61,700 kilograms (136,000 pounds) in 2003. Other species have shown declines in commercial catch. Opakapaka commercial landings have decreased each year for the past six years from 102,500 kilograms (226,000 pounds) in 1998 to 60,300 kilograms (133,000 pounds) in 2003. Ehu landings have gone from approximately 18,100 kilograms (40,000 pounds) 1998 to 10,900 kilograms (24,000 pounds) in 2003. Lehi and kalekale landings have been declining since 2000, although less dramatically. Onaga and goldflag jobfish values were not recorded over this time period by DAR. Over the last 40 to 50 years partial CPUE's for onaga, ehu and hāpuʻu has been reduced to half of what is was.

LOCATION AND CONDITION OF KEY HABITAT: Jacks have a variety of habitat preferences. Ulua aukea key habitat includes all nearshore habitats from rocky shores to embayments and reefs. They also occur in deeper waters up to 100 meters (300 feet) deep. Shallow waters over reefs and open waters are key foraging habitats. Juveniles prefer protected habitats such as sand flats and lagoons; however, many juveniles also utilize estuaries, although they are not "estuarine-dependent." Black ulua key habitat is off reef slopes in waters deeper than 30 meters (100 feet). Butaguchi occur in deep waters around the MHI and prefer banks and deep slopes. Key foraging grounds are near the bottom of deeper waters. Kahala inhabit areas with a large range of depth from nearshore to waters over 350 meters (1,100 feet). Hāpuʻu were probably historically found in shallower water but are now are only found in water deeper than 100 meters (300 feet) in the Main Hawaiian Islands with occasional sightings of juveniles in diving depths. In the NWHI, juveniles and adults have been seen as shallow as five meters (15 feet). Giant grouper are usually found from 12 meters to 60 meters (40 to 200 feet) deep. They can often be found in caves or overhangs. Most snappers inhabit intermediate to deep waters ranging anywhere from 30 meters to 4,570 meters (100 feet to 15,000 feet). Specifically, they prefer areas of high relief and deep slope with hard substrates and complex structures. Uku, however, are found in shallower waters than any of the other snappers. Opakapaka are known to migrate to shallower waters from 30 to 80 meters (100 to 250 feet) at night. Onaga often prefer areas close to or on the bottom of vertical drop-offs, pinnacles and ledges. Key habitat for juvenile snappers varies. Juvenile opakapaka, onaga and lehu prefer flat areas of shallower waters with few features, while ehu juveniles prefer habitats with carbonate, basalt, or mudstone substrate.

THREATS:

- Localized heavy fishing pressure threatens these bottomfishes. All jacks are fished commercially and recreationally; however, kahala is not of high commercial value due to its toxicity from ciguatoxin. Ulua aukea are also fished for subsistence by Native Hawaiians. Ulua aukea populations in the Main Hawaiian Islands are documented as depressed. Hāpuʻu are fished commercially and recreationally, while giant grouper are too rare to be targeted commercially. Size of groupers caught in the Main Hawaiian Islands (MHI) is about half that of those caught in the less-intensively fished NWHI. The protogynous sex-change in this family makes them particularly vulnerable to fishing pressure. All eight snapper species also are fished commercially and recreationally; however, the gindai is not a considerable part of the commercial bottomfish fishery. Ehu and onaga are considered locally depleted in the MHI, while all bottomfish populations are considered "relatively healthy" in the NWHI. Additionally, NMFS recently made a declaration of "overfishing" for all of Hawaii's bottomfish;
- Additionally, coastal water quality may negatively affect uluas, especially juveniles that spend time in estuaries;
- Global climate change has been suggested to affect their abundance and their prey.

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. Since 1998, seven species of bottomfish have been managed by DAR under special Hawaiʻi Administrative Rule 13-94. The rule limits fishing to hand lines only and establishes zones where bottomfishing is prohibited. Kahoʻolawe has its own fishing regulations. In the NWHI, the bottomfish are managed under the WPRFMC Bottomfish Fishery Management Plan, which limits fishing there. Additionally, in response to NMFS declaration of "overfishing" for Hawaii's bottomfish, the

WPRFMC has resolved to review a variety of different management alternatives and will probably decide to take action on these at their meeting in March 2006. In addition to common statewide and island conservation actions, specific actions include:

- Collaborate with the Western Pacific Regional Fisheries Management Council to decrease fishing effort in response to the declaration by NMFS of "overfishing" for Hawaii's bottomfish;
- Increase and improve data gathering on recreational bottomfish fishery;
- Consider increasing the number or location of Marine Protected Areas to protect bottomfishes;
- Improve coastal water quality to protect juvenile habitat;
- Maintain healthy populations with appropriate fishing regulations, enforcement, and education.

MONITORING:

- Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting population size and basic ecology and biology of these species.

References:

Gulko D. 2004. Hawaiian marine species for Endangered Species Act candidate listing, revised candidate list 2004. Honolulu, HI: Hawaiʻi Division of Aquatic Resources. 21 pp.

Haight WR. 2004. [Internet]. Seafood Watch seafood reports. International Maritime Alliance and Monterey Bay, Aquarium. Available from: http://www.mbayaq.org/cr/cr_seafoodwatch/sfw_factsheet.aspx?fid=168 (accessed May 2005).

Hawaiʻi Division of Aquatic Resources Fishery Statistics. [Internet]. Available from: http://www.hawaii.gov/dlnr/dar/stats.htm (accessed May 2005).

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.

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).

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp.

Rick Gaffney & 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.

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.

Western Pacific Fishery Information Network. online data. Available from: http://www.pifsc.noaa.gov/wpacfin/ (accessed May 2005).

Western Pacific Regional Fishery Management Council. 2003 annual report for the bottomfish and seamount groundfish management plan. Available from: http://www.wpcouncil.org/bottomfish.htm.

Marine Fishes

Deep Fishes

Ateleopodiformes

Ijimaia plicatellus

Beryciformes

Aulotrachichthys heptalepis

Gadiformes

Caelorinchus doryssus
Caelorinchus gladius
Hymenocephalus antraeus
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 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: *Ijimaia,* common big-eyed grenadier, *Physiculus*, *Pycnocraspedum, Epigoinus glossodontus* and *Argyripnus* have been found from the island of Hawaiʻi to Oʻahu. *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 Oʻahu; and Cramer's grenadier, *Grammonus, Microbrotula, Saccogaster*, and the *Eustomias* species have also only been collected off Oʻahu. The Hawaiian softhead grenadier and the humped grenadier are found from the island of Hawaiʻi to French Frigate Shoals. Bower's grenadier is found from Kauaʻi to French Frigate Shoals. Beaked salmon have been collected from Maui to Oʻahu. *Lophiodes* is found from Maui to Necker Island. Red bat fish are found from Maui to Kauaʻi. *Luciobrotula* and *Cataetyx* are known only from the island of Hawaiʻi. *Epigonius devaneyi* has been found from Necker Island to Maro Reef. *Osopsaron* occurs from Maui to Laysan Island. *Synagrops* occurs from the island of Hawaiʻi to Laysan Island. *Araiophos* is known from the island of Hawaiʻi to St. Rogatien Bank. All the other species occur throughout the Hawaiian Islands.

ABUNDANCE: 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.

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:

- Maintenance of habitat.

MONITORING:

- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size.

References:

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.

Nelson, J.S. 1994. Fishes of the World. 3rd edition. John Wiley and Sons, Inc. NY, NY. 600 pp.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Aseraggodes borehami
Courtesy Keoki Stender

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 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: 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 Hawaiʻi to Oʻahu. *Aseraggodes holcomi* has only been collected off Oʻahu. All the other species occur throughout the Hawaiian Islands.

ABUNDANCE: 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.

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:
- Restoration of habitat;
- Maintain healthy populations with appropriate fishing regulations and education.

MONITORING:
- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the species population size.

References:
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.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 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.

DISTRIBUTION: They are found throughout the State.

ABUNDANCE: ʻIao 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 also 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:

Gulko D. 2005. Hawaii Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai#i Division of Aquatic Resources.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.


Calotomus zonarchus male
Courtesy Keoki Stender

tacled parrotfish
Uhu
Chlorurus perspicillatus

owbar parrotfish
Uhu
Calotomus zonarchus

SPECIES STATUS:
IUCN Red List – Not considered

Endemic, except spectacled parrotfish which also occurs at Johnston Atoll

SPECIES INFORMATION: 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: Spectacled parrotfish occur throughout the State. Yellowbar parrotfish occur from O'ahu and northwest throughout the Northwestern Hawaiian Islands.

ABUNDANCE: They 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 available online. Spectacled parrotfish numbers have declined in the populated areas of the main islands.

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).

THREATS:
- They are fished commercially and recreationally. They are sensitive to night-time spear fishing 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.

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 12 inches (30 centimeters). In addition to common statewide and island conservation actions, specific actions include:
- Maintain healthy populations with appropriate fishing regulations 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.

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.

Hoover J. 1993. Hawai'i's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

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 Hawai'i. Honolulu, HI: University of Hawai'i Press. 216 pp.

Marine Fishes

Hawaiian sea moth
Eurypegasus papilio

Ball's pipefish
Cosmocampus balli

Redstripe pipefish
Doryrhampus baldwini

Edmondson's pipefish
Halicampus edmondsoni


Doryhampus baldwini
Courtesy Keoki Stender

Fisher's seahorse
Hippocampus fisheri

Spiny seahorse
Hippocampus histrix

Yellow seahorse
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: 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: 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: 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:
- 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.

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.

MONITORING:
- Continue to survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the species population size;
- Support aquacultural 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.

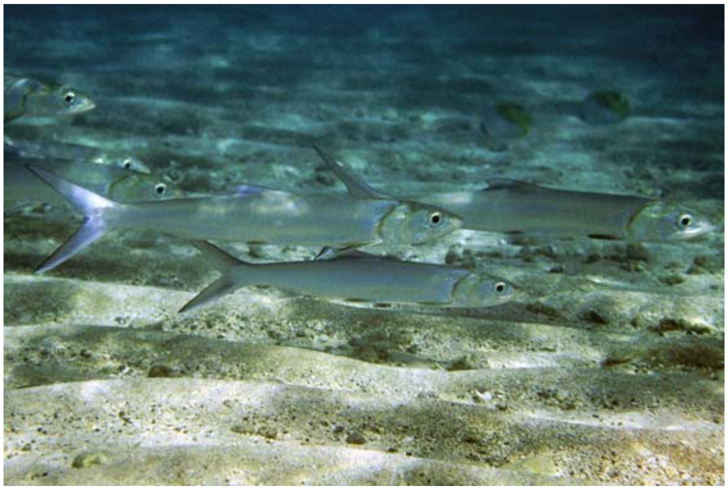
Gulko D. 2005. Hawai'i Endemic Species Status Chart spreadsheet. Honolulu, HI: Hawai'i Division of Aquatic Resources.

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

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).

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.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.



Marine Fishes

Hawaiian ladyfish
Awaʻaua
Elops hawaiensis

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: The awaʻaua is 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 throughout the State and especially common at Hanauma Bay, Oʻahu.

ABUNDANCE: 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: Awaʻaua 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.

THREATS:
- Localized heavy fishing pressure and susceptibility to nearshore pollution and runoff.

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:
- Restoration of habitat through reduction in pollution;
- Restore healthy populations with appropriate fishing regulations and education.

MONITORING:
- Survey populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting population size, ecology, and basic biology of this species.

References:
Fishbase. [Internet] online data. http://fishbase.sinica.edu.tw/Summary/SpeciesSummary.cfm?genusname=Elops&speciesname=hawaiensis (accessed May 2005).

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

Randall JE. 1998. Shore fishes of Hawaii. Honolulu, HI: University of Hawaii Press. 216 pp.

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

Hawaiian flagtail Āholehole

Kuhlia xenura

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: Āholehole in Hawaiʻi 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: 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:
- They are fished commercially and recreationally;
- Historically they were important in Native Hawaiian religious ceremonies.

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:
- Maintain healthy populations with appropriate fishing regulations and education.

MONITORING:
- Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size.

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.

Hawai'i Division of Aquatic Resources, State of Hawaii. Commercial marine landings data. 1997 – 2003. Honolulu, HI: Division of Aquatic Resources.

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

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.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Fishes

Whitesaddled goatfish
Kūmū

Paurupeneus porphyreus

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Kūmū are goatfish that 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: 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.

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.

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). In addition to common statewide and island conservation actions, specific actions include:
- Maintain healthy populations with appropriate fishing regulations and education.

MONITORING:
- Continue surveys of population and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the species population size.

References:

Hawai'i Division of Aquatic Resources, State of Hawaii. Commercial marine landings data. 1997 – 2003. Honolulu, HI: Division of Aquatic Resources.

Hoover J. 1993. Hawaii's fishes. Honolulu, HI: Mutual Publishing. 183 pp.

Tinker S. 1978. Fishes of Hawaii. Honolulu HI: Hawaiian Service, Inc. 532 pp.

Marine Invertebrates

Miscellaneous Filter Feeders

Brachiopod

Lingula reevii

Yellow crust bryozoan

Parasmittina sp.

Ascidians

Aplidium crateriferum
Aplidium sp.

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:

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.

Cephalopods

Heʻe or Hawaiian octopus

Octopus hawiiensis

Mūheʻe or Bobtail squid

Euprymna scolopes

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Heʻe or Hawaiian octopus (*Octopus hawaiiensis*) and mūheʻe or bobtail squid (*Euprymna scolopes*) are endemic cephalopods. Both are nocturnal predators using venoms or poisons to capture and kill their prey. Hawaiian octopus feed primarily on crabs and other mollusks and occasionally on fish. Mūheʻe feed mainly on the shrimp *Palemon debilis*, but also feed on small worms. Heʻe and mūheʻe have complex mating behaviors. Males use a specially modified arm to insert sperm into the female's mantle cavity. Eggs are laid on the bottom of the ocean in clusters. Heʻe guards their eggs. Larvae are pelagic. Mūheʻe bury themselves during the day. They protect themselves from predators on moonlit nights by masking their silhouette using organs that contain bioluminescent bacteria. Little is known of the habits of Hawaiian octopus.

DISTRIBUTION: Both species are found throughout the Hawaiian Islands.

ABUNDANCE: Not known for either species.

LOCATION AND CONDITION OF KEY HABITAT: Hawaiian octopus primary habitat is rocky substrate in waters ranging from approximately five to nine meters (15 to 30 feet) deep. Mūheʻe are found in sand and mud flats in shallow waters. This habitat is important to the squid, because it uses the substrate during the day to burrow, and its main prey is found in this area. Its habitat 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 results from urbanization, runoff, and sedimentation. These threats not only alter its habitat but may negatively affect prey availability;
- Recreational collectors fish for Hawaiian octopus;
- Aquarium and research fishing pressure also is a concern for mūheʻe.

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 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.

References:

Gulko D. 2004. Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Division of Aquatic Resources, State of Hawaiʻi.

Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Marine Invertebrates

Other Crustaceans

Unauna or Hermit crabs

Aniculus hopperae
Calcinus hazletti
Calcinus laurentae

Crabs

Aethra edentate
Carpilius maculatus
Dromia dromia
Ligia hawaiensis
Lybia edmondsoni
Pseudopalicus oahuensis

Shrimps

Cinetorhynchus hawaiiensis
Cinetorhynchus hendersoni
Gnathophyllum precipuum
Hymenocera picta
Levicaris mammilata
Liomera supernodosa
Metapenaeopsis sp.
Rhynchocinetes rathbunae
Stenopus earlei

SPECIES STATUS:
IUCN Red List - Not considered
All Endemic except for *Carpilius*, *Dromia*, and *Hymenocera*

SPECIES INFORMATION: The following are the Hawaiian, common, and scientific names for the Unauna or hermit crabs, true crabs, and shrimps: Hopper's hermit crab (*Aniculus hopperae*), Hazlett's hermit crab (*Calcinus hazletti*) and Laurent's hermit crab (*Calcinus laurentae*); flat elbow crab (*Aethra edentata*), alakuma or 7-11 crab *(Carpilius maculates)*, makua-o-ka-lipoa or sponge crab (*Dromia dormia)*, *Ligia hawaiensis* (no common name), kūmimi pua or Hawaiian pom pom crab or (*Lybia edmondsoni*), and button crab (*Pseudopalicus oahuensis*); Hawaiian hinge-beaked shrimp (*Cinetorhynchus hawaiiensis*), Henderson's hinge-beaked shrimp (*Cinetorhynchus hendersoni*), Hawaiian cave shrimp (*Gnathophyllum precipuum*), harlequin shrimp (*Hymenocera picta*), red pencil urchin shrimp (*Levicaris mammilata*), knotted liomera (*Liomera supernodosa*), bicolor sand shrimp (*Metanpenaeopsis sp.*), Rathbun's hinge-beaked shrimp (*Rhynchocinetes rathbunae*), and Earl's coral shrimp (*Stenopus earlei*). The unauna, alakuma, button crab, hinge-beaked shrimp, Hawaiian cave shrimp, and the bicolor sand shrimp are nocturnal. Hermit crabs are scavengers, Earl's coral shrimp are cleaners, alakuma crush other crustaceans and snails, button crabs feed on algae, and kūmimi pua use anemones on their claws to capture prey and feed on invertebrates. Harlequin shrimp are predators of seastars, including crown-of- thorns starfish. It is also monogamous and pair-bonding. Specific feeding information for the other species is unknown, but they are likely scavengers. All species have separate sexes and reproduce through copulation. All females brood eggs under their tails, except for the bicolor sand shrimp that releases eggs directly into the ocean. Newly hatched larvae are part of the plankton community for weeks to months. Makua-o-ka-lipoa is the largest sponge crab in the world. Rathbun's hinge-beaked shrimp is known as the mandarin shrimp in the aquarium trade.

DISTRIBUTION: Earl's coral shrimp is found off O'ahu and Kaua'i. The other species are found throughout the Hawaiian Islands. Knotted liomera is found throughout the Main Hawaiian Islands, but it is more common in the Northwestern Hawaiian Islands.

ABUNDANCE: Unknown. Henderson's hinge-beak shrimp are found throughout the islands, but they are abundant of the coast of Kona, Hawai'i. Earl's coral shrimp is rare.

LOCATION AND CONDITION OF KEY HABITAT: Most of these crustaceans are bottom dwellers. Hopper's hermit crab has primary habitat in caves and under ledges, but on exposed rocky shores from three feet to seventy feet (one to 21 meters). Hazeltt's and Laurent's hermit crabs live below the intertidal zone from six meters (20 feet) or deeper and occur on branching corals. The flat elbow crab is found on sandy bottom areas and kūmimi pua is found under stones in sand or on rubble in waters from approximately a meter to 30 meters (few feet to 100 feet) deep. The button crab is found on rocky bottom habitat. The shrimp species inhabit a large range of areas. Hawaiian hinge-beak shrimp inhabit finger coral; Henderson's hinge-beak shrimp inhabit shallow, sheltered reefs; and Rathbun's hinge-beak shrimp prefer rocky substrates. Hawaiian cave shrimp are found only in caves. Red pencil urchin shrimp live commensally with the sea urchin *Heteroentrotus mammillatus*. The knotted liomera is found on reef and reef flats. Bicolor sand shrimp prefer sandy rubble while Earls' coral shrimp inhabit caves, crevices and under ledges. Hinge-beak shrimp live on reefs.

THREATS:

- Aquarists collect alakuma, kūmimi pua, and makua-o-ka-lipoa, the hinge-beaked shrimps, and harlequin shrimp.

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:
- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the species population sizes and distributions;
- Support aquaculture research to develop captive breeding for species used in the aquarium trade.

References:
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.

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.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaii, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.

Marine Invertebrates

Ula poni or Spiny lobster

Panulirus marginatus

SPECIES STATUS:
IUCN Red List - Not considered
Endemic

SPECIES INFORMATION: Ula poni or the spiny lobster (*Panulirus marginatus*) lacks large pincers on its first pair of legs and has one pair of antennae that is often bigger than its other antennae. Ula poni feed across sandy bottom areas that are next to reefs. They are carnivorous and feed at night on mollusks, echinoderms, crustaceans and fish. They may spawn up to four times a year from May to August and November to December. Females can produce up to half a million bright orange eggs each time they spawn. The mass of eggs is held in the female's swimmerets under her abdomen. They hatch in four weeks and go through various pelagic larval stages that last almost a year. After a year in the open ocean, they return to the reef. Juveniles are usually a few centimeters (one inch) long.

DISTRIBUTION: Historically, ula poni were distributed throughout the Hawaiian Archipelago. Today, they are still are found throughout the Archipelago. Pelagic larval distribution is not well understood, but one study shows that larvae move with ocean currents northwest along the ridge of the Archipelago to the southeast and then southwest.

ABUNDANCE: Numbers can be relatively high in pristine areas; however, numbers are greatly reduced from historic abundance due to over-fishing. Over the past four years, commercial catch has continued a long decline, slipping below 4,500 kilograms (10,000 pounds) for the past three years. The recreational fishery catch is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Ula poni are found in crevices and caves, as well as under ledges. They may be found in shallow waters of approximately a meter (three feet) or in areas up to 180 meters (600 feet) deep. Key foraging habitats are sandy areas next to coral reefs. Healthy coral reefs are important habitat. Not much is known of the pelagic lifecycle of ula poni larvae.

THREATS: Ula poni were traditionally eaten by Native Hawaiians and were taken commercially in the trap fishery from the mid-1970s to 1999 in the Northwestern Hawaiian Islands (NWHI), specifically at Necker Island and Maro Reef. Populations experienced a serious decline in the early 1990s that continued until the late 1990s.

- Localized heavy fishing pressure remains a serious threat in the commercial and recreational fishery, although the fishery is closed in the NWHI and regulated in the Main Hawaiian Islands. Young are also collected for the aquarium trade;
- Habitat alteration such as degradation to coral reefs may also be an issue.

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 monitor population size to determine if fishing regulations and other conservation actions are successful.

RESEARCH PRIORITIES:

- Continue studies of larval distribution;
- Improve understanding of factors affecting the species population size and distribution.

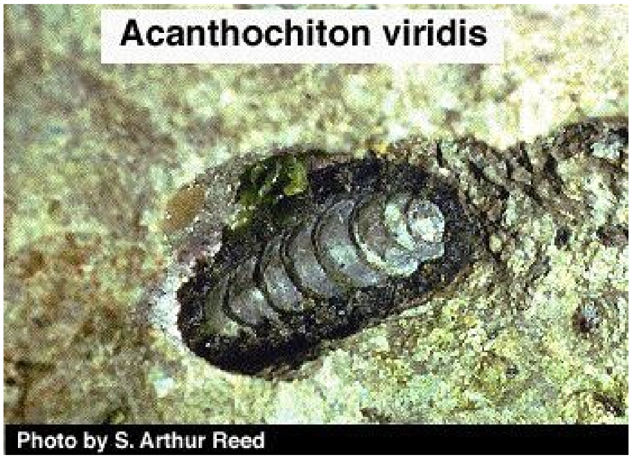
References:

Gulko D. 2005. Hawaiʻi Endemic Species Status Chart spreadsheet. Hawaiʻi Division of Aquatic Resources.

Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Kanciruk P. 1980. Ecology of juvenile and adult Palinuridae (spiny lobsters). pp. 59-66 In: JS Cobb and BF Phillips, editors. The Biology and Management of Lobsters. Volume II.

Polovina JJ, Kleiber P, and 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.



Marine Invertebrates

Pūpū moʻo or chitons

Acanthochiton viridis
Ischnochiton petaloides

SPECIES STATUS:
IUCN Red List - Not considered
Endemic

SPECIES INFORMATION: Pūpū moʻo or chitons are primitive seashore molluscs. They both feed by browsing on algae adhered to hard substrates. Both the kuakulu or green chiton (*A. viridis*) and the flat chiton (*I. petaloides*) have separate sexes and external fertilization. The adult kuakulu, 28 millimeters long (one inch), is larger than the adult flat chiton (10 millimeters long or one-half inch).

DISTRIBUTION: They occur on rocky and hard substrates throughout the islands.

ABUNDANCE: Unknown

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for both the kuakulu and flat chiton are reef flats and tidepools. Kuakulu, however, prefers small depressions on limestone reef flats and holes or areas underneath the rubble of tidepools. Flat chitons prefer areas under rocks in both tidepools and reef flats.

THREATS: None identified.

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:

- Ensure healthy habitat is maintained.

MONITORING:

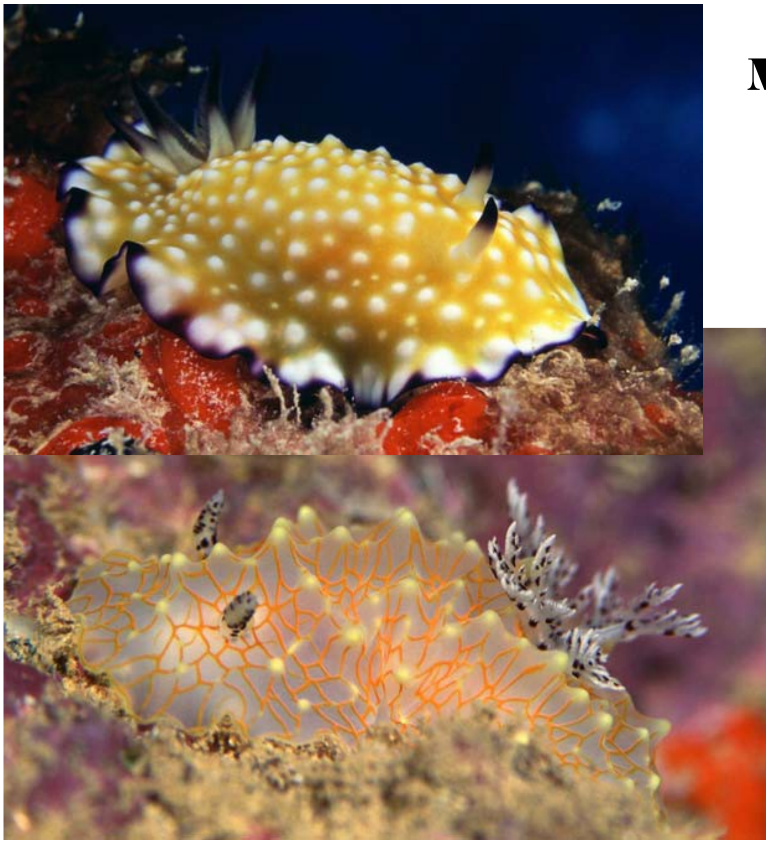
- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population size and distribution.

References:
Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaii, section 4: Mollusca. Honolulu, HI:Bishop Museum Press. 653 pp.



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 pitted nudibranch (*Aldisa pikokai*), Scott Johnson's nudibranch (*Ardeadoris scottjohnsoni)*, trembling nudibranch (*Chromodoris vibrata*), snow goddess nudibranch (*Glossodoris poliahu*), gold lace nudibranch (*Halgerda terramtuentis*), Anderson's nudibranch (*Hypselodoris andersoni*), *Melibe megaceras* (no common name*),* Fellow's nudibranch (*Peltodoris fellowsi*), and pali nudibranch (*Sclerodoris paliensis*) are carnivores and feed on a variety of organisms ranging from sponges, hydroids, and corals to other nudibranchs. The only nocturnal feeder is the pitted nudibranch. All nudibranchs are hermaphroditic and mate through mutual insemination. Eggs are laid in coiled ribbons. Eggs hatch and trochopore larvae develop into planktonic veligers that lose their shell once they settle. Most nudibranchs do not live longer than one year. It is interesting to note that nudibranchs have few natural predators. They are usually toxic, although they do not produce their own toxins, but recycle those of their prey.

DISTRIBUTION: Most species are found throughout the Hawaiian archipelago; however, the gold lace nudibranch is only found in the Main Hawaiian Islands.

ABUNDANCE: Snow goddess nudibranch is uncommon. There is little quantitative abundance or trend data for any of the species.

LOCATION AND CONDITION OF KEY HABITAT: The pitted nudibranch's key habitat is in waters two to nine meters (six to 30 feet), but they can be found in waters up to 24 meters (80 feet) deep. They prefer areas with stones and crevices. Primary habitat for the trembling nudibranch is sea level to water down to 24 meters (80 feet) deep. Gold lace nudibranchs are found around caves in waters from approximately five to 30 meters (15 to 100 feet). Anderson's nudibranch's primary habitat is in caves as well as under overhangs on exposed rocky shores from five to 18 meters (15 to 60 feet). Anderson's nudibranchs also live on the yellow sponge *Luffariella metachromia*. Additionally, they occasionally have been found in shallower waters of harbors and boat channels. Fellow's nudibranch is found at the entrance of caves from six to fifteen meters (20 to 50 feet) or more and live on sponges. The pali nudibranch's primary habitat is waters from two to six meters (six to 20 feet) deep. Specific habitat for the other species has not been delineated.

THREATS:

- The aquarium trade targets gold lace, Fellow's, and pali nudibranchs.

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 aquarium fishing regulations, enforcement, and education.

MONITORING:

- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

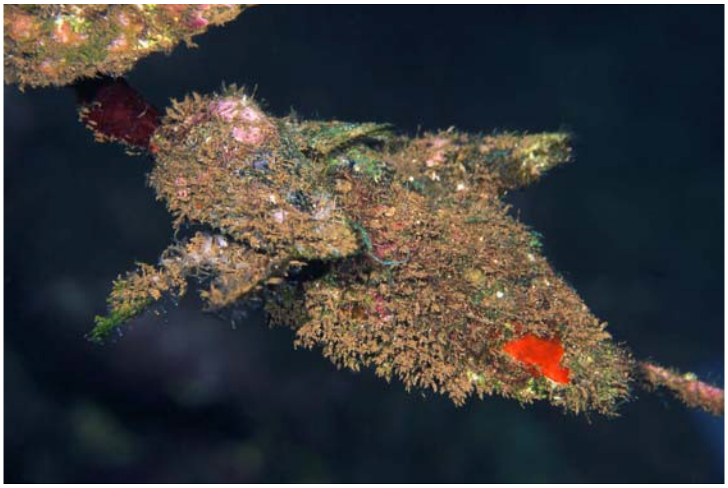
- Improve understanding of factors affecting the species population sizes and distributions.

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 JP. 1998. Hawaii's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaiʻi, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.



Marine Invertebrates

Bivalves

Judd's scallop
Haumea juddi

Nahawele liʻi liʻi or Hawaiian mussel
Brachidontes crebristriarus

Pa or Pearl oyster
Pinctada margaritifera

Winged pearl oyster
Pteria brunnea

Nahawele or Black purse shell
Isognomon californicum

SPECIES STATUS:
IUCN Red List - Not considered
All Endemic except for *Pinctada*

SPECIES INFORMATION: Judd's scallop (*Haumea juddi*), nahawele liʻi liʻi or the Hawaiian mussel (*Brachidontes crebristriarus*), the winged pearl oyster (*Pteria brunnea*) and nahawele or the black purse shell (*Isognomon californicum*) are endemic, filter feeding bivalves, while pa or the pearl oyster (*Pinctada margaritifera*) is a widespread species. All have separate sexes and external fertilization. Both nahawele liʻi liʻi and pa attach to their substrates using strong byssal threads, while nahawele can move using its large foot. Judd's scallop can swim by clapping its shells.

DISTRIBUTION: All species were historically distributed throughout the state. Today they are found throughout the Hawaiian Archipelago; however, nahawele is most abundant around

Maui and the island of Hawaiʻi. Nahawele liʻi liʻi is primarily found on the windward or Main Hawaiian Islands.

ABUNDANCE: Pearl oysters were harvested at Pearl and Hermes Atoll in the Northwestern Hawaiian Islands, the only place they were common, but overfishing in the 1930s led to their decline and regulations limiting their harvest. The National Marine Fisheries Service surveyed Pearl and Hermes recently and found that pearl oysters were not rare, but would still not support a commercial fishery. Abundance is unknown for the rest of the species.

LOCATION AND CONDITION OF KEY HABITAT: Judd's scallop's primary habitat is on sandy ocean bottoms at depths of eight to 100 meters (26 to 328 feet). They are situated so their open shells face into the current with their top shell thinly covered with sand. If disturbed, they have been documented to swim two to three meters (six to ten feet). Both Judd's scallop and nahawele liʻi liʻi form patches or beds. Nahawele liʻi liʻi primary habitat is limestone shoreline at the low tide mark. However, in shoreline areas where freshwater and salt water mix they grow to their largest size. They can also be found on basalt shorelines, although in lower densities. Pa is found in shallow waters in between corals. The winged pearl oyster's primary habitat is on species of black coral; however, they also can cluster on wire corals. They may also host bryozoans on their shells. Nahawele form clusters in crevices at the high tide mark and prefer brackish waters. Nahawele on islands other than Maui and the island of Hawaiʻi are found individually in more saline waters.

THREATS:

- Historically, pearl oysters were threatened by harvesting them for their pearls;
- Pollution is a direct threat to these species, because they are filter feeders. This also makes them potentially good indicators of water quality in their 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 state-wide and island conservation actions, specific actions include:

- Collaborate to reduce nearshore pollution;
- Maintain healthy 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:

Hoover JP. 1998. Hawaii's sea creatures, A guide to Hawai`i's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaii, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.

Marine Invertebrates

ʻOpihi or Limpets

Cellana exarata
Cellana melanostoma
Cellana sandwicensis
Cellana talcosa

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: The endemic ʻopihi makaiauli or black foot ʻopihi (*C. exarata*), the 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 graze on algae and most may creep about to graze, but return to their "home scar" after feeding. Both ʻopihi ʻalinalina and ʻopihi koʻele often are covered with seaweed. Gametes are shed into the water where fertilization is external. Veligers have a short planktonic life. Spawning occurs mainly in December and January for ʻopihi makaiauli and ʻopihi ʻalinalina. Spawning information is unknown for the green foot ʻopihi and ʻopihi koʻele. ʻOpihi makaiauli grows to 40 millimeters (1.6 inches) in diameter, the green foot ʻopihi to 43 millimeters (1.7 inches), the ʻopihi ʻalinalina to 32 millimeters (1.3 inches), and ʻopihi koʻele to 90 millimeters (3.5 inches). Besides eating them, native Hawaiians used the shells as scrapers and tools.

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 green foot ʻopihi 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. About 3,175 kilograms (7,000 pounds) of ʻopihi were collected in the commercial fishery in 2003, which is a decline of about 2,268 kilograms (5,000 pounds) from recent years. The recreational fishery catch is unknown.

LOCATION AND CONDITION OF KEY HABITAT: Primary habitat for all ʻopihi is the intertidal zone to ten feet deep waters. ʻOpihi makaiauli thrives in the spray 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. ʻOpihi ʻalinalina are found on and below the zero tide mark where there is a steady splash, and they are often on coralline algae. ʻOpihi koʻele are found below the tide mark from 0.5 to three meters (one to ten feet) deep, often between boulders.

THREATS:

- Localized heavy fishing 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;
- Climate change, habitat disturbance, and nearshore pollution are also potential 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. In addition to common statewide and island conservation actions, specific actions include:

- Maintain healthy populations with appropriate fishing regulations, enforcement, and education;
- Restore habitat.

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 green foot and giant ʻopihi.

References:

Gulko D. 2005. Hawaiʻi endemic species status chart spreadsheet. Honolulu, HI: Hawaiʻi 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 Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaii, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.

Duplicara gouldi
Courtesy Keoki Stender

Nerita polita
Courtesy Keoki Stender

Marine Invertebrates

Snails

Charonia tritonis
Chicoreus insularum
Conus abbreviatus
Cypraea burgessi
Cypraea gaskoini
Cypraea granulate
Cypraea mauiensis
Cypraea ostergaardi
Cypraea rasleighana
Cypraea semiplota
Cypraea sulcidentata
Cypraea tessellata
Cypraea tigris
Duplicara gouldi
Epitonium ulu
Nerita picea
Nerita plicata
Nerita polita
Smaragdia bryannae
Strombus vomer hawaiiensis
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*), pūpūʻala 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 (*Strombus vomer hawaiiensis*), and pūpū mahina or Hawaiian turban (*Turbo sandwicensis*). Pu reaches twenty inches in length (second largest snail in the Pacific) and feeds on sea stars and sea urchins, including crown-of-thorns starfish. *Chicoreus* and pūpūʻala are carnivores. *Chicoreus* feeds exclusively on bivalves drilling through the bivalve's shell and inserts a digestive enzyme and ingests the tissues through its proboscis. Pupuʻala feeds exclusively on polychaete worms using its teeth that are connected to a venom gland and paralyzes its prey and swallows it whole. Leho or cowries are nocturnal and can be herbivores and omnivores as well as sponge feeders (*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*. 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:

- Localized excessive harvesting of these species for their shells by collectors and for cultural uses is the primary threat to these snail species. Kūpeʻe was eaten by native Hawaiians and used in shell lei. *Cyprea mauiensis* is extremely rare due to over collection;
- Pollution is another threat for those found in intertidal areas and shallow 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:

- Maintain healthy populations with appropriate fishing regulations, enforcement, and education.

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:

Gulko D. 2005. Hawaiʻi endemic species status chart spreadsheet. Honolulu, HI: Hawaiʻi 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.

Kay AE. 1979. Hawaiian marine shells reef and shore fauna of Hawaiʻi, section 4: Mollusca. Honolulu, HI: Bishop Museum Press. 653 pp.

No photo available

Marine Invertebrates

Hawaiian oyster

Ostraea sandvicensis

SPECIES STATUS:
IUCN Red List – Not considered
Endemic

SPECIES INFORMATION: This is an oyster endemic to Hawai'i. Little else is known about their life history.

DISTRIBUTION: Unknown.

ABUNDANCE: Unknown.

LOCATION AND CONDITION OF KEY HABITAT: Unknown.

THREATS: None identified.

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:

- Work to clean estuaries with significant pollution;
- Restore habitat.

MONITORING:

- Establish survey schedule to determine population size and distribution.

RESEARCH PRIORITIES:

- Improve understanding of the life history, biology, and ecology of these oysters.

References:

None identified.

No Photo available

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, Oʻahu and along the Kona Coast on the island of Hawaiʻi.

ABUNDANCE: Previously, it was the most common large sponge in the Hawaiian Islands and was very abundant in Hanauma Bay, Oʻahu 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.

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:

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 p.

Marine Invertebrates

Echinoderms

Echinoids

Actinocidaris thomasi
Lissodiadema purpureum
Lovenia hawaiiensis

Asteroid

Mithrodia fisheri

Holothuroids

Stichopus sp.1
Stichopus sp. 2

SPECIES STATUS:
IUCN Red List – Not Considered
Endemic

SPECIES INFORMATION: Thomas' sea urchin (*Actinocidaris thomasi*), fined spined urchin (*Lissodiadema purpureum, Leptodiadema* is a junior synonym), Hawaiian lovenia (*Lovenia hawaiiensis*), the sea star *Mithrodia fisheri*, the Hawaiian spiny sea cucumber (*Stichopus sp. 1*), and Hawaiian yellow-tip sea cucumber (*Stichopus sp. 2*) are all endemic. Specific feeding habits are known for two species: the fine spined sea urchin grazes on algae and *M. fisheri* probably 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. 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.

ABUNDANCE: Unknown

LOCATION AND CONDITION OF KEY HABITAT: Thomas's sea urchin primarily is found in deeper waters, but may be found in waters as shallow as 9 meters (30 feet). It stays under coral slabs and in crevices during the day. Fine 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. Hawaiian spiny sea cucumbers are found out in the open beside coral reefs in sand and rubble. They also 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. *M. fisheri* primary habitat is on cave ceilings and walls.

THREATS:

- Aquarium collectors harvest Thomas's and fine spined sea urchins.

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:

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.

Pseudobiceros sp. 2
Courtesy Jerry Kane
SeaLifeImages.smugmug.com

Marine Invertebrates

Worms

Annelid worm
Vermiliopsis torquata

Flatworms
Pericelis hymanae
Pseudobiceros sp. 2

Ko'e kai or Ribbon worm
Baseodiscus cingulatus

SPECIES STATUS:
IUCN Red List - Not considered
Endemic

SPECIES INFORMATION: *Vermiliopsis torquata* (no common name), Hyman's flatworm (*Percelis hymanae*), the Hawaiian spotted flatworm (*Pseudobiceros sp. 2*), and ko'e kai or banded ribbon worm (*Baseodiscus cingulatus*) are all endemic worms. All are carnivores and nocturnal. The ko'e kai uses its long proboscis to attack and entrap their prey. Hyman's and Hawaiian spotted flatworms are hermaphroditic. Fertilization is internal and eggs are laid in a gelatinous material. Eggs develop into free-swimming larvae or directly into small flatworms. The ko'e kai has separate sexes and eggs are laid in a gelatinous material and are fertilized externally. Both the flatworms and ko'e kai reproduce asexually by fragmentation or budding.

DISTRIBUTION: All species are found throughout the Hawaiian Archipelago.

ABUNDANCE: Unknown. Hyman's flatworm is common at Black Point, O'ahu.

LOCATION AND CONDITION OF KEY HABITAT: Hyman's flatworm prefers shallow waters and is commonly found under stones. They may also associate with the brown purse shell (*Isognomon perna*). Like Hyman's flatworm, the Hawaiian spotted flatworm is found under stones; however, it is found from the shoreline to waters down to 15 meters (50 feet) deep. Ko' kai has a large range of primary habitat. It has been found as deep as 76 meters (250 feet), but also lives in shallow waters and tidepools.

THREATS: None identified.

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 habitats.

MONITORING:

- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:

- Improve understanding of factors affecting the species population sizes and distributions.

References:

Barnes RD. 1980. Invertebrate zoology, 4th edition. Philadelphia, PA: Saunders College Publishing.

Hoover JP. 1998. Hawaii's sea creatures: A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Other Anthozoans

Octocorals
Acabaria bicolor
Anthelia edmondsoni
Sinularia molokaiensis

ʻŌkole or Anemones
Cladactella manni
Heteractis malu

Zoanthids
Palythoa psammophilia
Palythoa toxica
Parazoanthus sp.
Zoanthus kealakekuaensis

SPECIES STATUS:
IUCN Red List - Not considered
All Endemic except *Heteractis*

SPECIES INFORMATION: Bicolor gorgonian (*Acabaria bicolor*), blue octocoral (*Anthelia edmondsoni*), Molokaʻi leather coral (*Sinularia molokaiensis*), Mann's anemone or ʻōkole (*Cladactella manni*) are all endemic anthozoans with common names, and the Hawaiian sand anemone or ʻōkole (*Heteractis malu*) is not endemic. The zoanthids have no common names except for *Parazoanthus*, which is the commercially valuable deep water gold coral. The bicolor gorgonian, the blue octocoral, and the Molokaʻi leather coral have less stinging cells than other cnidarians, and they feed on planktonic plant cells or other types of small particles. The blue octocoral also harbors symbiotic zooxanthellae. Mann's anemone feeds on small bottom-dwelling organisms and plankton, and they also have symbiotic zooxanthellae. Like corals, zoanthids use their nematocysts to capture and sting prey, while also utilizing the sugars produced by zooxanthellae for nutrition. All of the anthozoan species lack a medusa life stage. The octocoral animals have eight-tentacled polyps with an internal skeleton. The bicolor gorgonian forms colonies that are five centimeters (two inches) across and three centimeters (one and a half inches) high. Blue octocoral polyps grow to one centimeter (one quarter inch) and colonies are eight to 30 centimeters (three to 12 inches) across, while leather corals can grow to about the same size, and Mann's anemones are solitary. Mann's anemones can be either hermaphroditic or single-sexed. Sperm and eggs are released through the mouth. Asexual reproduction is achieved by fission or detaching pieces of tissue, most often from the foot, that regenerate into another organism. They grow to five centimeters (two inches) high and ten centimeters (four inches) across. *Palythoa psammophilia, Palythoa toxica*, and *Zoanthus kealakekuaensis* are colonial and lack a hard skeleton. *P. toxica* contains toxins that can affect people, but also have anti-cancer properties.

DISTRIBUTION: Molokaʻi leather coral only occurs on the southeast side of Molokaʻi. Hawaiian sand anemone is mostly found in Kāneʻohe Bay, Laie, and Kahuku, Oʻahu, and Maalaea Bay, Maui. *Palythoa psammophilia* occurs in Kāneʻohe Bay only, *Palythoa toxica* is found only off Maui and Oʻahu, *Parazoanthus* occurs off Oʻahu, and *Zoanthus kealakekuaensis* only occurs in Kealakekua Bay on the island of Hawaiʻi. All other species are found throughout the Hawaiian Archipelago.

ABUNDANCE: Unknown.

LOCATION AND CONDITION OF KEY HABITAT: Bicolor gorgonians prefer rocky crevices in areas that are "surgy" or directly in the current. They occur from depths of two to 430 meters (six to 1,400 feet). The primary habitat of blue octocoral includes both hard and soft surfaces that are exposed. Moloka`i leather coral colonies encrust on limestone and volcanic rocks in waters approximately 35 meters (115 feet) or deeper; however, they also can be located in shallow water areas. Mann's anemones live in intertidal areas on rocky shores in crevices, pockets or ledges that are constantly washed by waves. Zoanthids usually prefer shallow waters.

THREATS:

- Use in the marine ornamental trade is the primary threat to *Heteractis* and *Cladectella* and for use in the precious coral trade (*Parazoanthus* sp.);
- Habitat degradation from shoreline development such as nutrient and freshwater runoff and sedimentation threatens these anthozoans;
- Introduced algae are also a threat. Hawaiian sand anemone is particularly susceptible, because its main population is in Kāneʻohe Bay, and it is out competed by introduced algae.

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. Precious coral harvesting in federal waters is managed under a Fisheries Management Plan of the Western Pacific Regional Fisheries Management Council. In addition to common state-wide and island conservation actions, specific actions include:

- Maintain healthy populations with appropriate fishing regulations, enforcement, and education;
- Work with partners to minimize nutrient loading and other pollution from land-based sources;
- 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.

MONITORING:
- Monitor alien macroalgae and removal operations to determine impacts on these species;
- Implement comprehensive disease monitoring statewide;
- Survey for populations and distribution in known and likely habitats.

RESEARCH PRIORITIES:
- Improve understanding of factors affecting the species population sizes and distributions.

References:

Gulko D. 2005. Hawai'i endemic species status chart spreadsheet. Honolulu, HI: Hawai'i Division of Aquatic Resources.

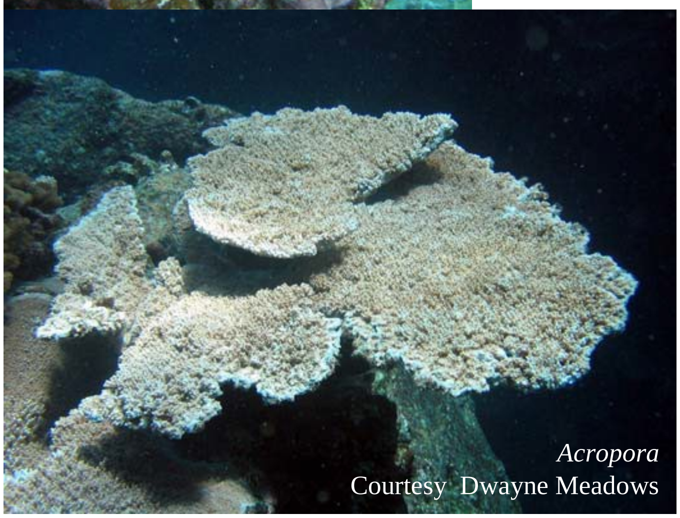
Gulko D. 2004. Hawaiian marine species for ESA Candidate listing revised Candidate list. Honolulu, HI: Division of Aquatic Resources, State of Hawai'i.

Hoover JP. 1998. Hawai's sea creatures, A guide to Hawaii's marine invertebrates. Honolulu, HI: Mutual Publishing. 366 pp.

Russo R. 1994. Hawaiian Reefs. California, USA: Wavecrest Publications. 174 pp.

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.

Pavona Courtesy NMFS



Acropora
Courtesy Dwayne Meadows

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 for details)

SPECIES INFORMATION: All stony corals feed on small plankton or dissolved organic matter that is in the waters. Most corals use their nematocysts on their tentacles to capture and sting their prey and feed at night. Others such as *Pavona duerdenni* are suspension feeders. Stony corals with symbiotic zooxanthellae can get up to 98 percent of their nutrition from the sugars produced by the algae. *Balanophyllia* and *Tubastrea* lack zooxanthellae. Stony corals lack a polyp stage, but reproduce both sexually and asexually. A particular combination of day length, tide, and moonlight prompts spawning events. Other corals such as the *Pocillopora sp.* and *Porites sp.* brood their eggs and release the larvae or planulae completely formed. Asexual reproduction is achieved through budding or when pieces are broken off and grow into new colonies. *Porites spp.* 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). Fenner (2005) has recently questioned the endemic status and taxonomy of many species. We have chosen to retain the taxonomy that has been in place for some time until Fenner's work can be evaluated and accepted by the wider community.

The following are the endemic stony corals of Hawaii and their common and Hawaiian names: serpentine cup coral (*Dendrophyllia serpentine,* also known as *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 molokaiensis*), Brigham's coral (*Porites brighami*), pohaku puna or compressed coral (*Porites compressa*), thick finger coral (*Porites duerdeni*), pohaku puna or Evermann's coral (*Porites evermanni*, also known as *P. lutea*), *Porites pukoens*is (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 cytheria*), *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 (*Coscinaraea wellsi*), fragile mushroom coral (*Cycloseris fragilis*, also called *Diaseris fragilis*), humpback coral (*Cycloseris hexagonalis*, also called *C. vaughani*), ocellated coral (*Cyphastrea ocellina*), distorted mushroom coral (*Diaseris distorta*), granulated mushroom coral (*Fungia granulosa*), mushroom coral (*Fungia scutaria*), *Fungia sp.* (no common name), honeycomb coral (*Gardineroseris planulata*), Bewick's coral (*Leptastrea bewickensis*), *Leptastrea bottae* (no common name, also known as *L. hawaiiensis* and *Cyphastrea agassizi*), spotted coral (*Leptastrea pruinosa*), 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 pollicata* (no common name, also known as *P. maldivensis*), corrugated coral (*Pavona varians*), Lace coral (*Pocillopora damicornis*), antler coral (*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 convexa*, also known as *P. 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 (*Psammocora explanulata*), Haime's lump coral (*Psammocora haimeana*), Nierstrasz's coral (*Psammocora nierstraszi*), stellar coral (*Psammocora stellata*), superficial coral (*Psammocora superficialis*), 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 scleratinian 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: *A. cytheria* 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. *Acropora gemmifera*, *Acropora humilis*, *Acropora paniculata, Acropora 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* is found only from the island of Hawaiʻi through Oʻahu. *Leptoseris foliosa* is only known from Maui. *Montipora dilitata* 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 Hawaii. All groups maintain data accessible to managers. There is no evidence of widespread decline for any species, though localized declines from habitat alteration, shipwrecks, runoff, and coral bleaching in the NWHI have been documented.

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* occurs in water over 30 meters (100 feet) deep. The really 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:

- 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 and walk on the coral and when boats anchor on reefs or spill fuel;
- Alien species such as macroalgae or snowflake coral (*Carijoa*) can quickly dominate coral reef habitat and form floating mats;
- Marine debris gets stuck on coral reefs and can break off large pieces of colonies. Corals also are important to the aquarium trade;
- Taking or harvesting stony corals is prohibited by law; however, they are still removed;
- Marine debris is a threat to coral, especially in the NWHI. The debris, primarily derelict fishing gear, entangles pieces of coral and it scours the reef as it moves around in the waves;
- Climate change may be linked to recent events of coral bleaching in the NWHI in 2002 and 2004;
- Disease is a potential threat in all areas but has not yet caused serious mortality of corals in Hawaiʻi.

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 Hawaiʻi 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;
- Continue working to remove marine debris.

MONITORING:
- Monitor alien macroalgae and removal operations to determine impacts on coral;
- Implement comprehensive disease monitoring statewide;
- 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 most effective means for removing invasive macroalgae.

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.

ʻekaha kū moana or Black corals

Order Antipatharia
Antipathidae
Leiopathidae
Myriopathidae
Schizopathidae

SPECIES STATUS:
IUCN Red List - Not considered
Only *A. grandis* is Endemic

SPECIES INFORMATION: The whole taxonomic order of Black Corals is listed as a "Species of Greatest Conservation Need." The common names of the species that occur in Hawai`i are: branching black coral (*Antipathes dichotoma*), grand black coral (*Antipathes grandis*), small feathery black coral (*Antipathes intermedia*), *Antipathes punctata* (no common name), *Antipathes subpinnata* (no common name), *Antipathes undulata* (no common name), common wire coral (*Cirrhipathes anguina*), *Bathypathes patula* (no common name), *Cirrhipathes spiralis* (no common name), *Leipoathes glaberrima* (no common name), feathery black coral (*Myriopathes ulex*), *Parantipathes sp.* (no common name), and *Schizopathes conferta* (no common name). Dense feathery black coral (*Myriopathes* cf. *japonica*) and red wire coral (*Stichopathes* cf. *echinulata*) may also be present. Many symbiotic species of bryozoans, fishes, shrimps, and winged pearl oysters live on or in the branches of these corals. Black corals lack a polyp stage, but reproduce both sexually and asexually. Their group, the antipatharians, has flexible, horny skeletons, usually with six unbranched tentacles. They lack symbiotic zooxanthellae. Only their skeletons are black, the skin covering the skeleton can also be red, yellow, green, white, or brown. Growth is slow and they are long-lived. Fenner (2005) believes *A. dichotoma* is another *Antipathes* species. *M. japonica* is a tentative identification of a second form of what used to be called *A. ulex*. Fenner (2005) reports that there is a deeper water species that is definitely *S. echinulata*, and a shallow water form may also be this species.

DISTRIBUTION: *A. intermedia*, *A. punctata*, *A. subpinnata, A. undulata, Parantipathes,* and *Schizopathes* are known from off Oʻahu only. *C. spiralis,* and *Leiopathes* occurs from Oʻahu through Kauaʻi. Distribution of the other species is statewide. Black coral beds that are commercially harvested occur between Maui and Lānaʻi and other beds off Kauaʻi and the island of Hawaiʻi have been harvested in the past.

ABUNDANCE: The precious black coral beds are monitored every few years by researchers working for the Western Pacific Fisheries Management Council, and the state has recently conducted a survey with collaborators. There is concern of a possible decrease in recruitment and a decrease in size of harvested black corals.

LOCATION AND CONDITION OF KEY HABITAT: All species prefer deeper areas with current. *A. dichotoma* can be found as shallow as 18 meters (60 feet) and *C. anguina* can be found as shallow as nine meters (30 feet). *A. intermedia, A. punctata, A. subpinnata, A. undulata, C. spiralis, Leiopathes,* and *Schizopathes* only occur deeper than 185 meters (600 feet).

THREATS:

- Overharvesting is a significant threat to black corals. *A. dichotoma*, *A. grandis*, and *A. ulex* are sought after in the shallow water precious coral fishery that currently uses SCUBA. Black corals are protected under Appendix II of the Convention on International Trade in Endangered Species (CITES). The IUCN listed black corals as commercially threatened in 1983 under older listing criteria;
- Introduced species threaten black corals. Alien species such as snowflake coral (*Carijoa*) may dominate black coral habitat. Disease is a potential threat in all areas but has not yet caused serious mortality of corals in Hawaii.

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. Black corals are protected under Appendix II of the Convention on International Trade in Endangered Species (CITES). Precious coral harvesting in federal waters is managed under a Fisheries Management Plan of the Western Pacific Regional Fisheries Management Council. In addition to common state-wide and island conservation actions, specific actions include:

- Work to adopt fishing regulations that correspond to regulations enacted in federal waters and that ease and maximize enforceability;
- Prevent alien species from entering the ecosystem by preventative measures, education, and rapidly responding to new intruders;
- Participate in black coral workshop to develop actions and research needed to conserve these species;
- Collaborate with the Western Pacific Fisheries Management Council on a black coral workshop to continue successful management of this fishery including possible MPAs,
- 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:

- Cooperate with the Western Pacific Fisheries Management Council in understanding the relationship between colony height and basal diameter and the effect of *Carijoa*;
- Improve understanding of factors affecting the species population sizes and distributions.

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 Hawai`i'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

CHAPTER 8: MONITORING, IMPLEMENTATION, AND ADAPTIVE MANAGEMENT

The need for monitoring is a consistent theme throughout Hawaiʻi'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 status level (monitoring of specific taxa and habitats), as well as monitoring the effectiveness level (monitoring if conservation actions are leading to the expected results and impacts); it outlines monitoring needs, and recommendations; it discusses needed modifications in the monitoring and evaluation strategy in order to better demonstrate the linkages between the identified conservation actions and the expected results; it discusses standardization measures needed and allows for more integrated data management and data sharing. 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 Hawaiʻi. Monitoring programs are essential to describe the status of the state's wildlife resources and their habitats, guide the development of plans, identify needed changes in strategy and actions to increase the effectiveness and efficiency of management and recovery programs to improve cost-efficiency and achieve goals. Monitoring does this by providing ways to track population trends, to describe habitat health, to assess threats and limiting factors, to test the effectiveness of conservation actions in achieving the assumed results and impacts, to evaluate and document progress of actions and to inform management of modifications needed to improve both effectiveness and efficiency of actions that improve native wildlife status. Monitoring programs are also tools to communicate conservation achievements, helping to develop support for conservation actions with decision-makers such as legislators, funding organizations, non-profit organizations, as well as the general public.

The Association of Fish and Wildlife Agencies' (AFWA) Teaming with Wildlife (TWW) Committee formed a Working Group which published "Measuring the Effectiveness of State Wildlife Grants: Final Report" (2011) (Appendix E). In the report, the AFWA/TWW working group describes a monitoring framework constructed around two principal levels of monitoring in conservation. The first is status-level monitoring, which "identifies how populations of species as well as the habitats and natural processes on which they depend are doing over time." The second is the effectiveness-level monitoring which "determines if conservation actions are having their intended impacts and how they can be improved" and thus, it all feeds naturally into an adaptive management cycle.

CURRENT ASSESSMENT OF MONITORING IN HAWAII

Monitoring is integral to most existing conservation programs and partnerships in Hawaiʻi. Current programs focus more on measuring and monitoring the status of specific species and the habitats on which they depend (status-level monitoring) and to a much lesser extent on monitoring the effectiveness of actions and testing the causality of the actions implemented and the results and assumed impacts of those actions (effectiveness-level monitoring). Additionally, monitoring protocols are varied and depend upon the nature of the resource being monitored, set objectives and goals, and funding capabilities and staff commitments, resulting in an abundance of data scattered among the many projects that is difficult or impossible to combine for larger more in-depth analysis.

This chapter describes the status-level monitoring and identifies the current monitoring programs and plans that are in place. It also discusses ways to improve effectiveness-level monitoring for projects based on the AFWA/TWW 2011 report on Measuring the Effectiveness of State Wildlife Grants: Final Report (Appendix E).

SUMMARY OF MONITORING EFFORTS AND CHALLENGES IN THE STATE

Monitoring in Hawaiʻi is conducted at multiple scales by various entities and at differing frequencies and quality. Status-level monitoring, both taxa and habitat monitoring, is conducted by state and federal agencies as well as private and public partners. 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 and partners also occurs on a program- or area-specific level, 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 Hawaiian Islands Humpback 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 Hawaiʻi and Maui Land and Pineapple, Inc. Additionally, private landowners conduct monitoring when participating in conservation programs such as the State's Habitat Conservation 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 mid-term 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 Hawaiʻi Audubon Society, which has conducted annual Christmas bird counts on Oʻahu, Kauaʻi, Maui, Hawaiʻi, 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 Hawaiʻi 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) Hawaiʻi 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 challenge to monitoring, however, is being able to balance staff effort, cost, and issues of what to monitor in order to best measure the effectiveness of conservation actions and achieve objectives and goals. 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. On the effectiveness-level monitoring, few projects have well developed monitoring plans that specifically follow the series of linkages between specific conservation actions and the assumed result or desired impact. Lacking a theory-of-change, or causality component, the effectiveness of a given action is difficult to quantify and describe which leaves the assumed cause and effect open to challenges. To address this shortfall, a monitoring working group will be established to improve status monitoring and develop a more robust effectiveness monitoring program. One of the primary goals of the working group will be to develop project-specific results chains for conservation actions and identify potential indicators and effectiveness measures to guide monitoring programs across the state. The working group will also help the districts assure protocols are in place to collect, analyze, and share data about the effectiveness measures, providing the District Managers with the information they need to adaptively manage the targeted SGCNs and the associated habitats. Figure 8.1 illustrates a sample results chain and identifies a few potential indicators.

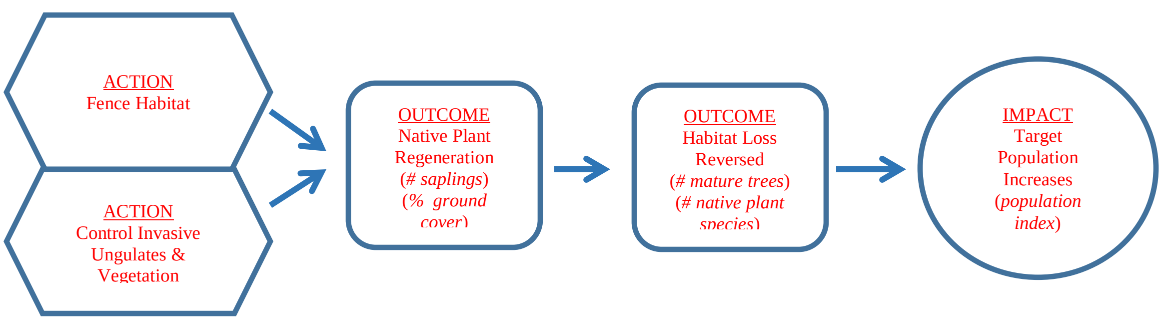


Figure 8.1Results Chain Showing Linkage Between Actions and Impact

TAXON MONITORING (Status Monitoring)

Most monitoring in the state consists of counting individuals and nests. 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 Hawaiʻi 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, Kauaʻi, and Oʻahu, 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. Additional research is being developed due to needs from the wind power corporations for better information on bat movements, particularly as they relate to seasonality through sites. Data is also sorely needed on basic life-history and demographic information, so that the effectiveness of mitigation actions can be more clearly defined and evaluated.

Forest Birds

Certain of Hawaiʻi'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 Hawaiʻi. 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 or expanded 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.

Monitoring has been improved in recent years by the development of new technologies and techniques. For example, "peeper" nest cameras that can reach forest bird nests at the canopy level have increased our ability to assess the success of nests, as well as more accurately determine the causes of failure, which we can then address on a management level. Another key tool is the development of remote tower systems that have deployed across the landscape to detect radio-tagged birds as they utilize the habitat. These towers are cost-effective compared to the costs of planes or helicopters traditionally used for such tracking. While the principal use has been to study forest birds on the Big Island, it has also been used for waterbirds on Oahu, and has been planned for use to examine home range and movement of the bat and ʻalalā.

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. However, plans are underway to develop protocols to survey this species, particularly on Oahu, where the species is listed as endangered by the state.

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. However, currently it appears that downlisting is the more likely scenario.

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

criteria for koloa maoli, mallards, and hybrids; greater consistency in coverage of wetlands each year; development of more accurate methods of surveying ‘alae ‘ula (such as using playbacks); and coverage of montane stream habitats to better detect koloa maoli populations.
Additional recent monitoring has looked at the movement patterns of these species between wetland areas on Oahu, both daily and seasonally. This is done through satellite and radio-tracking and has provided much-needed information regarding how different species are utilizing the few remaining wetlands on both public and private lands.

Nēnē were also part of a large effort to translocate individuals away from a wetland near the main airport on Kaua‘I, where they were a human health and safety hazard, to locations on other islands where they were more suited. By satellite-tracking individuals, valuable information was gained about the movements of these birds across the islands, as well as the high-priority habitats that are used.

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,‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]), and ‘ake‘ake (*Oceanodroma castro* [band-rumped storm-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, remote game cameras and song meters. 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, which will be the future site of translocation of endangered seabirds. DOFAW has also developed a monitoring program to protect and manage the ‘ua‘u colony on Lana‘ihale, which was rediscovered as an important breeding site in 2006. Current management and monitoring is being undertaken by the private landowner for this site.

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, Hawaiʻi 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 and annual monitoring of the Nihoa finch (*Telespiza ultima*) and Nihoa millerbird (*Acrocephalus familiaris kingi*) are conducted by USFWS staff.

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 Hawaiʻi conducted comprehensive surveys of 376 perennial streams across Hawaiʻi for the Hawaiʻi 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

Hawaiʻi has a large number of anchialine ponds, but very few (such as at ʻĀhihi-Kīnaʻu, Maui, and Lua o Palahemo, Hawaiʻi) 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 Hawaiʻi island with significant pool resources: Hawaiʻi Volcanoes, Kaloko-Honokōau, and Puʻuhonua 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 Hawaiʻi. 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 Hawaiʻi Institute of Marine Biology (HIMB) routinely monitors reefs and marine habitats in Kāneʻohe Bay, Oahʻu, 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 (Status 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 Hawaiʻi Gap Analysis Program (HI-GAP) is a helpful tool. However, monitoring gaps 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 Hawaiʻi 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 Heʻeia estuary in Kāneʻohe. 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 Hawaiʻi has a foundation for status-level monitoring of species and habitats, this foundation needs to be expanded by strengthening existing efforts and improving and standardizing methodology and developing new techniques and tools. 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 in addition to the development of clearly defined linkages between the specific actions and the desired outcomes and impacts, the identification of effectiveness measures to assess progress at key points throughout the life of the project, as discussed above. 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 without adding much extra effort. The recommendations are discussed below.

DEVELOP MONITORING WORKING GROUPS

The establishment of monitoring working groups throughout the state is needed to improve status monitoring and develop a more robust effectiveness monitoring program, which would create a standardized and accessible suite of performance data to evaluate conservation actions and guide adaptive management. These working groups will provide expert advice, based on the AFWA/TWW Measuring the Effectiveness of State Wildlife Grants: Final Report (Appendix E), to guide monitoring programs across the state. The working groups will help projects identify monitoring gaps; prioritize needs; better define conservation actions; describe how specific actions leads to desired impacts, creating a “results chain”; develop and test an appropriate set of effectiveness measures and ensure they provide meaningful information within existing human, legal, and financial constraints; assure protocols are in place to “collect, analyze, and share data about the effectiveness measures to show whether or not the conservation action achieved the desired impact, why it succeeded or failed, and how implementation of the action can be improved over time under different conditions; and finally the monitoring working groups will oversee the implementation of monitoring actions. Many of these working groups already exist for species-level monitoring, such as the Hawaii Forest Bird Interagency Database project, the Hawaii Seabird Hui, and the Nene Recovery Action Group. Identifying and filling gaps in this monitoring network is essential for understanding the complete set of needs across the state.

IMPROVE MONITORING FOR ALL TAXA (Status monitoring)

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 ʻōpeʻapeʻa, 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). Current progress in population modeling of seabirds, in collaboration with USFWS, needs to be continued and adapted to other avian populations in order to more accurately calculate population statistics.
- 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 based on the AFWA/TWW 2011 Final Report, 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. Also, there is a need to develop an accessible database that can be made available, in its entirety or in parts, to collaborating partners and the public. While forest birds are covered by the Hawaii Forest Bird Interagency Database and waterbird data is coordinated into a database by DOFAW and USFWS, for many other species, a cross-agency database is needed. A recent initiative by the state to establish a statewide invertebrate database and populate it with all historical data has achieved great success and is nearly complete. However, in Hawaiʻi, database needs are complicated by the overwhelming number of listed species, many of which are extremely rare with associated location data that is sensitive. Land snails, plants, and some marine species are affected the most by this limitation, which often keeps collaboration with private organizations and landowners from being more effective.

IMPROVE MONITORING FOR ALL HABITATS

Priority habitat monitoring needs are to support efforts already underway, to standardize data collection and methodologies, 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 describe the importance of these habitats to species' survival. Other habitats that need better and more 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. Finally, an accessible database should be created that can be made available, in its entirety or in parts, to collaborating partners and the public to allow for more extensive analysis in the future.

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, Hawaiʻi Forest Bird Interagency Database Project, the Hawaiʻi Biodiversity and Mapping Program, and HI-GAP. Other information is collated by the individual island Invasive Species Committees and the various watershed partnerships across the island chain. 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 AND NATIONALLY

Effective status-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 Hawaiʻi Conservation Conference, annual coral reef conference, and meetings of the Hawaiʻi Association of Watershed Partnerships, as well as AFWA and other national monitoring initiatives and the development of new forums on specific topics as needed, provide opportunities for the sharing of information.

It is also essential to have the ability to share effectiveness-monitoring data and effective conservation strategies across the state as well as lessons learned. It is important to be able to have access to a toolkit of effective and proven conservation actions along with efficient implementation plans that have been tested locally and nationally and will 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. A recent effort coordinated by the Hawaiʻi Conservation Alliance aims to achieve many of these objectives to coordinate and standardize existing natural resource data across the state.

IMPLEMENTATION OF HAWAIʻI'S SWAP

Implementation of certain elements of Hawaiʻi's SWAP has already begun. 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 Hawaiʻi'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 Oʻahu; and
- Seabird habitat management on Kauaʻi.

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

- Predator control for Oʻahu ʻelepaio (*Chasiempis sandwichensis ibidis*) and seabirds on Oʻahu; and
- predator control for forest birds on Kauaʻi and the Big Island.

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, Kauaʻi, Oʻahu, and Hawaiʻi;
- Surveys for nest colony locations of ʻuaʻu and ʻaʻo;
- 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 Oʻahu.

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 directly linked to practicing adaptive management through the evaluation of the effectiveness measures, which assess progress at key points throughout the life of the project providing evidence that the actions being implemented are, or are not, achieving the identified results leading to the ultimate impact expected. The adaptive management cycle results in the integration of monitoring and evaluation results into the strategic management planning process for the following phase of the plan implementation. The evaluation results identify what works and what did not work and 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 and the ultimate desired impact. 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 the state’s result chains, or the “theory of change” is valid. In other words, annual reviews will assure that the state’s conservation actions are indeed leading to the expected outcomes and ultimate impacts identified in the SWAP. If the expected results are not being achieved our actions can be modified. This review will include identification of new or altered threats; review of recent surveys, data, and research; evaluation of the effectiveness of conservation actions by reviewing and testing the theory of change; identification of urgent conservation actions; 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. Each forest bird recovery project has an inter-agency advisory group that provides guidance for each year’s work plan through annual meetings. Similarly, the captive breeding program for forest birds is managed through the Hawaiian Endangered Bird Recovery Program, a partnership between DLNR, USFWS, and the San Diego Zoo, which also meets regularly to determine priorities for the following year. Forest birds are also directed by species-specific 5-year recovery plans developed by the working groups. Additional advisory groups that are topic-driven (outreach, monitoring, habitat management, etc.) are also being developed. 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 for the following ten years plan. The major ten-year revision should start in 2024, at least 18 months before deadline, beginning with an internal review, summarizing the small-scale annual reviews, 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 or delayed 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.

Bibliography:

Association of Fish and Wildlife Agencies’ (AFWA) Teaming With Wildlife (TWW). Effectiveness Measures Working Group. 2011. Measuring the Effectiveness of State Wildlife Grants: Final Report. Available at: http://teaming.com/tool/measuring-effectiveness-state-wildlife-grants-final-report-apr-2011

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 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 strategies.

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).

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. 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. 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)

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.

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.

Kupuna: grandparent, ancestor, relative or close friend of the grandparent's generation, grandaunt, granduncle.

Lo‘i: irrigated terrace, especially for taro, but also for rice: paddy.

Maui Nui: the islands of Moloka‘i, Lāna‘i, Maui, and Kaho‘olawe.

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.

Association of Fish and Wildlife Agencies' (AFWA) Teaming With Wildlife (TWW). Effectiveness Measures Working Group. 2011. Measuring the Effectiveness of State Wildlife Grants: Final Report. Available at: http://teaming.com/tool/measuring-effectiveness-state-wildlife-grants-final-report-apr-2011

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 Oʻahu (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 Hawaiʻi. 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 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.

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.

Bakutis A, et al. 2002. Draft comprehensive wildlife management plan. Honolulu (HI): University of Hawaiʻi.

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 cavernicolous 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, ‘Alala, and Crested Honeycreeper. Hilo, Hawai‘i.

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 Hawai‘i. 2003. Kipuka Kanohina Cave Preserve management plan. Cave Conservancy of Hawai‘i.

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.

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.

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 Hawaiʻi 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., ’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, 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.

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.

Hawaiʻi 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).

Hawaiʻi 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.

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

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

Hawaiʻi Department of Land and Natural Resources. 1983. Hawaiʻi wildlife plan. Honolulu (HI): DLNR.

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Hono o Na Pali Natural Area Reserve management plan. Honolulu (HI).

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

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Laupahoehoe Natural Area Reserve management plan. Honolulu (HI).

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Puʻu Makaʻala Natural Area Reserve management plan. Honolulu (HI).

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1989. Puʻu ʻO Umi Natural Area Reserve management plan. Honolulu (HI).

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

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Kahaualea Natural Area Reserve management plan. Honolulu (HI).

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1992. Manuka Natural Area Reserve management plan. Honolulu (HI).

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 1993.

Kipahoehoe Natural Area Reserve management plan. Honolulu (HI).

Hawaiʻi 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).

Hawaiʻi Department of Land and Natural Resources (DLNR). 2003. Ahihi-Kinau NAR/Keoneoʻio plan of action draft for discussion purposes.

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife and Division of State Parks. 2003. Management plan for the Ahupuaʻa of Puʻu Waʻawaʻa and the Makai lands of Puʻu Anahulu. State of Hawaiʻi.

Hawaiʻi Department of Land and Natural Resources (DLNR). 2004. Statewide report on invasive species. Honolulu (HI): DLNR.

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

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

Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Forest legacy: amended assessment of needs, State of Hawaiʻi. Honolulu (HI).

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

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

Hawaiʻi Department of Land and Natural Resources. 2013. Division of Forestry and Wildlife Snail Extinction Puu Makaʻala Natural Area Reserve (NAR) Management Plan. Honolulu.

Hawaiʻi 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).

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

Hawaiʻi 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).

[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.

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.

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 Kauaʻi Cave Wolf Spider and the Kauaʻi Cave Amphipod Island of Kauaʻi, 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 Hawaiʻi Third Edition. Honolulu: University of Hawaiʻi Press.

Kahoʻolawe Island Reserve Commission. Available at: http://www.state.hi.us/kirc/ (accessed 9 March 2005).

Kahoʻolawe 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 Hawaiʻi 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, Hawaiʻi 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).

Koʻolau Mountains Watershed Partnership. 2002. Koʻolau 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 Hawaiʻi Press.

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.

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: 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).

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 Hawaiʻi Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawaiʻi, Honolulu, Hawaiʻi. 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 Hawaiʻi 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. Puʻu 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, Hawaiʻi, 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 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.

Nature Conservancy of Hawaiʻi. 2003. Kapunakea Preserve: long range management plan fiscal years 2004-2009. Honolulu, Hawaiʻi: 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 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. 2003. Last Stand: the Vanishing Hawaiian Forest.

Nature Conservancy. 2004. Kanepuʻu 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. Kaua‘i (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 Hawai‘i Press.

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.

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 Hawaiʻi 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 Hawaiʻi. Honolulu: University of Hawaiʻi Press. 216 pp.

Rauzon M. 2001. Isles of refuge: wildlife and history of the Northwestern Hawaiian Islands. Honolulu: University of Hawaiʻi 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, Hawaiʻi. 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. Hawaiʻi 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%20 December%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	'ōpe'ape'a	'Ōpe'ape'a	**X**		**X**	**X**		**X**		**X**		**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis ibidis*	O'ahu 'elepaio	'elepaio	Oahu 'elepaio			**X**							**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis sandwichensis*	Hawai'i 'elepaio	'elepaio	Hawai'i 'elepaio								**X**			
Forest Birds	T	*Chasiempis sandwichensis sclateri*	Kaua'i 'elepaio	'elepaio	Kaua'i 'elepaio	**X**										
Forest Birds	T	*Corvus hawaiiensis*	Hawaiian crow	'alalā	Hawaiian Crow								X		**E**	**E**
Forest Birds	T	*Hemignathus flavus*	O'ahu 'amakihi	'amakihi	O'ahu 'amakihi			**X**								
Forest Birds	T	*Hemignathus kauaiensis*	Kaua'i 'amakihi	alawī kihi	Kaua'i 'amakihi	**X**										
Forest Birds	T	*Hemignathus lucidus affinis*	Maui nuku pu'u	nuku pu'u	Maui nuku pu'u						X				**E**	**E**
Forest Birds	T	*Hemignathus lucidus hanapepe*	Kaua'i nuku pu'u	nuku pu'u	Kaua'i nuku pu'u	X									**E**	**E**
Forest Birds	T	*Hemignathus munroi*	'akiapōlā'au	'akiapōlā'au	'Akiapōlā'au								**X**		**E**	**E**
Forest Birds	T	*Hemignathus parvus*	Lesser 'amakihi	'anianiau	'Anianiau	**X**										
Forest Birds	T	*Hemignathus procerus*	Kaua'i 'akialoa	'akialoa	Kaua'i 'akialoa	X									**E**	**E**
Forest Birds	T	*Hemignathus virens*	Hawai'i 'amakihi	'amakihi	Hawai'i 'amakihi				**X**	X	**X**		**X**			
Forest Birds	T	*Hemignathus virens wilsoni*	Maui 'Amakihi	'Amakihi	see: Hawai'i 'amakihi					X	**X**					**E**
Forest Birds	T	*Himatione sanguinea*	'apapane	'apapane	'Apapane	**X**		**X**	**X**	**X**	**X**		**X**			
Forest Birds	T	*Loxioides bailleui*	Palila	palila	Palila								**X**		**E**	**E**
Forest Birds	T	*Loxops caeruleirostris*	Kaua'i ākepa	'akeke'e	'Akeke'e	**X**									**E**	**E**
Forest Birds	T	*Loxops coccineus coccineus*	Hawai'i 'ākepa	'ākepa	'Ākepa								**X**		**E**	**E**
Forest Birds	T	*Loxops coccineus ochraceus*	Mau'i 'ākepa	'ākepa	Maui 'ākepa						X				**E**	**E**
Forest Birds	T	*Melamprosops phaeosoma*	Po'ouli	po'ouli	Po'ouli						**X**				**E**	**E**
Forest Birds	T	*Moho bishopi*	Bishop's 'ō'ō	'ō'ō	Bishop's 'ō'ō				X		X?					
Forest Birds	T	*Moho braccatus*	Kaua'i 'ō'ō	'ō'ō 'ā'ā	Kaua'i 'ō'ō	X									**E**	**E**
Forest Birds	T	*Myadestes lanaiensis*	Moloka'i thrush	oloma'o	Oloma'o			X?	X	X	X?				**E**	**E**
Forest Birds	T	*Myadestes myadestinus*	Large Kaua'i thrush	kāma'o	Kāma'o	X									**E**	**E**
Forest Birds	T	*Myadestes obscurus*	Hawai'i thrush	ōma'o	Ōma'o								**X**			
Forest Birds	T	*Myadestes palmeri*	Small Kaua'i thrush	puaiohi	Puaiohi	**X**									**E**	**E**
Forest Birds	T	*Oreomystis bairdi*	Kaua'i creeper	'akikiki	'Akikiki	**X**									**E**	**E**
Forest Birds	T	*Oreomystis mana*	Hawai'i creeper	none	Hawai'i creeper								**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**
Forest Birds	T	*Palmeria dolei*	Crested honeycreeper	ʻākohekohe	ʻĀkohekohe				X		**X**				**E**	**E**
Forest Birds	T	*Paroreomyza flammea*	Molokaʻi creeper	kākāwahie	Molokaʻi creeper				X						**E**	**E**
Forest Birds	T	*Paroreomyza maculata*	Oʻahu creeper	ʻalauahio	Oʻahu ʻalauahio			**X**							**E**	**E**
Forest Birds	T	*Paroreomyza montana*	Maui creeper	ʻalauahio	Maui ʻalauahio					X	**X**					
Forest Birds	T	*Pseudonestor xanthophrys*	Maui parrotbill	kīkēkoa	Maui Parrotbill				X		**X**				**E**	**E**
Forest Birds	T	*Psittirostra psittacea*	ʻōʻū	ʻōʻū	ʻŌʻū	**X**		X	X	X	X		**X**		**E**	**E**
Forest Birds	T	*Vestiaria coccinea*	ʻiʻiwi	ʻiʻiwi	ʻIʻiwi	**X**		**X**	**X**	X	**X**	X?	**X**			**E**
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**		
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	ʻakekeke	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**		
Molluscs	F	*Erinna newcombi*	Newcomb's snail	none	Newcomb's Snail	**X**									**T**	**T**
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**
Raptors	T	*Buteo solitarius*	Hawaiian hawk	ʻio	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**
Seabirds	T	*Oceanodroma castro*	Band-rumped storm petrel	ʻakēʻakē	Band-rumped Storm Petrel	**X**		X	X	X	**X**	**X**	**X**		**E**	**E**
Seabirds	T	*Phoebastria albatrus*	Short-tailed albatross	none	Short-tailed Albatross									**X**	**E**	**E**
Seabirds	T	*Pterodroma sandwichensis*	Hawaiian petrel	ʻuaʻu	Hawaiian Petrel	**X**		**X**	**X**	**X**	**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
Seabirds	T	*Puffinus auricularis newelli*	Newell's shearwater	'a'o	Newell's Shearwater	**X**		**X?**	**X**	**X?**	**X?**		**X**		**T**	**T**
Seabirds	T	*Gygis alba*	White (Fairy) tern	manu-o-Kū	White (Fairy) Tern			**X**						**X**		**T**
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	*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**		
Seabirds	T	*Puffinus nativitatis*	Christmas shearwater	none	Christmas Shearwater	**X**		**X**						**X**		
Seabirds	T	*Oceanodroma tristrami*	Tristram's storm petrel	none	Tristram's Storm Petrel									**X**		
Seabirds	T	*Phaethon lepturus*	White-tailed tropicbird	koa'e kea	White-tailed Tropicbird	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Seabirds	T	*Phaethon rubricauda*	Red-tailed tropicbird	koa'e 'ula	Red-tailed Tropicbird	**X**		**X**		**X**		**X**		**X**		
Seabirds	T	*Sula dactylatra*	Masked (blue-faced) booby	'ā	Masked (blue-faced) Booby			**X**			**X**			**X**		
Seabirds	T	*Sula leucogaster*	Brown booby	'ā	Brown Booby	**X**		**X**						**X**		
Seabirds	T	*Sula sula*	Red-footed booby	'ā	Red-footed Booby	**X**		**X**						**X**		
Seabirds	T	*Fregata minor*	Great frigatebird	'iwa	Great Frigatebird	**X**		**X**						**X**		
Seabirds	T	*Sterna lunata*	Gray-backed tern	pākalakala	Gray-backed Tern			**X**						**X**		
Seabirds	T	*Sterna fuscata*	Sooty tern	'ewa'ewa	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**		
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**

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**
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**
Waterbirds	T/F/A	*Nycticorax nycticorax hoactli*	Black-crowned night heron	‘auku‘u	Black-crowned Night Heron	**X**	**X**	**X**	**X**	**X**	**X**		**X**			
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**
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	*Achatinella spp.*	O‘ahu tree snail	none	*Achatinella spp.*			**X**							**E**	**E**

Species						*Island Distribution (Current (bold) and historic (unbold))*									**Status**	
Group	**Habitat***	**Scientific Name**	**Common Name**	**Hawaiian Name**	**Fact sheet**	***Kauaʻi***	***Niʻihau***	***Oʻahu***	***Molokaʻi***	***Lānaʻi***	***Maui***	***Kahoʻolawe***	***Hawaiʻi***	***NWHI***	******Federal***	*****State***
Invertebrates - snails	T	*Amastra cylindrica*	Oʻahu terrestrial snail	none	*Amastra cylindrica*			**X**								
Invertebrates - snails	T	*Amastra spirizona*	Oʻahu terrestrial snail	none	*Amastra spirizona*			**X**								
Invertebrates - snails	T	*Auriculella pulchra*	Oʻahu tree snail	none	*Auriculella pulchra*			**X**								
Invertebrates - snails	T	*Cookeconcha hystricella*	Oʻahu tree snail	none	*Cookeconcha hystricella*			**X**								
Invertebrates - snails	T	*Kaala subrutila*	Oʻahu terrestrial snail	none	*Kaala subrutila*			**X**								
Invertebrates - snails	T	*Laminella aspera*	Maui terrestrial snail	none	*Laminella aspera*						**X**					
Invertebrates - snails	T	*Laminella sanguinea*	Oʻahu terrestrial snail	none	*Laminella sanguinea*			**X**								
Invertebrates - snails	T	*Newcombia cumingi*	Newcomb's tree snail	none	*Newcombia cumingi*						**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	*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 semicarinata*	Lānaʻi tree snail	pupu kani oe	*Partulina semicarinata*					**X**					**E**	**E**
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 variabilis*	Lānaʻi tree snail	pupu kani oe	*Partulina variabilis*					**X**					**E**	**E**
Invertebrates - arachnids	T	*Adelocosa anops*	Kauaʻi cave wolf spider	none	Kauai cave arthropods	**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**	?		
Invertebrates - arachnids	T	Order Pseudoscorpionida	Pseudoscorpions	none	False Scorpions	**X**		**X**			**X**		**X**	**X**		
Invertebrates	T	*Spelaeorchestia koloana*	Kauaʻi cave amphipod	none	Kauai cave arthropods	**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	*Drosophila digressa*	Hawaiian picture-wing fly	none	*Drosophila digressa*								**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**
Invertebrates - insects	T	*Drosophila mulli*	picture-wing fly	none	*Drosophila mulli*								**X**		**E**	**T**
Invertebrates - insects	T	*Drosophila musaphila*	picture-wing fly	none	*Drosophila musaphila*	**X**									**E**	**E**
Invertebrates - insects	T	*Drosophila sharpi*	Hawaiian picture-wing fly	none	*Drosophila sharpi*	**X**									**E**	**E**
Invertebrates - insects	T	Drosophilidae	Pomace flies	none	Pomace flies											

**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	*Drosphila hemipeza*	picture-wing fly	none	*Drosphila hemipeza*			**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	*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 hilaris*	Hilaris yellow-faced bee	none	*Hylaeus hilaris*				**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	*Manduca blackburni*	Blackburn's sphinx moth	none	Blackburn's Sphinx Moth	X		X	X		**X**	**X**	**X**		**E**	**E**
Invertebrates - insects	T/F	*Megalagrion leptodemas*	crimson Hawaiian damselfly		crimson Hawaiian damselfly			**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'***	***Lāna'i***	***Maui***	***Kaho'olawe***	***Hawai'i***	***NWHI***	****Federal**	****State**
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 Archaeognatha	Bristlethighs	none	Bristlethighs	**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	Order Collembola	Springtails	none	Springtails	**X**		**X**	**X**	**X**	**X**		**X**	**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	Order Heteroptera	True bugs	none	True bugs	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Order Homoptera	Aphids, plant hoppers, leaf hoppers, psyllids,	none	Aphids, Hoppers, Whiteflies,	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Invertebrates - insects	T	Order Hymenoptera	Ants, bees, and wasps	none	Bees and Wasps	**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***
Invertebrates - insects	T	Order Lepidoptera	Moths, butterflies, and hyposmocoma	none	Moths and Butterflies	**X**	**X**	**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**	?		
Invertebrates - insects	T-F	Order Odonata	Damselflies, dragonflies	none	Damselflies and Dragonflies	**X**	**X**	**X**	**X**	**X**	**X**		**X**	?		
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**	?		
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	*Procanace* spp.	Beach Flies	none	Beach flies	**X**		**X**	**X**	**X**	**X**	X	**X**	X		
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**			

**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	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**			
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	*Antecaridina lauensis*	none	none	Anchialine Shrimp						**X**		**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**			

**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	*Holocaridina rubra*	none	ʻōpae ʻula, ʻōpae 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**					
Crustaceans	A	*Parhyale hawaiensis*	none	none	Anchialine Amphipod						**X**		**X**			
Crustaceans	A	*Procaris hawaiana*	none	none	Anchialine Shrimp						**X**		**X**		**E**	**E**
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**
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											

**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**	***Kauaʻi***	***Niʻihau***	***Oʻahu***	***Molokaʻi***	***Lānaʻi***	***Maui***	***Kahoʻolawe***	***Hawaiʻi***	***NWHI***	****Federal**	****State**
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											
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**

**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**
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	*Rhincodon typus*	Whale shark	lele wa'a	Sharks and Rays											
Sharks	M	*Carcharodon carcharias*	Great white shark	niuhi	Sharks and Rays											
Rays	M	*Manta alfredi or birostris*	Manta Ray	none	Sharks and 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											
Fishes	M	*Antennarius commersoni*	Commerson's frogfish	none	Cryptic Reef Fishes											
Fishes	M	*Aphareus rutlians*	Lehi	none	Bottomfishes											
Fishes	M	*Apogon maculiferus*	Spotted cardinalfish	'upāpalu	Cryptic Reef Fishes											
Fishes	M	*Apolemichthys arcuatus*	Bandit angelfish	none	Active Reef Fishes											
Fishes	M	*Aprion virescens*	Green jobfish	uku	Bottomfishes											
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											

**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	*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	*Caranx ignobilis*	Giant Ulua or Trevally	ulua aukea	Bottomfishes											
Fishes	M	*Caranx lugubrius*	Black ulua	gunkan	Bottomfishes											
Fishes	M	*Cataetyx hawaiiensis*	none	none	Deep Fishes											
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											

**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**	**Kauaʻi**	**Niʻihau**	**Oʻahu**	**Molokaʻi**	**Lānaʻi**	**Maui**	**Kahoʻolawe**	**Hawaiʻi**	**NWHI**	****Federal**	****State**
Fishes	M	*Chromis struhsakeri*	Struhsaker's chromis	none	Active Reef Fishes											
Fishes	M	*Cirripectes obscurus*	Gargantuan blenny	pāoʻo	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 ʻaua	HI Ladyfish											
Fishes	M	*Enchelycore pardalis*	Dragon eel	pūhi-kauila	Eels											
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	pāoʻo	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 lanceolatus*	Giant grouper	none	Bottomfishes											
Fishes	M	*Epinephelus quernus*	Hawaiian grouper	hāpuʻu	Bottomfishes											
Fishes	M	*Etelis carbunculus*	Ehu	ulaʻula	Bottomfishes											
Fishes	M	*Etelis coruscans*	Onaga	ulaʻula koaʻe	Bottomfishes											
Fishes	M	*Etmopterus villosus*	Hawaiian lanternshark	none	Deep Fishes											
Fishes	M	*Eurypegasus papilio*	Hawaiian sea moth	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	Kauaʻi	Niʻihau	Oʻahu	Molokaʻi	Lānaʻi	Maui	Kahoʻolawe	Hawaiʻi	NWHI	**Federal	**State
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											
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											

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	*Istiblennius zebra*	Zebra blenny	pāoʻo	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											
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											

**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	*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	ʻāweoweo	Active Reef Fishes											
Fishes	M	*Pristipomoides auricillia*	Glodflag jobfish	kali kali	Bottomfishes											
Fishes	M	*Pristipomoides filamentosus*	ʻŌpakapaka	none	Bottomfishes											
Fishes	M	*Pristipomoides sieboldi*	Kalekale	none	Bottomfishes											
Fishes	M	*Pristipomoides zonatus*	Gindai	ukikiki	Bottomfishes											
Fishes	M	*Pseudanthias thompsoni*	Hawaiian anthias	none	Sex Changers											
Fishes	M	*Pseudocaranx dentex*	Thick or Pig Ulua	butaguchi	Bottomfishes											
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											
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	*Seriola dumerili*	Amberjack	kahala	Bottomfishes											

**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	*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	*Euprymna scolopes*	Hawaiian Bobtail Squid	mūhe'e	Cephalopods											
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 hazletti*	Hazlett's hermit crab	unauna	Other Crustaceans											
Crustaceans	M	*Calcinus laurentae*	Laurent's hermit crab	unauna	Other Crustaceans											
Crustaceans	M	*Carpilius maculatus*	7-11 crab	'alakuma	Other Crustaceans											
Crustaceans	M	*Cinetorhynchus hawaiiensis*	Hawaiian hinge-beak shrimp	none	Other Crustaceans											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

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	M	*Cinetorhynchus hendersoni*	Henderson's hinge-beak shrimp	none	Other Crustaceans											
Crustaceans	M	*Dromia dormia*	Sponge crab	makua-o-ka-lipoa	Other Crustaceans											
Crustaceans	M	*Gnathophyllum precipuum*	Hawaiian cave 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	*Ligia hawaiensis*	none	none	Other Crustaceans											
Crustaceans	M	*Liomera supernodosa*	Knotted liomera	none	Other Crustaceans											
Crustaceans	M	*Lybia edmondsoni*	Hawaiian pom-pom crab	kū mimi pua	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											
Molluscs	M	*Cellana exarata*	Black foot limpet	‘opihi makaiauli	Limpets											
Molluscs	M	*Cellana melanostoma*	Green -foot opihi	none	Limpets											
Molluscs	M	*Cellana sandwicensis*	Yellow foot limpet	‘opihi ‘ālinalina	Limpets											

*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 talcosa*	Yellow foot limpet	‘opihi kō‘ele	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 ‘alā	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	*Duplicaria gouldi*	Gould’s Auger	pūpū loloa, ‘oi‘oi	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											
Molluscs	M	*Haumea juddi*	Judd’s scallop	none	Bivalves											
Molluscs	M	*Hypselodoris andersoni*	Anderson's Nudibranch	none	Nudibranchs											
Molluscs	M	*Ischnochiton petaloides*	Flat chiton	pupu mo‘o	Chitons											
Molluscs	M	*Isognomon californicum*	Black purse shells	nahawele	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	*Melibe megaceras*	Dendronotid	none	Nudibranchs											
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	*Strombus vomer hawaiiensis*	Hawaiian Stromb	none	Snails											
Molluscs	M	*Turbo sandwicensis*	Hawaiian Turban	'ailea	Snails											
Molluscs	M F	*Ostrea sandvicensis*	Hawaiian Oyster	none	HI Oyster											
Sponge	M	*Spongia oceania*	none	none	Sponge											
Echinoderm	M	*Actinocidaris thomasi*	Thomas's sea urchin	none	Echinoderms											
Echinoderm	M	*Lissodiadema purpureum*	Fine-spined urchin	none	Echinoderms											
Echinoderm	M	*Lovenia hawaiiensis*	Hawaiian lovenia	none	Echinoderms											
Echinoderm	M	*Mithrodia fisheri*	Fisher's star	none	Echinoderms											
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	*Acabaria bicolor*	Bicolor Gorgonian	none	Other Anthozoans											
Cnidaria	M	*Acropora cytherea*	Table 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	*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	*Anthelia edmondsoni*	Blue soft coral	‘okole	Other Anthozoans											
Cnidaria	M	*Anthemiphyllia pacifica*	none	none	Stony Corals											
Cnidaria	M	*Antipathes dichotoma*	Branching Black coral	none	Black Corals											
Cnidaria	M	*Antipathes grandis*	Grand Black coral	‘ekaha kū moana	Black Corals											
Cnidaria	M	*Antipathes intermedia*	Small feathery black coral	none	Black Corals											
Cnidaria	M	*Antipathes punctata*	none	none	Black Corals											
Cnidaria	M	*Antipathes subpinnata*	none	none	Black Corals											
Cnidaria	M	*Antipathes undulata*	none	none	Black Corals											
Cnidaria	M	*Balanophyllia desmophylloides*	none	none	Stony Corals											
Cnidaria	M	*Balanophyllia diomedeae*	none	none	Stony Corals											
Cnidaria	M	*Balanophyllia hawaiiensis*	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											
Cnidaria	M	*Cirrhipathes anguina*	Common wire coral	none	Black Corals											
Cnidaria	M	*Cladactella manni*	Mann's Anemone	‘okole, ‘okola	Other Anthozoans											
Cnidaria	M	*Coscinaraea wellsi*	Wells coral	none	Stony Corals											

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	*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 ocellina*	Ocellated coral	‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Deltocyathus andamanicus*	none	none	Stony Corals											
Cnidaria	M	*Dendrophyllia oahensis*	none	none	Stony Corals											
Cnidaria	M	*Dendrophyllia serpentina*	Serpentine cup coral	none	Stony Corals											
Cnidaria	M	*Desmophyllum cristagallis*	none	none	Stony Corals											
Cnidaria	M	*Diaseris distorta*	Distorted mushroom 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	*Leiopathes glaberrima*	none	none	Black Corals											
Cnidaria	M	*Leptastrea bewickensis*	Bewick coral	none	Stony Corals											
Cnidaria	M	*Leptastrea bottae*	none	‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Leptastrea pruinosa*	Spotted coral	none	Stony Corals											
Cnidaria	M	*Leptastrea purpurea*	Crust coral	none	Stony Corals											
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											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
****Status: E = Endangered; T = Threatened; C = Candidate*

Species						***Island Distribution (Current (bold) and historic (unbold))***									**Status**	
Group	**Habitat***	**Scientific Name**	**Common Name**	**Hawaiian Name**	**Fact sheet**	***Kauaʻi***	***Niʻihau***	***Oʻahu***	***Molokaʻi***	***Lānaʻi***	***Maui***	***Kahoʻolawe***	***Hawaiʻi***	***NWHI***	****Federal**	****State**
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	*Myriopathes cf. japonica*	Dense feathery black coral	none	Black Corals											
Cnidaria	M	*Myriopathes ulex*	Feathery Black coral	none	Black Corals											
Cnidaria	M	*Palythoa psammophilia*	Toadstool Zoanthid	none	Other Anthozoans											
Cnidaria	M	*Palythoa toxica*	Toadstool 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	*Parantipathes*	none	none	Black Corals											
Cnidaria	M	*Parazoanthus sp.*	none	none	Other Anthozoans											
Cnidaria	M	*Pavona duerdeni*	Flat lobe coral	none	Stony Corals											
Cnidaria	M	*Pavona pollicata*	none	none	Stony Corals											
Cnidaria	M	*Pavona varians*	Corrugated coral	ʻākoʻakoʻa	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	*Placotrochus fuscus*	none	none	Stony Corals											
Cnidaria	M	*Pocillopora damicornis*	Lace coral	‘ākoʻakoʻa	Stony Corals											
Cnidaria	M	*Pocillopora eydouxi*	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 convexa*	Plate and knob coral	none	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 lichen*	Lichen coral	none	Stony Corals											
Cnidaria	M	*Porites lobata*	Lobe coral	pō haku puna, ‘ākoʻakoʻa	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 stellata*	Stellar coral	‘ākoʻakoʻa	Stony Corals											

**T=terrestrial, F=freshwater, A=anchialine, M=marine*
***Status: E = Endangered; T = Threatened; C = Candidate*

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 superficialis*	Superficial coral	none	Stony Corals											
Cnidaria	M	*Psammocora verrilli*	Verril's lump coral	none	Stony Corals											
Cnidaria	M	*Rhizopsammia verrilli*	Verrill's lump coral	none	Stony Corals											
Cnidaria	M	*Schizopathes conferta*	none	none	Black Corals											
Cnidaria	M	*Sinularia molokaiensis*	Hawaiian Leather Coral	none	Other Anthozoans											
Cnidaria	M	*Stephanophyllia formosissima*	none	none	Stony Corals											
Cnidaria	M	*Stichopathes cf. echinulata*	Red wire coral	none	Black 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											

**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, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Abutilon	*eremitopetalum*				E	X	
Abutilon	*menziesii*				E		
Abutilon	*sandwicense*				E		
Acaena	*exigua*				E	X	
Achyranthes	*mutica*				E	X	
Achyranthes	*splendens*	var.	*rotundata*		E		
Adenophorus	*periens*				E	X	
Alectryon	*macrococcus*	var.	*auwahiensis*	mahoe	E	X	
Alectryon	*macrococcus*	var.	*macrococcus*	mahoe	E		
Amaranthus	*brownii*				E		
Argyroxiphium	*kauense*				E		
Argyroxiphium	*sandwicense*	subsp.	*sandwicense*	'ahinahina	E	X	X
Asplenium	*diellaciniatum*				E	X	
Asplenium	*fragile*	var.	*insulare*		E		
Astelia	*waialealae*			pa'iniu	E	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	*micrantha*	subsp.	*ctenophylla*	ko'oko'olau	E		
Bidens	*micrantha*	subsp.	*kalealaha*	ko'oko'olau	E		
Bidens	*wiebkei*			ko'oko'olau	E		
Bonamia	*menziesii*				E		
Brighamia	*insignis*			'olulu	E	X	
Brighamia	*rockii*				E	X	
Caesalpinia	*kavaiensis*			uhiuhi	E		X
Calamagrostis	*expansa*			Maui reedgrass	E		
Calamagrostis	*hillebrandii*			Hillegrand's reedgrass	E		
Canavalia	*molokaiensis*			awikiwki	E		
Canavalia	*napaliensis*			awikiwki	E		
Canavalia	*pubescens*			awikiwki	E	X	
Cenchrus	*agrimonioides*	var.	*agrimonioides*		E		
Centaurium	*sebaeoides*			awiwi	E		
Chamaesyce	*celastroides*	var.	*kaenana*	'akoko	E		X
Chamaesyce	*deppeana*			'akoko	E		
Chamaesyce	*eleanoriae*			'akoko	E		
Chamaesyce	*halemanui*			'akoko	E		
Chamaesyce	*herbstii*			'akoko	E		
Chamaesyce	*kuwaleana*			'akoko	E		
Chamaesyce	*remyi*	var.	*kauaiensis*	'akoko	E		
Chamaesyce	*remyi*	var.	*remyi*	'akoko	E		
Chamaesyce	*rockii*				E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Chamaesyce	*skottsbergii*	var.	*skottsbergii*		E		
Charpentiera	*densiflora*				E		
Clermontia	*drepanomorpha*				E		
Clermontia	*lindseyana*				E		
Clermontia	*oblongifolia*	subsp.	*brevipes*	'oha wai	E	X	
Clermontia	*oblongifolia*	subsp.	*mauiensis*	'oha wai	E		
Clermontia	*peleana*	subsp.	*peleana*	'oha wai	E	X	
Clermontia	*pyrularia*			'oha wai	E	X	
Clermontia	*samuelii*	subsp.	*hanaensis*		E		
Clermontia	*samuelii*	subsp.	*samuelii*		E	X	
Colubrina	*oppositifolia*				E		
Ctenitis	*squamigera*				E		
Cyanea	*kauaulaensis*				E	X	
Cyanea	*acuminata*				E		
Cyanea	*asarifolia*			haha	E		
Cyanea	*asplenifolia*			haha	E		
Cyanea	*calycina*			haha	E		
Cyanea	*copelandii*	subsp.	*copelandii*	haha	E	X	
Cyanea	*copelandii*	subsp.	*haleakalaensis*	haha	E		
Cyanea	*crispa*			haha	E	X	
Cyanea	*dolichopoda*			haha	E	X	
Cyanea	*dunbarii*			haha	E	X	
Cyanea	*eleeleensis*			haha	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	*humboldtiana*				E		
Cyanea	*koolauensis*				E		
Cyanea	*kuhihewa*			haha	E	X	
Cyanea	*kuthiana*			haha	E		
Cyanea	*lanceolata*			haha	E		
Cyanea	*lobata*	subsp.	*lobata*	haha	E	X	
Cyanea	*longiflora*				E		
Cyanea	*macrostegia*	subsp.	*gibsonii*	haha	E		
Cyanea	*mannii*				E		
Cyanea	*marksii*			haha	E	X	
Cyanea	*mceldowneyi*				E		
Cyanea	*obtusa*			haha	E	X	
Cyanea	*pinnatifida*			haha	E	X	
Cyanea	*platyphylla*			'aku'aku	E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need
Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Cyanea	*procera*			haha	E	X	
Cyanea	*profuga*			haha	E	X	
Cyanea	*purpurellifolia*			haha	E	X	
Cyanea	*recta*				E		
Cyanea	*remyi*				E	X	
Cyanea	*shipmanii*			haha	E	X	
Cyanea	*solanacea*			popolo, haha nui	E	X	
Cyanea	*st.-johnii*			haha	E	X	
Cyanea	*stictophylla*			haha	E	X	
Cyanea	*superba*	subsp.	*superba*	haha	E	X	
Cyanea	*tritomantha*			aku	E		X
Cyanea	*truncata*			haha	E	X	
Cyanea	*undulata*			haha	E	X	
Cyclosorus	*boyidiae*			Boyd's maidenfern	E		
Cyperus	*neokunthianus*				E	X	
Cyperus	*pennatiformis*				E		
Cyperus	*trachysanthos*				E		
Cyrtandra	*hematos*			ha'iwale	E	X	
Cyrtandra	*crenata*			ha'iwale	E		
Cyrtandra	*cyaneoides*			Mapele	E		
Cyrtandra	*dentata*			ha'iwale	E		
Cyrtandra	*filipes*			ha'iwale	E	X	
Cyrtandra	*giffardii*			ha'iwale	E		
Cyrtandra	*gracilis*			ha'iwale	E	X	
Cyrtandra	*kaulantha*			ha'iwale	E	X	
Cyrtandra	*munroi*			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		
Cyrtandra	*subumbellata*			ha'iwale	E		
Cyrtandra	*tintinnabula*			ha'iwale	E		
Cyrtandra	*viridiflora*			ha'iwale	E	X	
Cyrtandra	*waiolani*			ha'iwale	E	X	
Delissea	*rhytidosperma*				E	X	
Delissea	*rivularis*			oha	E		
Delissea	*subcordata*			oha	E		
Delissea	*undulata*				E		X
Deparia	*kaalaana*				E	X	
Diellia	*erecta*				E		
Diellia	*falcata*				E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Diellia	*mannii*				E		
Diellia	*pallida*				E		
Diellia	*unisora*				E		
Diplazium	*molokaiense*				E	X	
Doryopteris	*angelica*				E		
Doryopteris	*takeuchii*				E		
Dryopteris	*glabra*	var.	*pusilla*		E		
Dryopteris	*crinalis*	var.	*podosorus*		E	X	
Dubautia	*herbstobatae*			na'ena'e	E		
Dubautia	*imbricata*		*imbricata*	na'ena'e	E		
Dubautia	*kalalauensis*			na'ena'e	E	X	
Dubautia	*kenwoodii*			na'ena'e	E	X	
Dubautia	*latifolia*				E		
Dubautia	*pauciflorula*			na'ena'e	E	X	
Dubautia	*plantaginea*	subsp.	*magnifolia*		E		X
Dubautia	*plantaginea*	subsp.	*humilis*		E	X	
Dubautia	*waialealae*			na'ena'e	E		
Eragrostis	*fosbergii*				E	X	
Eugenia	*koolauensis*			nioi	E		
Euphorbia	*haeleeleana*				E		
Exocarpos	*menziesii*			Menzies ballart	E		
Exocarpos	*luteolus*				E		
Festuca	*hawaiiensis*				E		
Flueggea	*neowawraea*			mehamehame	E	X	
Gardenia	*remyi*			nanu	E		
Gardenia	*brighamii*			nanu	E	X	
Gardenia	*mannii*				E		
Geranium	*arboreum*			hinahina	E	X	X
Geranium	*hanaense*			nohoanu	E		
Geranium	*hillebrandii*			nohoanu	E		
Geranium	*kauaiense*				E		
Geranium	*multiflorum*				E		
Gouania	*hillebrandii*				E		
Gouania	*meyenii*				E	X	
Gouania	*vitifolia*				E	X	
Haplostachys	*haplostachya*				E		
Hesperomannia	*arborescens*				E		
Hesperomannia	*arbuscula*				E		
Hesperomannia	*lydgatei*				E		
Hibiscadelphus	*distans*			hau kuahiwi	E	X	
Hibiscadelphus	*giffardianus*			hau kuahiwi	E	X	
Hibiscadelphus	*hualalaiensis*			hau kuahiwi	E	X	

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Hibiscadelphus	*woodii*			hau kuahiwi	E	X	
Hibiscus	*arnottianus*	subsp.	*immaculatus*	hauhele, hau	E		X
Hibiscus	*brackenridgei*	subsp.	*mokuleianus*	ma'o hau hele	E		
Hibiscus	*brackenridgei*	subsp.	*brackenridgei*	ma'o hau hele	E	X	
Hibiscus	*brackenridgei*	subsp.	*molokaiana*	ma'o hau hele	E		
Hibiscus	*clayi*			koki'o 'ula 'ula; aloalo	E		
Hibiscus	*waimeae*	subsp.	*hannerae*		E		
Huperzia	*stemmermanniae*			wawae'iole	E	X	
Huperzia	*mannii*				E		
Huperzia	*nutans*			wawae'iole	E	X	
Hypolepis	*hawaiiensis*	var.	*mauiensis*	olua	E		
Ischaemum	*byrone*				E		
Isodendrion	*hosakae*				E		
Isodendrion	*laurifolium*				E		
Isodendrion	*pyrifolium*			aupaka; wahine noho kula	E	X	
Joinvillea	*adscendes*		*ascendes*	ohe	E		X
Kadua	*fluviatilis*				E		
Kadua	*haupuensis*				E	X	
Kadua	*cookiana*			'awiwi	E		
Kadua	*coriacea*			kio'ele	E		
Kadua	*degeneri*				E		
Kadua	*mannii*			pilo	E		
Kadua	*parvula*				E		
Kadua	*schlechtendahliana*	var.	*remyi*	kopa	E		
Kadua	*st.-johnii*				E	X	
Kanaloa	*kahoolawensis*			kohe malama malama o kanalo	E	X	
Keysseria	*erici*				E		
Keysseria	*helenae*				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*			kamakahala	E	X	
Labordia	*helleri*			kamakahala	E		
Labordia	*lydgatei*			kamakahala	E	X	
Labordia	*pumila*			kamakahala	E		
Labordia	*tinifolia*	var.	*wahiawaensis*	kamakahala	E	X	
Labordia	*tinifolia*	var.	*lanaiensis*		E	X	
Labordia	*triflora*			kamakahala	E	X	
Labordia	*lorenciana*				E	X	
Lepidium	*orbiculare*				E	X	
Lepidium	*arbuscula*			anaunau	E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Lipochaeta	*lobata*	var.	*leptophylla*	nehe	E		
Lobelia	*gaudichaudii*	subsp.	*koolauensis*		E		
Lobelia	*monostachya*				E	X	
Lobelia	*niihauensis*				E		
Lobelia	*oahuensis*				E	X	
Lysimachia	*daphnoides*			lehua makanoe	E		
Lysimachia	*filifolia*				E		
Lysimachia	*iniki*				E	X	
Lysimachia	*lydgatei*				E	X	
Lysimachia	*maxima*				E	X	
Lysimachia	*pendens*				E	X	
Lysimachia	*scopulensis*				E	X	
Lysimachia	*venosa*				E	X	
Mariscus	*fauriei*				E		
Marsilea	*villosa*			'ihi'ihi	E		X
Melanthera	*fauriei*				E		
Melanthera	*kamolensis*				E	X	
Melanthera	*micrantha*	subsp.	*exigua*	nehe	E		
Melanthera	*micrantha*	subsp.	*micrantha*	nehe	E	X	
Melanthera	*tenuifolia*			nehe	E		
Melanthera	*venosa*			nehe	E		
Melanthera	*waimeaensis*			nehe	E	X	
Melicope	*adscendens*			alani	E	X	
Melicope	*balloui*			alani	E		
Melicope	*christophersenii*			alani	E		
Melicope	*degeneri*			alani	E	X	
Melicope	*haupuensis*			alani	E	X	
Melicope	*hiiakae*			alani	E	X	
Melicope	*knudsenii*			alani	E	X	
Melicope	*lydgatei*			alani	E	X	
Melicope	*makahae*			alani	E		
Melicope	*mucronulata*			alani	E	X	
Melicope	*munroi*			alani	E		
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	X	
Melicope	*saint-johnii*			alani	E		
Melicope	*zahlbruckneri*			alani	E	X	
Microlepia	*strigosa*	var.	*mauiensis*		E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Munroidendron	*racemosum*				E		
Myrsine	*fosbergii*				E		
Myrsine	*juddii*				E		
Myrsine	*knudsenii*			kolea	E	X	
Myrsine	*mezii*			kolea	E	X	
Myrsine	*vacciniodes*			kolea	E		
Neraudia	*angulata*	var.	*dentata*		E	X	
Neraudia	*angulata*	var.	*angulata*		E		
Neraudia	*ovata*				E	X	
Neraudia	*sericea*				E	X	
Nothocestrum	*latifolium*			'aiea	E		X
Nothocestrum	*breviflorum*			'aiea	E		X
Nothocestrum	*peltatum*			'aiea	E	X	
Nototrichium	*humile*				E		
Ochrosia	*haleakalae*				E		
Ochrosia	*kilaueaensis*				E		
Panicum	*fauriei*	var.	*carteri*		E		
Panicum	*niihauense*			lau'ehu	E	X	
Peperomia	*subpetiolata*			'ala 'ala wai nui	E	X	
Phyllostegia	*brevidens*				E	X	
Phyllostegia	*helleri*				E	X	
Phyllostegia	*stachyoides*				E	X	
Phyllostegia	*bracteata*				E	X	
Phyllostegia	*floribunda*				E	X	
Phyllostegia	*glabra*	var.	*lanaiensis*		E		
Phyllostegia	*haliakalae*				E	X	
Phyllostegia	*hirsuta*				E	X	
Phyllostegia	*hispida*				E	X	
Phyllostegia	*kaalaensis*				E	X	
Phyllostegia	*knudsenii*				E	X	
Phyllostegia	*mannii*				E	X	
Phyllostegia	*mollis*				E	X	
Phyllostegia	*parviflora*	var.	*parviflora*		E	X	
Phyllostegia	*parviflora*	var.	*lydgatei*		E	X	
Phyllostegia	*parviflora*	var.	*glabriuscula*		E	X	
Phyllostegia	*pilosa*				E	X	
Phyllostegia	*racemosa*			kiponapona	E	X	
Phyllostegia	*renovans*				E		
Phyllostegia	*velutina*				E		
Phyllostegia	*waimeae*				E	X	
Phyllostegia	*warshaueri*				E	X	
Phyllostegia	*wawrana*				E	X	

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Pittosporum	*halophyllum*			ho'awa	E	X	
Pittosporum	*hawaiiense*			hoawa	E	X	X
Pittosporum	*napaliensis*			hoawa	E		
Plantago	*hawaiensis*			kuahiwi laukahi	E	X	
Plantago	*princeps*	var.	*anomala*	kuahiwi laukahi	E	X	
Plantago	*princeps*	var.	*laxifolia*	kuahiwi laukahi	E	X	
Plantago	*princeps*	var.	*longibracteata*	kuahiwi laukahi	E		
Plantago	*princeps*	var.	*princeps*	kuahiwi laukahi	E		
Platanthera	*holochila*				E	X	
Platydesma	*cornuta*	var	*cornuta*		E	X	
Platydesma	*cornuta*	var	*decurrens*		E		
Platydesma	*remyi*				E	X	
Platydesma	*rostrata*			pilo kea lau li'i	E		
Pleomele	*fernaldii*			hala pepe	E		
Pleomele	*forbesii*			hala pepe	E		
Pleomele	*hawaiiensis*			hala pepe	E		
Poa	*mannii*				E		
Poa	*sandvicensis*				E		
Poa	*siphonoglossa*				E		
Portulaca	*villosa*			ihi	E		
Portulaca	*sclerocarpa*			po'e	E	X	
Pritchardia	*bakeri*				E	X	
Pritchardia	*affinis*			lo'ulu	E		
Pritchardia	*aylmer-robinsonii*			lo'ulu	E		
Pritchardia	*hardyi*			lo'ulu	E		
Pritchardia	*kaalae*			lo'ulu	E		
Pritchardia	*munroi*			lo'ulu	E	X	
Pritchardia	*napaliensis*			lo'ulu	E		
Pritchardia	*remota*			lo'ulu	E		
Pritchardia	*schattaueri*			lo'ulu	E	X	
Pritchardia	*viscosa*			lo'ulu	E	X	
Pseudognaphalium	*sandwicensium*	var.	*molokaiense*	ena'ena	E		
Psychotria	*grandiflora*			kopiko	E	X	
Psychotria	*hexandra*	var.	*oahuensis*	kopiko	E	X	
Psychotria	*hobdyi*				E		
Pteralyxia	*kauaiensis*			kaulu	E		
Pteralyxia	*macrocarpa*			kaulu	E		X
Pteris	*lidgatei*				E	X	
Ranunculus	*mauiensis*			makou	E		
Ranunculus	*hawaiensis*			makou	E	X	
Remya	*kauaiensis*				E		
Remya	*mauiensis*				E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Remya	*montgomeryi*				E	X	
Sanicula	*sandwicensis*				E		
Sanicula	*mariversa*				E		
Sanicula	*purpurea*				E		
Santalum	*involutum*				E		
Santalum	*freycinetianum*	var.	*lanaiense*	Lāna‘i sandalwood, 'iliahi	E		
Scaevola	*coriacea*			dwarf naupaka	E		
Schiedea	*diffusa*	subsp.	*diffusa*		E		
Schiedea	*pubescens*				E		
Schiedea	*adamantis*			ma'oli'oli	E	X	
Schiedea	*apokremnos*			ma'oli'oli	E		
Schiedea	*attenuata*			ma'oli'oli	E	X	
Schiedea	*haleakalensis*			ma'oli'oli	E	X	
Schiedea	*hawaiiensis*			ma'oli'oli	E	X	
Schiedea	*helleri*			ma'oli'oli	E		
Schiedea	*hookeri*			ma'oli'oli	E		
Schiedea	*kaalae*			ma'oli'oli	E	X	
Schiedea	*kauaiensis*			ma'oli'oli	E	X	
Schiedea	*kealiae*			ma'oli'oli	E		
Schiedea	*lychnoides*			kuawawaenohu	E		
Schiedea	*lydgatei*				E		
Schiedea	*membranacea*				E	X	
Schiedea	*nuttallii*				E	X	
Schiedea	*obovata*				E	X	
Schiedea	*salicaria*				E		
Schiedea	*sarmentosa*				E		
Schiedea	*spergulina*	var.	*leiopoda*		E		
Schiedea	*stellarioides*				E		
Schiedea	*trinervis*				E		
Schiedea	*verticillata*				E		
Schiedea	*viscosa*				E		
Sesbania	*tomentosa*			'ohai	E		X
Sicyos	*lanceoloideus*			'anunu	E	X	
Sicyos	*macrophyllus*			'anunu	E	X	
Sicyos	*alba*			'anunu	E		
Silene	*alexandri*				E	X	
Silene	*lanceolata*				E		
Silene	*perlmanii*				E	X	
Solanum	*incompletum*			popolo ku mai	E		
Solanum	*sandwicense*			popolo 'aiakeakua	E	X	
Solanum	*nelsonii*			popolo	E		X
Spermolepis	*hawaiiensis*				E		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Stenogyne	*kaalae*	subsp.	*sherffii*		E	X	
Stenogyne	*angustifolia*	subsp.	*augustifolia*		E		
Stenogyne	*bifida*				E	X	
Stenogyne	*campanulata*				E	X	
Stenogyne	*cranwelliae*				E	X	
Stenogyne	*kanehoana*				E	X	
Stenogyne	*kealiae*				E	X	
Tetramolopium	*arenarium*	subsp.	*arenarium*		E		
Tetramolopium	*capillare*			pamakani	E		
Tetramolopium	*filiforme*	var.	*filiforme*		E		
Tetramolopium	*filiforme*	var.	*polyphyllum*		E		
Tetramolopium	*lepidotum*	subsp.	*lepidotum*		E	X	
Tetramolopium	*remyi*				E	X	
Tetraplasandra	*bisattenuata*			'ohe mauka	E		
Tetraplasandra	*flynnii*			'ohe'ohe	E		
Tetraplasandra	*gymnocarpa*			'ohe'ohe	E		
Tetraplasandra	*lydgatei*				E		
Trematolobelia	*singularis*				E		
Urera	*kaalae*			opuhe	E	X	
Vicia	*menziesii*				E	X	
Vigna	*o-wahuensis*				E		
Viola	*chamissoniana*	subsp.	*chamissoniana*	pamakani	E		
Viola	*helenae*				E	X	
Viola	*kauaensis*	var.	*wahiawaensis*	nani wai'ale'ale	E	X	
Viola	*lanaiensis*				E		
Viola	*oahuensis*				E		
Wikstroemia	*skottsbergiana*			'akia	E	X	
Wikstroemia	*villosa*				E	X	
Wilkesia	*hobdyi*				E		
Xylosma	*crenatum*				E	X	
Zanthoxylum	*dipetalum*	var.	*tomentosum*	kawa'u	E	X	
Zanthoxylum	*hawaiiense*				E		
Zanthoxylum	*oahuense*				E	X	
Argyroxiphium	*sandwicense*	subsp.	*macrocephalum*	'ahinahina	T		X
Cyrtandra	*limahuliensis*			ha'iwale	T		
Isodendrion	*longifolium*				T		
Myrsine	*linearifolia*			kolea	T		
Peucedanum	*sandwicense*			makoe	T		
Schiedea	*spergulina*	var.	*spergulina*		T		
Silene	*hawaiiensis*				T		
Tetramolopium	*rockii*	var.	*calcisabulorum*		T		
Tetramolopium	*rockii*	var.	*rockii*		T		

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Acacia	*koa*			koa			X
Acacia	*koaia*			koaia; koa oha			X
Acrochaetium	*dotyi*						X
Alphitonia	*ponderosa*			kauila			X
Alsidium	*cymatophilum*						X
Alyxia	*oliviformis*			maile			X
Antidesma	*platyphyllum*			hame			X
Antithamnion	*erucacladellum*						X
Aquatic Plants							
Argyroxiphium	*virescens*					X	
Asplenium	*diemannii*					X	
Asplenium	*dielpallidum*					X	
Asplenium	*dielerectum*	form	*erecta*			X	
Astelia	*menziesiana*			pa'iniu			X
Athyrium	*microphyllum*			'akolea			X
Batrachospermum	*spermatiophorum*						X
Bidens	*hillebrandiana*	subsp.	*hillebrandiana*	ko'oko'olau			
Bidens	*spp.*			ko'oko'olau			X
Bjornbergiella	*hawaiiensis*						X
Bobea	*elatio*			ahakea			X
Bobea	*mannii*			ahakea			X
Boehmeria	*grandis*						X
Bolboschoenus	*maritimus*	subsp.	*paludosus*				X
Boodleopsis	*hawaiiensis*						X
Broussaisia	*arguta*			kanawao			X
Callidictyon	*abyssorum*						X
Callithamniella	*pacifica*						X
Canthium	*odoratum*			alahe'e			X
Capparis	*sandwichiana*			maiapilo			X
Carex	*alligata*						X
Carex	*spp.*			sedge			X
Carex	*wahuensis*	subsp.	*herbstii*			X	
Centroceras	*corallophilloides*						X
Ceramium	*cingulum*						X
Ceramium	*dumosertum*						X
Ceramium	*hanaense*						X
Ceramium	*tranquillum*						X
Ceramium	*womersleyi*						X
Chamaesyce	*olowaluana*			'akoko			X
Charpentiera	*obovata*			papala			X
Charpentiera	*spp.*			papala			X
Cheirodendron	*platyphyllum*			lapalapa			X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Cheirodendron	*trigynum*			'olapa			X
Chenopodium	*oahuense*			'aweoweo			X
Chrysymenia	*glebosa*						X
Cibotium	*chamissoi*			hapu'u			X
Cibotium	*glaucum*			hapu'u			X
Cibotium	*spp.*			hapu'u			X
Cladium	*jamaicense*			'uki			X
Cladophora	*longiarticulata*	var.	*valida*				X
Claoxylon	*sandwicense*			pooloa			X
Clermontia	*clermontioides*			ohawai			X
Clermontia	*fauriei*			haha'aiakamanu			X
Clermontia	*peleana*	subsp.	*singuliflora*			X	
Clermontia	*spp.*			oha, 'oha wai, haha, oha kepau			X
Codium	*cicatrix*						X
Codium	*extricatum*						X
Conferva	*sandvicensis*						X
Coprosma	*elliptica*			pilo			X
Coprosma	*ernodeoides*			kukainene			X
Coprosma	*kauensis*			pilo			X
Coprosma	*menziesii*			pilo			X
Coprosma	*montana*			pilo			X
Coprosma	*ochracea*			pilo			X
Coprosma	*pubens*			pilo			X
Coprosma	*rhynchocarpa*			pilo			X
Coprosma	*spp.*			pilo			X
Corallophila	*ptilocladioides*						X
Cosmarium	*depauperatum*						X
Crouania	*sp.*						X
Cryptocarya	*mannii*			holio			X
Cryptocarya	*oahuense*					X	
Cyanea	*fernaldii*					X	
Cyanea	*gibsonii*					X	
Cyanea	*horrida*			haha		X	
Cyanea	*kolekoleensis*					X	
Cyanea	*konahuanuiensis*					X	
Cyanea	*lobata*	subsp.	*baldwinii*			X	
Cyanea	*magnicalyx*			haha		X	
Cyanea	*maritae*					X	
Cyanea	*munroi*			haha		X	
Cyanea	*pycnocarpa*					X	
Cyanea	*rivularis*					X	
Cyanea	*sessilifolia*						

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Cyanea	*spp.*						X
Cyclosorus	*interruptus*			neke fern			X
Cyperus	*laevigatus*			makaloa			X
Cyperus	*odoratus*						
Cyrtandra	*halawensis*			ha'iwale			
Cyrtandra	*kealiae*	subsp.	*kealiae*	ha'iwale			
Cyrtandra	*spp.*			ha'iwale			X
Cyrtandra	*wagneri*					X	
Dasya	*iridescens*						X
Dasya	*kriseniae*						X
Dasya	*muurayana*						X
Delissea	*argutidentata*					X	
Delissea	*kauaiensis*					X	
Delissea	*niihauensis*	subsp.	*kauaiensis*				
Delissea	*niihauensis*	subsp.	*niihauensis*				
Delissea	*waianaeensis*					X	
Deschampsia	*nubigena*						X
Dianella	*odorata*			uki			X
Dicranopteris	*linearis*			'uluhe			X
Diospyros	*sandwicensis*			lama			X
Diplazium	*sanwichiananum*			ho'i'o			X
Diprora	*haenaensis*						X
Ditria	*reptans*						X
Dodonaea	*viscosa*			'a'ali'i			X
Dotyella	*irregularis*						X
Dotyella	*hawaiiensis*						X
Dotyophycus	*pacificum*						X
Dracaena	*aurea*			halapepe			X
Dryopteris	*angelica*						
Dryopteris	*spp.*						X
Dryopteris	*tetrapinnata*						
Dubautia	*arborea*			na'ena'e			X
Dubautia	*paleata*			na'ena'e pua kea			X
Dubautia	*raillardioides*			na'ena'e 'ula			X
Dubautia	*spp.*			na'ena'e			X
Dudresnaya	*littleri*						X
Elaeocarpus	*bifidus*			kalia			X
Elaphoglossum	*spp.*			ekaha; laukahi nunui			X
Endemic Freshwater Algae							
Endemic Marine Algae							
Endemic Terrestrial Algae							
Eragrostis	*monticola*						X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Eragrostis	*variabilis*			kawelu			X
Erythrina	*sandwicensis*			wiliwili			X
Eunotia	*abbottiae*						X
Eunotia	*smithiae*						X
Euphorbia	*eleanoriae*					X	
Euphorbia	*herbstii*					X	
Euphorbia	*spp.*			koko or akoko			X
Euphorbia	*remyi*	var.	*hanaleiensis*			X	
Euptilocladia	*magruderi*						X
Fernandosiphonia	*ecorticata*						X
Freycinetia	*arborea*			ieie			X
Frustulia	*creuzburgensis*						X
Gahnia	*lanaiensis*						
Gelidiella	*womersleyana*						X
Gelidium	*pluma*						X
Gelidium	*reediae*						X
Geranium	*tridens*			hinahina			X
Gossypium	*tomentosa*			ma'o			X
Gracilaria	*abbottiana*						X
Gracilaria	*coronopifolia*						X
Gracilaria	*dawsonii*						X
Gracilaria	*dotyi*						X
Gracilaria	*epihippisora*						X
Grateloupia	*hawaiiana*						X
Haematococcus	*thermalis*						X
Halophila	*hawaiiana*			seagrass			X
Halymenia	*stipitata*						X
Halymenia	*chiangiana*						X
Halymenia	*cromwellii*						X
Hawaiia	*trichia*						X
Heliotropium	*anomalum*			hina hina			X
Heliotropium	*curassavicum*			kipukai			X
Helminthocladia	*rhizoidea*						X
Helminthocladia	*simplex*						X
Herposiphonia	*dubia*						X
Hesperomannia	*oahuensis*					X	
Heteropogon	*contortus*			pili grass			X
Hibiscadelphus	*stellatus*					X	
Hibiscus	*kokio*						X
Hibiscus	*tiliaceus*			hau			X
Hypoglossum	*wynnei*						X
Ilex	*anomala*			kawa'u			X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Ipomoea	*spp.*						X
Isachne	*distichophylla*			ohe			X
Jacquemontia	*ovalifolia*	subsp.	*sandwicensis*				X
Janczewskia	*hawaiiana*						X
Kadua	*cordata*	subsp.	*remyi*			X	
Kadua	*degeneri*	var	*coprosmifolia*			X	
Kadua	*laxifolia*					X	
Kadua	*terminalis*			manono			X
Labordia	*sp. nov.*						
Labordia	*waialaeale*			kamakahala lau li'I			X
Laurencia	*crustiformans*						X
Laurencia	*mcdermidae*						X
Lepturus	*repens*						X
Liagora	*perennis*						X
Lipochaeta	*spp.*						X
Lobelia	*dunbariae*	subsp.	*dunbariae*			X	
Lobelia	*spp.*						X
Lophocladia	*kipukaia*						X
Lophopodium	*sandvicense*						X
Lyngbya	*cladophorae*						X
Lysimachia	*ovoidea*					X	
Lysimachia	*spp.*						X
Machaerina	*angustifolia*			'uki			X
Melanthera	*populifolia*					X	
Melicope	*anisata*			mokihana			X
Melicope	*clusiifolia*			kukaemoa			X
Melicope	*cruciata*			pilo 'ula			
Melicope	cf. *knudsenii (* cauliferous leaves*)*					X	
Melicope	*macropus*						
Melicope	*sp. nov.*					X	
Melicope	*wailauensis*					X	
Metrosideros	*polymorpha*			'ohi'a			X
Micrasterias	*adscendens*						X
Micropeuce	*setosus*						X
Myoporum	*sandwicense*			naio			X
Myrsine	*lessertiana*			kolea			X
Myrsine	*sandwichensis*			kolea lauli'I			X
Myrsine	*sp.*			kolea			X
Naccaria	*hawaiiana*						X
Nama	*sandwicensis*						X
Navicula	*contenta*						X
Navicula	*hawaiiensis*						X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Navicula	*thurstonensis*						X
Navicula	*genustriata*						X
Navicula	*oahuensis*						X
Navicula	*testata*						X
Neowawraea	*phyllanthoides*			mehamehame			X
Nestegis	*sandwicensis*			olopua			X
Nothocestrum	*longifolium*			'aiea			X
Nothocestrum	*spp.*						X
Oreobolus	*furcatus*						X
Osmanthus (Olea)	*sandwicensis*						X
Osteomeles	*anthyllidifolia*			uulei			X
Padina	*melemele*						X
Padina	*thivyae*						X
Pandanus	*odoratissiumu*			hala; lauhala			X
Pandanus	*tectorius*			hala			X
Panicum	*spp.*						X
Pelea	*spp.*			alani			X
Peleophycus	*multiprocarpium*						X
Peperomia	*degeneri*					X	
Perrottetia	*sandwicensis*			olomea			X
Phaeocolax	*kajimurai*						X
Pipturus	*spp.*			mamaki			X
Pisonia	*sandwicensis*			aulu			X
Pisonia	*spp.*			papala kepau			X
Pisonia	*umbellifera*			papala kepau			X
Pithophora	*affinis*						X
Pithophora	*macrospora*						X
Pittosporum	*hosmeri*			hoawa			X
Pittosporum	*spp.*			hoawa			X
Pittosporum	*terminalioides*			hoawa			X
Platoma	*ardreanum*						X
Platydesma	*campanulata*			pilo kea			X
Pleonosporium	*intricatum*						X
Plocamium	*sp.*						X
Polyopes	*hakalauensis*						X
Polyscias	*flynnii*					X	
Polyscias	*lydgatei*					X	
Polysiphonia	*tuberosa*						X
Polysiphonia	*profunda*						X
Polysiphonia	*rubrorhiza*						X
Portulaca	*sp. A*						

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Prionitis	*corymbifera*						X
Pritchardia	*beccarriana*			lo'ulu			X
Pritchardia	*glabrata*			lo'ulu		X	
Pritchardia	*gordonii*					X	
Pritchardia	*kahukuensis*					X	
Pritchardia	*maideniana*					X	
Pritchardia	*sp. 1*			lo'ulu			
Pseudochlorodesmis	*hawaiiensis*						X
Pseudomorus	*sandwicensis*			aiai			X
Psychotria	*sp.*			kopiko			X
Psydrax	*odorata*			alahe'e			X
Pterocladiella	*bulbosa*						X
Pyschotria	*hawaiiensis*			kopiko			X
Racomitrium	*lanuginosum*						X
Raowolfia	*sandwicensis*			hao			X
Reticulocaulis	*mucosissimus*						X
Reynoldsia	*sandwicensis*			ohe, ohe makai			X
Rhynchospora	*chinensis*	subsp.	*spiciformis*	kuolohia			X
Rubus	*hawaiensis*			'akala			X
Ruppia	*maritima*			widgeon grass			X
Sadleria	*cyatheoides*			amaumau			X
Santalum	*ellipticum*			'iliahialo'e			X
Santalum	*freycinetianum*			'iliahi			X
Santalum	*paniculatum*	var.	*paniculatum*				X
Santalum	*paniculatum*	var.	*pilgeri*				X
Sapindus	*oahuensis*			kaulu			X
Sapindus	*saponaria*			a'e			X
Sargassum	*echinocarpum*						X
Sargassum	*obtusifolium*						X
Sargassum	*polyphyllum*						X
Scaevola	*glabra*			'ohe naupaka			X
Scaevola	*hobdyi*					X	
Scaevola	*procera*			naupaka kuahiwi			X
Scaevola	*sericea*			naupaka kahakai			X
Scaevola	*sp.*			naupaka			X
Schiedea	*diffusa*	subsp.	*macraei*			X	
Schiedea	*jacobii*			ma'oli'oli		X	
Schiedea	*lauii*			ma'oli'oli		X	
Schiedea	*perlmanii*					X	
Schoenoplectus	*lacustris*	subsp.	*validus*	'aka'akai			X
Scinaia	*furcata*						X
Scinaia	*hormoides*						X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Scytonema	*javanicum*	var.	*hawaiiense*				X
Scytonema	*pulvinatum*						X
Sesuvium	*portulacastrum*			'akulikuli			X
Sicyos	*albus*					X	
Sida	*fallax*			'ilima			X
Sideroxylon	*sandwicense*			aulu, kaulu			X
Smilax	*melastomifolia*			pi'oi			X
Solanum	*americanum*			popolo			X
Sophora	*chrysophylla*			mamane			X
Spirocladia	*hodgsoniae*						X
Sporobolus	*virginicus*			'aki'aki			X
Sporochnus	*dotyi*						X
Staurastrum	*monticulosum*	var.	*duplex*				X
Staurastrum	*subtile*						X
Stauroneus	*maunakeäensis*						X
Stenogyne	*kauaulaensis*					X	
Stenogyne	*macrantha*			ma'ohiohi			X
Stenogyne	*purpurea*						X
Stenogyne	*rugosa*			ma'ohiohi			X
Stenogyne	*scrophularioides*			ma'ohiohi			X
Stigonema	*aerugineum*						X
Styphelia	*tameiameiae*			pukiawe			X
Syzygium	*sandwicensis*			'ohi'a ha			X
Tetramolopium	*diersingii*					X	
Tetraplasandra	*hawaiensis*			'ohe'ohe			X
Tetraplasandra	*sp.*			ohe			X
Tolypothrix	*musicola*	var.	*havaiensis*				X
Touchardia	*latifolia*			olona			X
Trentepohlia	*cucculata*	var.	*sandvicensis*				X
Trentepohlia	*diffracta*	var.	*sandvicensis*				X
Trichogloeopsis	*hawaiiana*						X
Ululania	*stellata*						X
Urera	*sandvicensis*			opuhe			X
Vaccinium	*calycinum*			'ohelo; 'ohelo kau la'au			X
Vaccinium	*reticulatum*			'ohelo			X
Vaccinium	*spp.*						X
Valonia	*trabeculata*						X
Viola	*kauaensis*	var.	*hosakae*			X	
Wikstroemia	*monticola*			'akia			X
Wikstroemia	*oahuensis*			'akia			X
Wikstroemia	*oahuensis*			'akia			X
Wikstroemia	*phillyreifolia*			'akia			X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

Appendix B: Plant (Flora) Species of Greatest Conservation Need

Ferns, Fern Allies, and Flower Plants

Genus	Species	Var./Subsp.	Subspecies	Common/Hawaiian Name	Federal Status*	PEP**	Important Interaction***
Wikstroemia	*sanwicensis*			'akia			X
Wilkesia	*gymnoxiphium*			iliau			X
Wilkesia	*spp.*			iliau			X
Womersleyella	*pacifica*						X
Wrangelia	*elegantissima*						X
Xanthidium	*octocorne*	var.	*majus f. havaiensis*				X
Xylosma	*hawaiiense*			maua			X
Zanthoxylum	*spp.*			a'e or hea'e			X

**E = Endangered, T = Threatened, C = Candidate*
***X=fewer than 50 individuals in the wild*
****X=important habitat or dominant plant in community*

APPENDIX C: OVERVIEW OF MANAGEMENT PROGRAMS AND EXISTING REGULATIONS

A variety of land and water management programs and existing regulations protect Hawaiʻi'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 Hawaiʻi: Haleakalā National Park (Maui); Kalaupapa National Historical Park (Molokaʻi); Hawaiʻi Volcanoes National Park (Hawaiʻi); Kaloko-Honokōhau National Historical Park (Hawaiʻi); Puʻuhonua O Hōnaunau National Historical Park (Hawaiʻi); Ala Kahakai National Historic Trail (Hawaiʻi); Puʻukoholā Heiau National Historic Site (Hawaiʻi), the U.S.S. Arizona Memorial (Oʻahu); and the most recent addition, Honouliuli National Monument (Oʻahu).

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. Hawaiʻi's Refuges were established to protect the Islands' unique native plants and animals and their habitats. There are eleven wildlife refuges in Hawaiʻi: Hawaiian Islands NWR (Northwestern Hawaiian Islands, including marine waters), Hanalei NWR (Kauaʻi), Hulēʻia NWR (Kauaʻi), Kīlauea Point NWR (Kauaʻi), Oʻahu Forest NWR (Oʻahu), James Campbell NWR (Oʻahu), Pearl Harbor NWR (Oʻahu), Keālia Pond NWR (Maui), Kakahaiʻa NWR (Molokaʻi), Hakalau Forest NWR (Hawaiʻi), 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 Hawaiʻi, including:

- Oahu INRMP (covers U.S. Army installations at Dillingham Military Reservation, Kahuku Training Area, Kawailoa Training Area, Mākua Military

Reservation, 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 362,073 square kilometers (139,797 square miles) of the Pacific Ocean)—an area larger than all the country’s national parks combined. The Papahānaumokuākea Marine National Monument was established by Presidential Proclamation in 2006, under the authority of the Antiquities Act (16 USC 431-433). It was expressly created to protect an exceptional array of natural and cultural resources. No commercial or recreational fishing is allowed, and recreational use is limited to the Midway Atoll Special Management Area (SMA) and only for non-extractive activities that do not involve a fee-for-service transaction. Native Hawaiian practices may be authorized within the monument through a 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. 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 Hawaiʻi Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR), to protect humpback whales in federal and state waters. The sanctuary's goal is to promote comprehensive and coordinated management, research, education, and long-term monitoring for the endangered humpback whale and its habitat. 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. Funding and personnel for research, education, and enforcement also increase these actions in the state.

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 Hawaiʻi (Hawaiʻi 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 Hawaiʻi covering more than 50,000 hectares (123,000 acres): Hono o Na Pali (Kauaʻi), Kuʻia (Kauaʻi), Kaʻena Point (Oʻahu), Kaluanui (Oʻahu), Pahole (Oʻahu), Mt. Kaʻala (Oʻahu), West Maui (Maui), Hanawī (Maui), ʻĀhihi-Kīnaʻu (Maui) (contains both terrestrial and marine acreage), Kanaio (Maui), Nakula (Maui), Olokuʻi (Molokaʻi), Puʻu Aliʻi (Molokaʻi), Manukā (Hawaiʻi), Kīpāhoehoe (Hawaiʻi), Mauna Kea Ice Age (Hawaiʻi), Waiākea 1942 Flow (Hawaiʻi), Kahaualeʻa (Hawaiʻi), Puʻu Makaʻala (Hawaiʻi), Laupāhoehoe (Hawaiʻi), and Puʻu o ʻUmi (Hawaiʻi).

State Forest Reserves

The State Forest Reserves were first established in Hawaiʻi 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 Hawaiʻi 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 Marine Waters

DAR manages marine and freshwater areas throughout the state under general management authority from Hawaiʻi Revised Statutes Chapters 188 and 190. These areas include 11 Marine Life Conservation Districts (MLCDs), 19 Fishery Management Areas (FMAs), three Public Fishing Areas (PFA), two Wildlife Sanctuaries, and the South Kona ʻōpelu Fishing Area.

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. 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. Only the Waikiki Shoreline FMA is completely No Take. Many FMAs are in harbors, bays, or canals. PFAs are managed areas with regulations to protect introduced freshwater gamefish and other fishes. Access, take, size, gear, and season limits are used. The Sanctuaries are limited access and take areas set up for conducting scientific research (Coconut Island) and conservation (Paikō Lagoon).

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. Their goal is to protect stocks of bottomfish in the Main Hawaiian Islands. No fishing for state-defined bottomfish species is allowed in these areas. There are 12 BRFAs.

Fish Replenishment Areas

Fish Replenishment Areas (FRAs) are managed by DAR and were established in 2000 in order to protect the stocks of marine aquarium fishes on the island of Hawaiʻi and to manage conflicts 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 West Hawaiʻi.

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 Hawaiʻi'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 Hawaiʻi (including submerged lands) for the benefit of present and future generations, pursuant to Article XI, Section 1, of the Hawaiʻi 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 Hawaiʻi, four on Oʻahu, one on Kauaʻi, and one on Molokaʻi. 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 Oʻahu, two on Hawaiʻi, and one on Molokaʻi) and six reservoirs (four on Hawaiʻi, one on Molokaʻi, and one on Oʻahu).

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.

Cooperative Efforts

Invasive species committees

Over the past decade, partnerships and groups have organized to address gaps in Hawaiʻi's biosecurity system. These include the Hawaiʻi 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 Hawaiʻi, 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 Hawaiʻi 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. Hawaiʻi 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 (Kauaʻi, Oʻahu, Maui, Molokaʻi, and Hawaiʻi). 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 Hawaiʻi'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 Hawaiʻi, the

Hawaiian Humane Society, the Honolulu Zoo, Ducks Unlimited, and The Nature Conservancy (TNC) of Hawaiʻi. The West Nile Virus Prevention Group has developed a plan to respond to, track, and limit the spread of West Nile virus in Hawaiʻi. A multi-agency Brown Tree Snake Rapid Response Team has been formed to address potential brown tree snake sightings in Hawaiʻi. 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 Hawaiʻi 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 Oʻahu Offshore Islet Seabird Management project, a cooperative project between DOFAW and the Center for Conservation Research and Training, University of Hawaiʻi, has begun eliminating alien predators and removing non-native plants on priority islets.

Hawaiʻi and Pacific Plants Recovery Coordinating Committee
The Hawaiʻi 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, Hawaiʻi Biodiversity and Mapping program, University of Hawaiʻi, and the Hawaiʻi 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.

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

Hawaiʻi, the Hawaiʻi 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 Hawaiʻi Natural Resources Management, Bishop Museum, HISC, the Hawaiʻi Alliance of Watershed Partnerships, the Hawaiʻi 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 1-6.

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 Hawaiʻi: Puʻu Kukui (Maui), Kapunakea (Maui), Waikamoi (Maui), Waikamoi (East Maui Irrigation) (Maui), Moʻomomi (Molokaʻi), Kamakou (Molokaʻi), Pelekunu (Molokaʻi), Kanepuʻu (Lānaʻi), and Kaʻū (Hawaiʻi).

The Nature Conservancy Preserves

TNC Hawaiʻi 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: ʻIhiʻihilauakea Preserve (Oʻahu), Wainiha Preserve (Kauaʻi), and Kona Hema Preserve (Hawaiʻi). 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 Kauaʻi: 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 Hawaiʻi. 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

Hawaiʻi 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, Hawaiʻi 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 Hawaiʻi, 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 Hawaiʻi was approved in 1977 (HRS Chapter 205A), and is administered through the Department of Business, Economic Development and Tourism Coastal Zone Management Program (CZM Hawaiʻi). Within a framework of cooperation among federal, state, and local levels, CZM Hawaiʻi 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 Hawaiʻi is leading the preparation of a framework for updating the Ocean Resources Management Plan. CZM Hawaiʻi 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 RECEIVED

This appendix summarizes the public comments received during development of the 2015 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.

	Comment	How Addressed in Plan
Oʻahu Public Information Meeting		
1	Concerned about invasive species impact— Jackson's chameleon, mongoose, tilapia, and roi (peacock grouper).	Invasive species are identified as a major threat statewide in Chapters 4 and 5 and in the Oʻahu section of Chapter 6. Mongoose, Jackson's chameleon, and tilapia are identified as invasive species on Oʻahu. Conservation strategies for Oʻahu include actions to prevent and control terrestrial and marine invasive species.
2	Opposed to aerial control of ungulates.	Uncontrolled ungulates are identified as a major threat to native species statewide in Chapter 4 and a major threat to native species on each island in Chapter 6. Additional information was added to Chapters 3, 4, and 6 and Appendix C on DLNR's program to provide and manage the statewide hunting program. Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide more hunting in appropriate areas and developing policies to balance needs for conservation of native species with multiple uses of state lands.
3	Suggestion that DLNR hire people in local communities to implement projects to conserve native wildlife and habitat, including control of invasive species, control of ungulates, and control of aquatic pests.	Statewide conservation strategies include establishing new partnerships with nontraditional partners and community groups to implement conservation actions and expanding partnerships with the hunting community to control and reduce ungulates.
4	Suggestion that DLNR use inmate work crews to implement conservation management actions to clear land and control invasive species.	Expanding the partnership with the Department of Public Safety, Corrections Division, to increase the use of male and female inmate work crews for conservation management projects where feasible was added to the Oʻahu and Hawaiʻi sections of Chapter 6.
5	Concern about the introduction and impact of invasive species brought in by the pet trade, such as parrots and armored catfish.	Invasive species are identified as a major statewide threat in Chapters 4 and 5 and in the Oʻahu section of Chapter 6. Conservation strategies include funding for early

	Comment	How Addressed in Plan
		detection and control of new introductions and control of terrestrial and marine invasive species.
6	Concern that game animals are used by native Hawaiians for subsistence and native cultural practices and need to be preserved.	Additional information discussing the hunting program was added to Chapters 3, 4, and 6 and Appendix C. A discussion of the value of game to many communities and DLNR's program to provide and manage the statewide hunting program was added to Chapter 3. Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide more hunting in appropriate areas and developing policies to balance needs for conservation of native species with multiple uses of state lands.
7	Interest in funding for the plan, how it is used, and whether the plan is binding on DLNR and other agencies.	Chapter 1 provides information about the purpose and value of the plan and the funding available. Chapter 3 provides information about funding conservation programs, and Chapter 4 provides information about statewide conservation needs and strategies.
8	Interest in how Species of Greatest Conservation Need were identified.	Chapter 2 provides information on the approach and methods used in revising the plan; how species were chosen; and the sources used, including suggestions made by technical experts and the public during the public review process.
9	Suggestion to include an education plan in the SWAP.	Conservation strategies involve expanding and strengthening outreach and education efforts and 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 nongovernmental organizations).
10	Interest in finding out who the DLNR partners are and how to get involved in SWAP conservation actions.	Conservation strategies include establishing new partnerships with nontraditional partners and community groups to implement conservation actions and encouraging public participation and stewardship by expanding volunteer opportunities to contribute to native wildlife conservation. Many DLNR programs and partners are identified in Chapter 6 in the discussion of island conservation needs and in Appendix C in the overview of management programs.
Kaua'i Public Information Meeting		
1	Red mangrove was mentioned as a statewide invasive species threat in	Mangrove was added to the list of habitat-modifying invasive plants as a specific threat on Kaua'i. Text was

	Comment	How Addressed in Plan
	Chapter 4. It should also be mentioned in the Kauaʻi chapter. Although it is beneficial in some places, it is invasive in Hawaiʻi.	added to Chapter 4, stating that although mangrove species are beneficial elsewhere, they is a threat in Hawaiʻi.
2	The draft SWAP is more than 800 pages long, and a 30-day public review period is not enough time for the public to review and comment. The update should have been announced earlier with scoping meetings to gather public input on revisions.	The approach taken to obtain public input on the 2015 SWAP was to maintain a public website on the plan (DOFAW Comprehensive Wildlife Conservation Strategy website maintained since 2005) that requested the submittal of comments and suggestions on the document and its revisions. Starting a year before the due date, staff members began outreach to agencies and conservation partners to solicit input on the update and revisions. Staff members provided a revised draft for a 30-day public review in August. Plans for the next update have been revised. As detailed in Chapter 8, the public review period will begin 18 months before the submittal deadline, and a round of public scoping meetings on each island will be held rather than public information meetings on the completed draft. Also, the draft 2025 plan will be made available for a 60-day public review period to provide additional time for public review and comment.
3	Water diversions are a major threat affecting wildlife species and habitats on Kauaʻi.	Water diversions are identified as a major threat statewide in Chapter 4 and in the Kauaʻi section of Chapter 6. Stream diversions, dams, and channelizations, as well as instream flows insufficient to ensure the biological integrity of many stream systems, were identified as threats more acute or specific to Kauaʻi. The Kauaʻi section identifies conservation strategies to decrease the number of stream diversions and channelized streams and to work with the Commission on Water Resource Management to ensure a net increase in number of streams with biological integrity and instream flow standards sufficient to sustain viable native fish and invertebrate populations.
4	Not enough enforcement to prevent illegal stream diversions and effects on wildlife species and habitats.	The statewide conservation strategy identifies action to increase conservation enforcement efforts on all state-owned land and waters through increased funding for trained enforcement officers as a priority. The Kauaʻi section of Chapter 6 assesses ways to support increased enforcement capacities, including cross-deputation between agencies and expansion of community watch programs, such as the Makai Watch program initiated by DNLR as a Kauaʻi specific island strategy.

	Comment	How Addressed in Plan
5	Concern about the control of ungulates in the plan. Game animals have cultural value, and eradicating them could affect local communities.	Additional information discussing the hunting program was added to Chapters 3, 4, and 6 and Appendix C. A discussion of the value of game to many communities and DLNR's program to provide and manage the statewide hunting program was added to Chapter 3. Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide more hunting in appropriate areas and develop policies to balance needs for conservation of native species with multiple uses of state lands.
6	Suggest partnering with community colleges to write and submit grants and obtain new sources of funding.	Conservation strategies include establishing new partnerships with nontraditional partners and community groups to implement conservation actions and encouraging public participation and stewardship by expanding volunteer opportunities to contribute to native wildlife conservation.
7	The SWAP should identify feral cats as the top invasive species threat.	Feral cats are identified as a major threat statewide and on Kauaʻi. Conservation strategies include removing feral cats from important habitats.
8	The SWAP failed to address rainbow trout and bass as invasive species and as threats to native species.	The Kauaʻi section of Chapter 6 was revised to identify rainbow trout and smallmouth bass as threats to native wildlife. The plan also identifies strategies to decrease the number of invasive species or the total area of invasive species coverage in aquatic and marine ecosystems.
9	The SWAP and funding should be used for wetland restoration on Kauaʻi.	The SWAP includes the protection, restoration, and management of additional wetland habitat as needed for conservation actions and identifies 14 wetland sites on Kauaʻi as important habitat.
10	The SWAP needs to identify the difficulty for everyone to get permits to do restoration work.	Chapter 4 identifies regulatory hurdles and unclear or lengthy regulatory processes as constraints to management and identifies a strategy to update conservation district rules to encourage conservation management activities and to streamline EPA's labeling process for new control methods for invasive species.
11	The SWAP should include a section discussing the uniqueness of Hawaiʻi.	Chapter 3 provides an overview of the State of Hawaiʻi and discusses its unique wildlife and habitats. Chapters 4, 5, and 6 identify Hawaiʻi's unique conservation threats and needs, problems, and issues.
12	The SWAP needs to address the conflict between taro farmers and increasing	The SWAP includes the development of a Kauaʻi islandwide HCP for nēnē to resolve conflicts with agricultural producers and property owners and research in taro loi to identify management actions that support

	Comment	How Addressed in Plan
	numbers of endangered nēnē and waterbirds that are destroying crops.	both taro growth and high-quality wildlife habitat was identified as a needed conservation action.
13	Suggestion that the SWAP include translocation of problem nēnē and waterbirds off Kauaʻi to other islands.	The SWAP identifies conservation strategies to relocate native wildlife species away from situations that pose a significant threat to public safety and to wildlife species, specifically on Kauaʻi, including relocating nēnē away from the Lihuʻe Airport to safe locations on other islands.
14	Concern about increasing development, such as windfarms, having impacts on native wildlife.	The SWAP identifies urban development and the development of energy facilities, such as wind turbines and power lines, as major threats and hazards to native wildlife and identifies conservation strategies to collaborate with state agencies to ensure the protection of conservation district lands, and to review state policies and rules for gaps in protection.
Hawaiʻi Island - Hilo Public Information Meeting		
1	The ʻiliahi sandalwood tree is a significant species in the ecosystem and an important food plant for the endangered palila and needs to be listed as a SGCN. Sheep and goats have eaten all the ʻiliahi on Mauna Kea. The plan should include conservation actions to restore sandalwood. Turkeys, goats, sheep, and pigs should be removed from the mountain.	*Santalum paniculatum* var. *paniculatum and Santalum paniculatum* var. *pilgeri*, the sandalwood species found on the Big Island, were added as SGCN in Appendix B because of their importance as an element of native habitat. The SWAP calls for habitat restoration, fencing and ungulate control, and outplanting of native and endangered plants on Mauna Kea.
2	The SWAP is 865 pages long, and a 30-day review period is too short. Why did you not come to see the community earlier in March or April to incorporate concerns?	The revision process was started in September 2014 when staff members first contacted agencies and conservation partners to solicit input on the update. In August 2015, a revised draft was completed and made available for a 1-month public review period, and community meetings were held on each island. The process proposed for the next update, described in Chapter 8, would begin earlier, 18 months before the submittal deadline, and would include a round of public scoping meetings on each island early in the process. In addition, the amount of time provided for the public to review the draft document was increased to 60 days.
3	The definition of conservation in the SWAP is geared toward preservation of resources, rather than wise use of	Chapter 1 outlines the purpose of the SWAP, the legislative mandate for the State Wildlife Grants (SWG) program, and the congressional guidance regarding what content is included in the SWAP. The SWAP includes all

	Comment	How Addressed in Plan
	resources. What is the authorizing legislation?	the required elements. It identifies the Species of Greatest Conservation Need and the habitat essential to conserve these species and identifies the problems affecting these species and the conservation actions proposed to conserve the species. Those requirements dictate the conservation strategies in the plan. The Department of the Interior and Related Agencies Appropriations Act, 2002 (Public Law 107-63), is the authorizing legislation for the SWG program. That information was added to Chapter 1.
4	Concern about the control of ungulates in the plan and that game animals have cultural value and should not be eradicated.	Additional information addressing the hunting program was added to Chapters 3, 4, and 6 and Appendix C. A discussion of the value of game to many communities and DLNR's program to provide and manage the statewide hunting program was added to Chapter 3. Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide more hunting in appropriate areas; and developing policies to balance needs for conservation of native species with multiple uses of state lands.
5	Oppose the translocation of monk seal to the Main Hawaiian Islands because they will contract disease and spread it to the Northwest Hawaiian Islands. Oppose the translocation of monk seal to the Main Hawaiian Islands because they will compete with fishermen for fish.	The monk seal is identified as a Species of Greatest Conservation Need (SGCN) and is listed as endangered under both state and federal law. Furthering their conservation, along with the conservation of other SGCN, is the purpose of this plan. Challenges to their conservation are listed in Chapters 4, 5, and 6 and in the species fact sheet in Chapter 7. They include fisheries bycatch and increased interactions with humans related to the seals' increasing abundance in the main islands. SWAP conservation strategies call for continued cooperation and partnership with NOAA and USFWS to develop and implement conservation programs for federally protected species, support recovery of endangered species, and enhance conservation for marine wildlife. The SWAP also includes strategies to work with stakeholders to develop Habitat conservation plans to address wildlife-human conflicts.
6	Expressed concern about the small amount of funding available for the program and why the Northwest Hawaiian Islands, which are under federal	Chapter 1 provides information on the purpose and value of the program and identifies the amount of funding available, which equals $450,000–500,000 per year. Chapter 1 also states that the program is required to include all types of lands in the state, including federal,

	Comment	How Addressed in Plan
	management, are included in the program when funding is so limited for state lands.	state, county, and private land. The types of projects that the funds will be used for are identified in Chapter 8.
7	The process should involve better community planning and should start years ahead of time to allow more involvement by the public.	The process proposed for the next update is described in Chapter 8. It has been changed to begin earlier—18 months before the submittal deadline–and to include a round of public scoping meetings on each island early in the process.
8	Because it is such a large document, what chapters or sections of the plan would it be best for the public to review, and is there a specific one to focus on similar to the canary in the coal mine?	The SWAP presents a statewide overview in Chapters 4 and 5, an island overview in Chapter 6, and details of individual Species of Greatest Conservation Need in Chapter 7.
9	Opposes the eradication of game animals and would like to see more emphasis put on management of game because of their cultural value and importance to the community. Is opposed to calling game animals "ungulates" and requests that they be called by their Hawaiian names in the SWAP.	Additional information discussing the hunting program was added to Chapters 3, 4, and 6 and Appendix C. A discussion of the value of game to many communities and DLNR's program to provide and manage the statewide hunting program was added to Chapter 3. Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide more hunting in appropriate areas; and developing policies to balance the need to conserve native species with multiple uses of state lands.
Hawai'i Island—Waimea Public Information Meeting		
1	The SWAP should address management issues over a longer period than 10 years.	The period specified in the SWAP is 10 years, consistent with the SWG program requirement. Many of the threats and management issues identified, such as climate change, will persist beyond 10 years, and many of the conservation strategies identified, such as fencing to control ungulates, land acquisitions, and so on, are actions that will extend and provide benefits beyond 10 years.
2	The SWAP needs to place more emphasis on Hawaiian cultural aspects.	There is a brief discussion of the cultural significance of native wildlife in Chapter 3. The DLNR is beginning to work closely with native Hawaiian cultural practitioners through the Aha Moku Advisory Committee, and their expertise and assistance will be solicited in updating this section in the next SWAP update.

	Comment	How Addressed in Plan
3	The SWAP treats recreational overuse as a threat and a negative thing, but you need to encourage people to experience and enjoy wildlife to build appreciation and support for programs.	A requirement of the SWAP is to identify threats to native wildlife and habitat, and the increase in interest and access to outdoor and marine activities can lead to overuse and damage if it is not managed. The SWAP identifies conservation strategies to manage recreation to avoid overuse, but it also identifies strategies to balance the conservation of native species with multiple uses, such as hunting and recreation, and to expand and improve conservation education in the tourism industry regarding the appropriate use of natural areas and sensitive habitats.
4	The SWAP needs to identify additional innovative ways to conserve land, such as leasing lands for conservation purposes like reforestation rather than grazing.	Chapter 4 identifies a conservation strategy that involves using innovative tools, such as acquisition, grant agreements, conservation easements, leases, technical assistance, development of safe harbor agreements, and habitat conservation plans, to encourage protection and management.
5	The SWAP needs to include more specific details on how the success of conservation efforts will be monitored.	Chapter 8 and individual species fact sheets identify plans for monitoring the success of conservation efforts to conserve species. The monitoring plans also call for DOFAW and DAR to annually assess their success in implementing conservation actions in the SWAP.
6	The list of USFWS National Wildlife Refuges did not include Midway Atoll.	Midway Atoll was added to the list of National Wildlife Refuges in Appendix C.
7	The SWAP should be integrated with the Office of Planning's Ocean Resources Management Plan.	In Chapter 5 of the SWAP, the Ocean Resources Management Plan is identified as a plan and tool to aid management and address some of the threats facing native species and habitats, and the SWAP identifies the development and implementation of a comprehensive coastal policy as a conservation strategy.
8	There is a need to develop more fisheries management areas in west Hawai'i.	The SWAP identifies a conservation strategy to support development of community-based marine managed areas on Hawai'i and develop rules for community-based subsistence fishing areas as these partnerships develop.
9	The continued introduction and spread of invasive species is a huge problem affecting both wildlife and agricultural interests.	The SWAP identifies invasive species as a major threat. High priority conservation actions include Providing the invasive species programs adequate funding to support effective statewide early detection and rapid response to new introductions of invasive species; and continuing

	Comment	How Addressed in Plan
		coordination of invasive species prevention, management, and control programs for federal, state, county, and private-sector programs through the Hawai'i Invasive Species Council, the Coordinating Group on Alien Pest Species, and individual island invasive species committees.
10	Protection of coral reefs is a great concern.	The SWAP identifies coral as Species of Greatest Conservation Need and identifies bleaching, erosion, disease, and climate change as serious threats. It also identifies conservation strategies to 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.
11	Wetlands are critical habitats for native wildlife, and the specialized types, such as anchialine ponds, should be discussed separately, not clumped, and their unique needs identified.	The SWAP describes the importance of wetlands to native wildlife and describes the threats to these habitats, including climate change, sea level rise, and introduced invasive species. The SWAP identifies protecting remaining wetland habitat, including anchialine ponds, as a conservation strategy on Hawai'i. In addition, anchialine pond fauna are identified as Species of Greatest Conservation Need in Chapter 7, and their conservation needs are identified.
12	Preparedness for emergency response to disasters, such as oil spills and disease outbreak, needs to be included in the plan.	Additional language identifying the threats from contaminant spills and the outbreak of disease, such as avian botulism, was added to Chapter 4. Wildlife emergency response and preparedness was added as a conservation tool in Chapter 4.
Maui Public Information Meeting		
1	The SWAP should include more information on the success of species conservation efforts.	The SWAP identifies numerous key island-specific and statewide conservation and management programs, and reports are produced annually and made available to the public.
2	There is a polarization between hunters and conservationists that needs to be addressed.	We added discussion to the SWAP to address the need to enhance recreational and subsistence hunting opportunities statewide and present some of the public and community-based initiatives helping to direct management more effectively on Maui.

	Comment	How Addressed in Plan
3	The SWAP says that approximately $58.7 million in federal funding is expected under the State Wildlife Grants program in 2016. How much does Hawaiʻi typically receive?	Hawaiʻi generally receives no less than 1% of the annual funding available under the State Wildlife Grants system. In addition, in 2015, DLNR obtained three competitive grants totaling about $750,000 and anticipates funding under these grant programs to continue.
4	There seem to be disparities among invasive species priorities—big ticket issues versus pervasive threats. Private landowners and public agencies need to address their respective liabilities and engage the public to implement effective management.	Part of what the SWAP endeavors to achieve is highlighting these challenges and identifying current programs and vital management needs. The SWAP describes coordination among landowners and stakeholder groups to control damaging invasive species and establish more opportunities for public participation.
5	Need to improve statewide biosecurity and provide quarantine capacities at interisland ports to ensure the early detection and interception of invasive species.	The concept of improved biosecurity and early detection capacity is presented as a priority action throughout the SWAP. Public outreach and education are important elements of a much-improved biosecurity program in Hawaiʻi, and the SWAP points out the importance of funding and long-term commitment.
Molokaʻi Public Information Meeting		
1	On Molokaʻi, there is significant concern for the well-being of game animals because of our subsistence lifestyle; we recognize the importance of native species, but we also need to survive.	Game animals and the continued quality access to these and other subsistence resources are an important and recognized cultural foundation on Molokaʻi. Additional information discussing the hunting program was added to Chapters 3, 4, and 6 and Appendix C. A discussion of the value of game to many communities and DLNR's program to provide and manage the statewide hunting program was added to Chapter 3.
2	There was very little awareness among the community that the public information meeting to learn about the SWAP was taking place.	The approach taken for public input on the 2015 SWAP was to maintain a public website on the plan (DOFAW Comprehensive Wildlife Conservation Strategy website maintained since 2005) that invited comments and suggestions on the document and its revisions. Starting a year ago, staff began outreach to agencies and conservation partners to solicit input on the update and revisions. Staff provided a revised draft for a 30-day public review in August.

	Comment	How Addressed in Plan
3	The Aha Moku Advisory Committee should have been involved in the SWAP updating process.	To solicit greater public participation in future updates, plans for the next update as detailed in Chapter 8 were revised to start earlier, 18 months before the submittal deadline, and to include a round of public scoping meetings on each island rather than public information meetings on the completed draft. The DLNR is beginning to work closely with native Hawaiian cultural practitioners through the Aha Moku Advisory Committee, and their expertise and assistance will be solicited in the next SWAP update.
4	The DLNR needs to engage the hunting community on Molokaʻi to understand subsistence needs and establish greater trust on native species management priorities.	Chapters 4 and 6 identify conservation strategies to coordinate with the hunting community to provide more hunting in appropriate areas and develop policies to balance needs for conservation of native species with multiple uses of state lands.
5	Native Hawaiian values, traditions, and rights need to be acknowledged in the SWAP.	There is a brief discussion of the cultural significance of native wildlife in Chapter 3. The DLNR is beginning to work closely with native Hawaiian cultural practitioners through the Aha Moku Advisory Committee, and their expertise and assistance will be solicited in updating this section in the next SWAP update.
Lānaʻi Public Information Meeting		
1	Soil erosion and reef sedimentation are huge concerns for the Lānaʻi community. We need more accountability and a task force to oversee the process.	Chapter 6 presents discussions on island conservation needs, watershed partnerships, and various stewardship initiatives, such as the Natural Areas Partnership Program, that promote healthy watersheds; content was added to the Lānaʻi discussion, pointing out the need to continue watershed initiatives and increase use of best management practices that reduce soil erosion and coastal sedimentation.
2	The Lānaʻi community recommends that DLNR expand efforts to develop a more effective and transparent partnership with Pulama Lānaʻi.	DLNR and DOFAW are engaged in collaborative discussions with Pulama Lānaʻi to identify an appropriate process that will facilitate greater cooperation on wildlife and natural resource management issues and support related elements of the Lānaʻi Community Plan.

	Comment	How Addressed in Plan
3	Ever since the majority landownership changed, the Hawaiian petrel colony at Lānaʻihale has remained in an unmanaged condition, and this is a concern.	DLNR and DOFAW are engaged in collaborative discussions with Pulama Lānaʻi to identify an appropriate process that will facilitate greater cooperation on wildlife and natural resource management issues and support related elements of the Lānaʻi Community Plan, including needed management of the Hawaiian petrel colony at Lānaʻihale.
4	During the course of the last year, Lānaʻi has seen an alarming and widely distributed increase in the numbers of cane toads, and this should receive attention as an invasive species concern in the SWAP.	In the Lānaʻi discussion in Chapter 6, we identified the apparent increase in numbers and distribution of cane toads on Lānaʻi as a serious invasive species concern.
5	The SWAP should address insufficient enforcement capacity on Lānaʻi; most issues associated with game animals, bag limits, illegal take of marine life.	The statewide conservation strategy includes action to increase conservation enforcement efforts on all state-owned land and waters through increased funding for trained enforcement officers as a high priority.
Written Comments		
1	On page 3-6, there is a typo that states Hawaiʻi received 116 percent of appropriations; this should probably be 11.6 percent.	Hawaiʻi generally receives no less than 1% of the annual funding available under the State Wildlife Grants system; to clarify, in 2014, with 28 percent of the nation's imperiled species, Hawaiʻi received 16 percent of the national appropriation under the Endangered Species Act, Traditional Section 6 Program and just 3 percent of the Nontraditional Grant Programs.
2	Hawaiʻi Biodiversity and Mapping Program and Pacific Basin Information Node are essentially defunct and are referred to as information sources; therefore, these should not be included in the 2015 SWAP.	The defunct nature of these information resources warrants their removal from the current SWAP. This has been done throughout.
3	Ungulate control through public hunting is not an effective management tool but is listed as ongoing management in some of the Natural Area Reserves (in the Chapter 6 island summaries).	SWAP Chapter 3 contains information about the DLNR hunting program and how it is managed to help reduce ungulates in important native species habitat. Public hunting can contribute to ungulate control and help to reduce animals. SWAP Chapters 4 and 6 identify conservation strategies that involve coordinating with the hunting community to provide hunting opportunities and help control ungulates.

	Comment	How Addressed in Plan
4	Maui's island strategy should include reducing lighting and the profile of infrastructure such as powerlines and wind turbines to reduce seabird fallout.	Seabird fallout due to light attraction and mortality due to powerline collision are increasingly a concern on Maui. Ensuring that appropriate minimization and avoidance measures are implemented to reduce these impacts is emphasized.
5	In the bat species account, wind farms should be identified as a threat; substantial take has been documented and bat occurrence should be considered when sighting wind energy facilitates.	The risk of mortality due to interaction with wind farm facilities is identified in the SGCN fact sheet for the Hawaiian hoary bat; bat activity levels and occurrence in the vicinity of proposed wind farms is a requisite part of the preconstruction monitoring that is requirement of all proposed wind energy developments.
6	Populations of Kaua‘i Amakihi and Anianiau have declined dramatically (~ 90%) in recent years; these declines aren't represented in the species accounts.	We used the recent literature and available data on trends to substantiate that there have been considerable shifts in the abundance and distribution of Kaua‘i Amakihi and ‘Anianiau. These are now cited in the SGCN fact sheets for these species.
7	Laysan duck—the new population on Kure Atoll is not mentioned.	The Kure Atoll population is now discussed in the SGCN fact sheet for the Laysan duck.
8	Hawaiian petrel is mentioned as "possibly nesting on Lāna‘i," but the colony on Lāna‘i is considered a substantial population. Update the summary to reflect this.	This clarification has been made.
9	The information on Newell's shearwater is outdated. At-sea surveys have been analyzed, and there is a lot of research and management related to the HCP process that wasn't identified.	New information that substantiates recent population estimates for Newell's shearwater based on analysis of at-sea data has been incorporated into the SGCN fact sheet for this species, and additional information to fill in gaps associated with the HCP process and how research and management have informed the development of the HCP is presented in Chapter 6 (Kaua‘i).
10	Nihoa millerbird—the distribution section of the species account should mention Laysan Island. The population there is mentioned only in the abundance section.	The Nihoa millerbird translocation and population establishment on Laysan Island is now described in the "Distribution" section of the SGCN fact sheet for this species.
11	Recommend finding more recent higher quality photos for most of the bird accounts.	This was a priority for the 2015 SWAP, but a decision was made to defer this until the next SWAP update.

	Comment	How Addressed in Plan
12	A new publication suggests that toxoplasmosis, which is spread by feral and domestic cats, presents a serious threat to nēnē and other wildlife.	The threat presented by toxoplasmosis is recognized as serious issue, and text on this threat has been incorporated into the relevant sections of the document.
13	Hawai‘i Volcanos National Park does not manage marine resources below the mean high tide line.	This has been noted and revised in the SWAP.
14	Hawai‘i Volcanos National Park is 333,086 acres.	The SWAP has been updated accordingly.
15	Marine monitoring protocols are not in development for fishes, fisheries, or marine benthos for Hawai‘i Volcanos National Park.	This has been noted and revised in the SWAP.
16	Suggested revisions for the following content found on page 6-94: Under *Current Management*, Predator proof fences *and predator control for the protection of endangered species*; monitoring and management of endangered species (including nēnē, ua'u, and hawksbill turtles); Under Future Needs: The statement "Use Forward-Looking Infrared (FLIR) technology for detection and control of ungulates" should be moved from *Future Needs* to *Current Management*. The statement "Track nēnē reintroductions in the park" should be removed as this is covered under Current Management.	We incorporated the recommended revisions and clarifications into the respective sections of Chapter 6 (Hawai‘i).
17	To date nearly 600 nēnē have been translocated from Kaua‘i to Hawai‘i Island (draft says 312); the Future Needs for the nēnē translocation project should include long-term monitoring and associated management and outreach as birds disperse across the island.	We address these recommendations and clarification on the numbers of translocated nēnē where applicable in the SWAP.
18	There is no species account for white-tailed tropicbird although it is listed in Appendix A.	The SGCN fact sheet for the white-tailed tropicbird was somehow omitted from the draft but has now been incorporated and is consistent with Appendix A.

	Comment	How Addressed in Plan
19	Hawaiʻi Volcanos National Park is in the process of constructing a 600 acre predator proof fence for the protection of Hawaiian petrels. In addition, yearly monitoring is conducted following recently published standardized protocols.	We clarified that the NPS is constructing a 600 acre predator proof fenced exclosure designed to protect breeding Hawaiian petrels and other species on Mauna Loa.
20	The SWAP contains a large amount of narrative and background information. Detailed information concerning proposed actions for habitat protection or improvement or improved predator control actions for individual species is less substantive and the SWAP could benefit from more thorough discussion of the actual actions and plans. The following are recommended to streamline the document: place emphasis on actions, summarize background information, group taxa, and follow the format of the Alaska State Wildlife Action Plan.	The SWAP is a general plan that provides an overview of threats and needed conservation actions. The intention of SWAP is not to detail management plans or proposed actions but rather to summarize threats, challenges, and initiatives that are in place or needed to advance the conservation of SGCN. Each state produces a SWAP that is unique to the special needs of its SGCN. We agree that the Alaska SWAP is a good model and could be used as a reference as the format and structure of Hawaiʻi's SWAP evolves.
21	The SWAP defined actions for "invasive" species but is unclear what actions are proposed for other non-native species that are detrimental to habitat; we recommend clearly defining strategies to deal with these non-native species or creating an Invasive Species Action Plan to cite in the SWAP.	We cite several plans and guidance documents that identify invasive and non-native species management. Strategies are outlined throughout the document and discussions to emphasize the importance of invasive species prioritization are provided.
22	The SWAP fails to address the effects of habitat enhancements for target species on invasive and non-invasive species. For example, how will enhancing habitat for native species impact invasive and non-native species? Analysis of impacts of proposed habitat enhancements would be useful.	The effects of habitat enhancements or restoration initiatives to promote benefits for native species are detailed in analysis presented in the referenced management plans. SWAP provides an overview while the individual plans and progress reports are the sources of these analysis.

	Comment	How Addressed in Plan
23	Regarding species with the greatest conservation needs, we recommend the addition of Orangeblack damselfly (*Megalagrion xanthomelas*) which, although covered under the Order Odonata, could be named individually especially because of proposals for federal listing (under the ESA). In addition, the Order is incorrectly listed as terrestrial in Appendix A, in spite of some of the habitat for *M. xanthomelas* being anchialine pool-associated and/or aquatic.	The Orangeblack damselfly is represented as a stand-alone SGCN and a fact sheet is provided in Chapter 7; the habitat associations for this species, including all species of the genus *Megalagrion* and the Order Odonata, were changed in the appendix to include aquatic and anchialine pools.
24	The National Park Service has identified new threats and challenges for nēnē which should be included in the SWAP; a recent publication suggests that toxoplasmosis presents a serious parasitic infection risk for nēnē.	Toxoplasmosis was added to the discussion on disease threats in Chapter 4 and further clarification was given regarding the significance of this parasitic disease threat to native wildlife, particularly nēnē and Hawaiian monk seals.
25	The release of large numbers of Kaua‘i nēnē onto Hawai‘i Island has resulted in increased reports of nēnē in many new locations including places where they can readily come into contact with humans, cars, and aircraft. The behavioral plasticity of nēnē enable the species to become habituated to human activity and can lead to harmful or nuisance interactions. At the same time the well-being of these populations increasingly will depend on an informed and accepting public. Thus, public outreach, particularly with clear, unified messages, will be more important than ever. Recommend additional planning for public outreach be incorporated into SWAP.	We addressed these recommendations and concerns about the numbers of nēnē that have been translocated and the need to develop a management plan with sufficient monitoring, public education, and unified outreach aimed at communities and stakeholder groups.

	Comment	How Addressed in Plan
26	On Kauaʻi, Andre Raine and his colleagues have identified powerline collisions (not associated with artificial lighting) as a potentially serious sources of mortality of Newell's shearwaters and possibly Hawaiian petrels. On some of the main islands collisions with wind turbines are a documented source of mortality for both seabird species. While the severity of this threat is somewhat unknown, monitoring may provide the most reliable data. Recommend the SWAP address reduction of mortality to native birds and bats from wind turbines and powerlines.	Andre Raine and his colleagues at the Kauaʻi Endangered Seabird Recovery Project (KESRP) have been working to better quantify powerline collision of Newell's shearwaters (and Hawaiian petrels), refining estimates of annual mortality, and develop methods that can be used to reduce and mitigate losses. Relatively intensive biological monitoring has been part of implementing Habitat Conservation Plans for wind energy programs on Maui and Oʻahu for several years and analysis demonstrates that monitoring is critical for properly estimating project impacts and developing mitigation strategies.
27	A new monitoring protocol for Hawaiian petrels on Hawaiʻi and Maui should be included for consideration in the SWAP.	The new Hawaiian petrel monitoring protocol published by Hu et al. (2015) is designed specifically for use on Maui and Hawaiʻi; we included it in the SWAP where it can be accessed and cited as necessary.
28	The section of the SWAP on Haleakala National Park (6-67) contains inaccuracies. The following changes are recommended: Haleakala National Park comprises 33,465 acres of land of which 70.5% is Congressionally-designated Wilderness; under *Species*, remove the word "cave"; under Current Management, please revise to note that NPS staff implements Federally Threatened and Endangered native and rare plant restoration, and remove the word *herpetofauna*, and; under *Future Needs*, include secure monitoring and management for seabird, bat, terrestrial invertebrates, vegetation, and the effects of land use changes in and adjacent to the park; invasive species control; and water quality monitoring.	Each of these recommended clarifications were addressed and incorporated into the section on Haleakala National Park (6-67).

	Comment	How Addressed in Plan
29	DLNR and DOFAW needs to be more proactive about developing a functional partnership with Pulama Lānaʻi on natural resource management and environmental stewardship.	DLNR and DOFAW are engaged in collaborative discussions with Pulama Lānaʻi to identify an appropriate process that will facilitate greater cooperation on wildlife and natural resource management issues and support related elements of the Lānaʻi Community Plan
30	There currently is little or no evidence that efforts are ongoing to protect and properly manage the Hawaiian petrel colony on Lānaʻihale.	DLNR and DOFAW are engaged in collaborative discussions with Pulama Lānaʻi to identify an appropriate process that will facilitate greater cooperation on wildlife and natural resource management issues and support related elements of the Lānaʻi Community Plan (including needed management of the Hawaiian petrel colony at Lānaʻihale.
31	Goats are no longer a problem on Lānaʻi and therefore recommend they not be identified as continued contributors to soil erosion.	Goats are mentioned alongside sheep and deer as animals that have or continue to contribute to soil erosion on Lānaʻi. We note that goats are not believed to constitute a continued threat on Lānaʻi and clarified that they now represent far less of a threat than in the past.
32	The SWAP states that the USFWS has designated 320 hectares of critical habitat on Lānaʻi; however, Pulama Lānaʻi signed an MOU with the USFWS that eliminates any critical habitat designation on Lānaʻi, rendering the statement incorrect.	This will be updated and/or corrected if the proposed designation is determined to be within lands determined to be exempt from the designation.
33	Under "Strategies" in section 6-53, the SWAP states "Institute landscape-level predator management (primarily rodent and feral cat) around known and suspected Hawaiian petrel colonies". There is little evidence that the current majority land owner is engaging in this activity, which will require encouragement by DLNR.	DLNR and DOFAW are engaged in collaborative discussions with Pulama Lānaʻi to identify an appropriate process that will facilitate greater cooperation on wildlife and natural resource management issues and support related elements of the Lānaʻi Community Plan (including needed management of the Hawaiian petrel colony at Lānaʻihale.

	Comment	How Addressed in Plan
34	Also under the "Strategies" section, SWAP states "Control erosion and restore/reforest the northeast portion of the island to preserve the upland habitat and minimize sedimentation and runoff into coastal areas and ocean waters". It is assumed that the majority land owner is liable for sedimentation and runoff that is choking the Keomoku-side reef. How will DLNR handle that?	The regulatory language offered in this comment as they relate to land owner liability is outside the scope of SWAP. Content was added to the Lāna'i discussion pointing out the need to continue watershed initiatives and increase use of best management practices that reduce soil erosion and coastal sedimentation.
35	We were unable to find mention of state-sponsored marine protected areas as are seen in other states.	A number of marine managed areas are administered by the DLNR through the Division of Aquatic Resources in the main Hawaiian Islands and these include 11 Marine Life Conservation Districts (MLCD), 9 Fishery Replenishment Areas (FRA), and 20 Fishery Management Areas (FMA).
36	Whales visiting Hawaiian waters during the winter months are vulnerable to vessel collision and vessel speed limits should be established.	There are a number of federal regulatory provisions that apply to Humpback whales and other marine mammals including the Marine Mammal Protection Act and the Endangered Species Act in addition to minimum approach distances and recommendations on vessel speed during the winter calving and breeding months when the densities of Humpback whales in Hawai'i's coastal waters increases considerably.
37	There should be certain state waters where the Navy is prohibited from using explosives and active sonar.	No response was prepared to address this comment.
38	Hundreds of thousands of marine mammals are killed by fishermen and their nets. There should be limits to the types of hooks and nets that fishermen use.	Bycatch of marine mammals and other wildlife is well-documented. The National Marine Fisheries Service and the Western Pacific Regional Fisheries Management Council have adopted a number of successful strategies to reduce bycatch of marine mammals, turtles, and seabirds in the Hawai'i-based longline fishery. Thus, a number of regulations and gear modifications have been established to facilitate these reductions.
39	The Plan needs to identify contaminant spills in waterways and ocean as threats to wildlife and habitat.	Additional language was added to Chapter 4 to identify oil and contaminant spills as a major threat to seabirds, shorebirds, and marine life.
49	Preparedness for emergency response to disasters such as oil spills and disease outbreak needs to be included in the plan.	Additional language identifying the need for wildlife emergency response and preparedness was added as a conservation tool in Chapter 4.

	Comment	How Addressed in Plan
41	The seriousness of avian botulism as a disease to native waterbirds needs to be added to the plan.	Additional language identifying the threat from avian botulism was added to Chapter 4.
42	Need to add language that encourages educating the public on how to behave around native wildlife as they recovery and begin to spread into populated areas.	Additional language was added to the Chapter 4 Outreach and Education strategies to increase education about dealing with native wildlife in populated areas.
43	The importance of taro to the Hawaiian culture and as an agricultural crop needs to be mention.	An overview of the wildlife resources and habitat is provided in Chapters 4 and the Kauai section of Chapter 6. Language identifying the importance of taro is added to Chapter 6.
44	Nēnē and other waterbirds are having a big impact on taro production and taro farms in Hanalei Valley.	Additional language was added to Chapter 6 on Kauai identifying the damage that nēnē, Hawaiian moorhen and Hawaiian coots cause in taro farmer's fields.
45	More tools are needed to deal with nēnē and waterbird depredation in taro fields at Hanalei.	The SWAP includes the development of a Kauaʻi islandwide HCP for nēnē to resolve conflicts with agricultural producers and property owners. Research in taro loi to identify management actions that support both taro growth and high-quality wildlife habitat was identified as a needed conservation action.

Notes: DLNR = Department of Land and Natural Resources; EPA = U.S. Environmental Protection Agency; HCP = habitat conservation plan; NOAA = National Oceanic and Atmospheric Administration; SGCN = Species of Greatest Conservation Need; SWAP = State Wildlife Action Plan; SWG = State Wildlife Grants; USFWS = U.S. Fish and Wildlife Service.

Measuring the Effectiveness of State Wildlife Grants

FINAL REPORT

TENTH 10 ANNIVERSARY
INVESTING IN WILDLIFE SINCE 2000
STATE WILDLIFE GRANTS

April 2011

Measuring the Effectiveness of State Wildlife Grants: Final Report

A product of the Association of Fish & Wildlife Agencies' Teaming With Wildlife Committee
April 2011

ASSOCIATION of FISH & WILDLIFE AGENCIES

For additional resources and the most up-to-date information, visit www.fishwildlife.org

ACKNOWLEDGEMENTS

This report was produced by the Effectiveness Measures Working Group of the Association of Fish & Wildlife Agencies' (AFWA) Teaming With Wildlife (TWW) Committee. This report and its four main recommendations were officially approved by the AWFA TWW Committee at the March 16, 2011 meeting in Kansas City, MO. The report was then subsequently approved by the AFWA Executive Committee on April 4, 2011.

EFFECTIVENESS MEASURES WORKING GROUP

Faith Balch, *Minnesota Department of Natural Resources*
Danna Baxley, *Kentucky Dept. of Fish & Wildlife Resources*
Tara Bergeson, *Wisconsin Dept of Natural Resources*
Chris Burkett, *Virginia Dept of Game & Inland Fisheries*
Wendy Connally, *Texas Parks and Wildlife Dept*
Jenny Dickson, *Connecticut Dept. of Environmental Protection*
Mike Harris, *Georgia DNR, Wildlife Division*
Eric Rickerson, *Oregon Dept of Fish & Wildlife*
Tracey Tomajer, *New York Dept of Environmental Conservation*
Mark Humpert, *Association of Fish & Wildlife Agencies*
Priya Nanjappa, *Association of Fish & Wildlife Agencies*
Ron Essig, *US Fish & Wildlife Service*
Karl Hess, *US Fish & Wildlife Service*
Connie Young-Dubovsky, *US Fish & Wildlife Service*
Matthew Birnbaum, *National Fish & Wildlife Foundation*
Amielle DeWan, *Defenders of Wildlife*
Shelley Green, *The Nature Conservancy*
Mary Klein, *NatureServe*
Tess Present, *National Audubon Society*
Terra Rentz, *The Wildlife Society*
Nick Salafsky, *Foundations of Success*
Caroline Stem, *Foundations of Success*

WORKING GROUP ADVISORS/REVIEWERS

Jon Ambrose, *Georgia Dept of Natural Resources*
Gary Armstrong, *Indiana Dept of Fish & Wildlife*
Dan Brauning and Staff, *Pennsylvania Game Commission*
Bob Byrne, *Private Consultant*
John Emmerich and Staff, *Wyoming Game & Fish Dept*
Dennis Figg, *Missouri Dept of Conservation*
Jon Kart, *Vermont Fish & Wildlife Department*
Tom Nesler, *Colorado Division of Wildlife*
Jane Norris, *Minnesota Dept of Natural Resources*
Kelly Rezac, *Florida Fish and Wildlife Conservation Commission*
Kristal Stoner, *Nebraska Game & Parks Commission*
Christy Vigfusson, *US Fish & Wildlife Service*

A special thanks to State Wildlife Diversity Program Managers and State Wildlife Action Plan Coordinators who served as reviewers and Mary Pfaffko, *Association of Fish & Wildlife Agencies*, for editing and organizing printing.

FINANCIAL CONTRIBUTORS

The Association of Fish & Wildlife Agencies, Doris Duke Charitable Foundation, and Foundations of Success

Front, Inside & Back Cover Photo Credit:
George Andrejko, Arizona Game & Fish Department

Executive Summary

"Efficiency is doing things right; effectiveness is doing the right things." - Peter Drucker

The Need to Measure and Report Effectiveness of Conservation Actions

The Association of Fish and Wildlife Agencies' (AFWA) Teaming With Wildlife (TWW) Committee formed the Effectiveness Measures Working Group (Working Group) in September 2009 to develop and test a framework and effectiveness measures for the State and Tribal Wildlife Grants Program (SWG). The Working Group included representatives from state fish and wildlife agencies and key conservation partners. This report recommends a framework that includes an agreed upon set of effectiveness measures that can be used by states to improve performance reporting. The process demonstrated that data on effectiveness measures can be collected in large part by taking advantage of existing datasets, integrated into the project management and reporting cycle currently used, and implemented without burdening states with new and arduous reporting requirements.

The SWG program is the nation's CORE program for preventing endangered species listings and is a principal source of funding to implement and revise congressionally-mandated State Wildlife Action Plans (SWAPs). The development of SWAPs in every state and territory was a historic milestone and the plans are helping state fish and wildlife agencies and their partners target and improve management for the full array of fish and wildlife under their jurisdiction.

It has been an ongoing challenge to assess and communicate the effectiveness of the SWG program and SWAPs. Complex biological and ecological interactions make it difficult to attribute changes in species or habitat status to the effects of any single action and it can take decades for species to recover once conservation work begins. Nevertheless, a 2005 performance review of the US Fish & Wildlife Service's (USFWS) Wildlife and Sport Fish Restoration (WSFR) Program, from which SWG is administered, concluded that "results are not being demonstrated."

Although not directly related to the performance review, in February 2011, the US House of Representatives passed a continuing resolution for FY11 that eliminated funding for the SWG program. This served as a wake-up call for the 6,300-member TWW Coalition which sprang into action to help restore funding for the program. During completion of this report, the US Senate was deliberating its version of a continuing resolution and it is uncertain if there will be funding for the program in FY11. The identification of effectiveness measures for the SWG program is thus needed to not only improve conservation work, but also to help demonstrate to policy makers that the program is leading to the outcomes intended by Congress and therefore is a good investment of public funds.

Expected Results and Benefits of the Framework in this Report

Most state fish and wildlife agencies are facing severe financial challenges. This is affecting the capacity of states to conserve fish and wildlife under their jurisdiction. Development and implementation of an effectiveness measures framework can help agencies in these trying fiscal times in the following ways:

- Provide a means to evaluate conservation actions so that successful activities/programs can be continued and communicated and less successful ones improved or abandoned;
- Establish a standardized and accessible body of project performance data to inform and guide actions by current and future wildlife managers;

- Provide a cost-efficient mechanism for reporting data through regional and national summaries that will help meet congressional reporting expectations and articulate the value of SWG, and potentially SWAPs, to policy makers, conservation partners, and taxpayers.

Recommended Actions

The Working Group recommends that the TWW Committee adopt the following recommendations:

- **Approve the Proposed Effectiveness Measures Framework for SWG.** The framework and effectiveness measures described in this report are the result of more than a thousand hours of labor by the Working Group, state fish and wildlife agency staff, and others during the last 18 months. Initial draft measures were tested by nine pilot states, reviewed by State Wildlife Action Plan Coordinators, and distributed for review to states and partners. Drafts of the measures were also made available for review by the Office of Management and Budget and congressional appropriations staff. The resulting measures represent the best collective thinking on effectiveness measures that should stand the test of time and have applicability beyond SWG.
- **Integrate SWG Effectiveness Measures into the USFWS Wildlife TRACS Reporting and Tracking Tool.** The USFWS began work on a new reporting and data tracking system concurrent with the effectiveness measures project. Wildlife TRACS is being designed to make full use of the effectiveness measures developed by the Working Group and after an evaluation of potential information technology systems, TRACS was deemed the best system available to track and report on effectiveness of SWG as outlined in this report.
- **Explore Options for Integrating Effectiveness Measures into the Grant Application and Reporting Process.** The Wildlife TRACS Project Advisory Group is exploring ways to streamline the grant making and reporting process for SWG. To ensure that the framework can be successfully implemented, it is important that data collection and reporting not add substantially to existing grant making and reporting processes. Consideration should be given as to how best to incorporate effectiveness measures into these processes to ensure the utmost efficiency in data collection and reporting.
- **Form a Working Group to Assess and Recommend Improvements for SWAPs.** To ensure State Wildlife Action Plans remain relevant and effective, a Working Group should be convened in the future to identify best practices and to make recommendations on improving the plans. The Working Group should complete its work prior to the 10 year anniversary of the plans in 2015.

Conclusion

Because of the severe economic constraints that states are currently facing, it may seem like the wrong time to implement an effectiveness measures framework. However, increased scrutiny on budgets and growing expectations by the public require that states be as efficient and effective as possible or risk losing hard fought and much needed funding. This framework will lead to an improved understanding of how the SWG program is on a path to meet expected outcomes, promote adaptive management and provide a tool for the broader conservation community to improve its work. Since the capacity to collect and report data on effectiveness will vary among states, implementation of the framework should be voluntary and as efficient and streamlined as possible so resources are not diverted from doing on-the-ground conservation work. Lastly, although it was not feasible to develop a separate set of effectiveness measures for SWAPs, there is a need to assess the plans to determine if they are meeting their intended purpose and if there is a need for improvements. This assessment should be completed prior to the ten year anniversary of the plans in 2015.

Table of Contents

1. Introduction

1.1 The Need to Track and Report Effectiveness of Conservation Actions

The State and Tribal Wildlife Grants (SWG) program was created by Congress in 2000 to address a longstanding need to plan and implement actions to conserve declining fish and wildlife species before they become threatened or endangered. It is the core federal program for preventing future endangered species listings, and is a principal source of funding to implement and revise congressionally-mandated State Wildlife Action Plans. Each state and territorial fish and wildlife agency receives an apportionment based on a state's human population and its land area. Apportionments average about $1.2 million annually for each state/territory. State Wildlife Action Plans (SWAPs) were completed in 2005 and they identified more than 12,000 Species of Greatest Conservation Need (SGCN), their key habitats, priority threats, and thousands of on-the-ground conservation actions needed to stabilize or reverse declining species populations.

Despite the importance of SWG and SWAPs to the states and their partners, there is a need to better demonstrate effectiveness. In 2005, the U.S. Fish and Wildlife Service's (USFWS) Wildlife and Sport Fish Restoration Program (WSFR) that oversees SWG was assessed using the Office of Management and Budget's (OMB) Performance and Reporting Tool. The program was given a rating of "*Results Not Demonstrated*" because it lacked long-term outcome and annual output-oriented performance goals, lacked regular independent evaluation, and did not have a strong accountability system. In 2007, the US House of Representatives included report language in the bill funding the US Department of Interior that requested the USFWS require regular performance reporting to measure the success of SWAP implementation.

In this era of record-high budget deficits, the Administration has asked federal agencies to develop their 2012 budgets against a backdrop of fiscal austerity. Budget guidance released in a June 8, 2010 memo from OMB instructed federal agencies to "eliminate low-priority programs and activities to free up the resources necessary to continue investments in priority areas." The guidance also directed agencies to "identify the programs accounting for five percent of their discretionary spending that have the lowest impact on agency missions." In February 2011, under growing pressure to reduce the federal deficit, the US House of Representatives passed a Continuing Resolution that cut nearly $60B from the FY11 budget compared to the previous year. In that bill a number of conservation programs including the SWG Program had their funding eliminated. Action in the US Senate is pending.

During the first decade of SWG funding and after five years of SWAP implementation, state fish and wildlife agencies have made enormous strides in implementing conservation actions to conserve our nation's most at-risk fish and wildlife. However, it is an ongoing challenge to assess and communicate the effectiveness of these efforts. Disparate reporting measures, a lack of a robust reporting system and national framework for identifying effectiveness measures makes it difficult for state fish and wildlife agencies individually and the WSFR program nationally to demonstrate the importance and effectiveness of the SWG program. These deficiencies could put the program at-risk, particularly in light of the significant federal budget cuts looming on the horizon. This report recommends a framework that could help address these challenges.

In addition to demonstrating effectiveness of SWG-funded conservation actions to policy makers, there is also a need to help managers learn from and improve upon the conservation actions they implement. The framework proposed in this report can help managers learn from their successes and failures and share this information with their peers, so that they can become even more effective over time.

1.2 Using an Adaptive Management Approach to Measure Effectiveness

There are two principal types of monitoring questions in conservation. *Status monitoring* identifies how populations of species as well as the habitats and natural processes on which they depend are doing over time. *Effectiveness monitoring* determines if conservation actions are having their intended impacts and how they can be improved (see definitions in Figure 1).

State fish and wildlife agencies and their partners have a long history of collecting and reporting on measures that address status questions (e.g., which species are of greatest conservation need; what issues are impacting species of greatest conservation need and their habitats). They have also tracked the *implementation* and *immediate outputs* of conservation actions supported by funding through SWG and other sources (e.g., acres of land purchased, number of dams removed). Given the complexity of ecological and socioeconomic systems, rapidly changing circumstances, and the lengthy timeframes in which conservation actions are generally implemented, it has been much more difficult to bring these two sets of data together to attribute changes in species or habitat status to the effects of any one action. It has been equally difficult to roll up the results of many different actions into meaningful reports within and across state boundaries.

Systematically measuring the effectiveness of conservation actions requires specifying a "theory of change" linking these actions to their ultimate desired impacts (Figure 2) through a five-step process:

1. Define the conservation action;
2. Describe, via a results chain, the theory of change as to how the action will lead to desired impacts;
3. Identify a limited set of effectiveness measures to assess progress at key points throughout the life of the project;
4. Develop and test effectiveness measures to ensure they provide meaningful information within existing human, legal, and financial constraints, and;
5. Collect, analyze, and share data about the effectiveness measures to show whether or not the conservation action achieved the desired impact, why it succeeded or failed, and how implementation of the action can be improved over time under different conditions.

Figure 1. Clarification on Terminology

The following definitions describe key terms used in this report.

Effectiveness measures: Indicators used to assess whether a given conservation action is leading to its desired objectives and ultimate impacts.

Framework: The process and products (definitions of actions, results chains, effectiveness measures, and data questionnaires) that are proposed in this report to assess the effectiveness of each generic conservation action.

Generic (conservation) action: A group of similar actions that follow the same general theory of change (e.g., species restoration, outreach and education).

Objective: A specific, measurable, acheivable, relevent, and time-limited statement that describes the desired short, medium, or long-term outcomes of a conservation action.

Process: The five steps the Working Group used to develop and test results chains, effectiveness measures, and questionnaires.

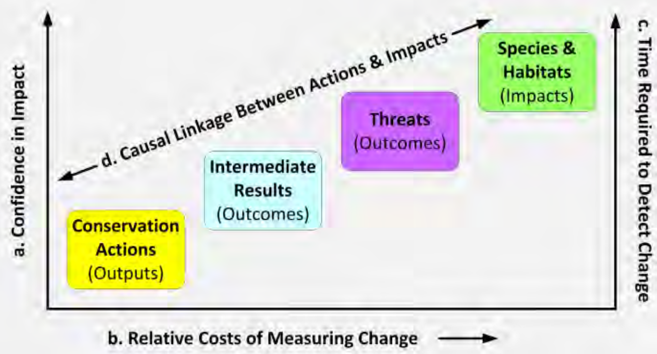
Questionnaire: A survey form that provides a user-friendly way to collect data related to the effectiveness measures.

Results chain: A graphical diagram that links an action to the desired impact through a series of short, medium, and long-term results in an "if-then" fashion. Also called a ***Theory of Change***.

Status measures: Indicators used to assess how species or their habitats are doing over time, without reference to specific conservation actions.

Figure 2. Measuring Effectiveness Requires Linking Conservation Actions to Impacts

Measuring the effectiveness of a conservation action requires more than counting short-term outputs such as dollars spent or the number of pamphlets distributed. But paradoxically, we also cannot rely solely on measures of the ultimate impacts – the status of the species and habitats of interest—to measure effectiveness. This is because as depicted in the diagram, as confidence in our measures increases, the cost of measurement and the time required to detect change also increase. To this end, the best effectiveness measures require defining a *theory of change* or *results chain* that links actions through outcomes to the ultimate impact, and then collecting data at key steps.



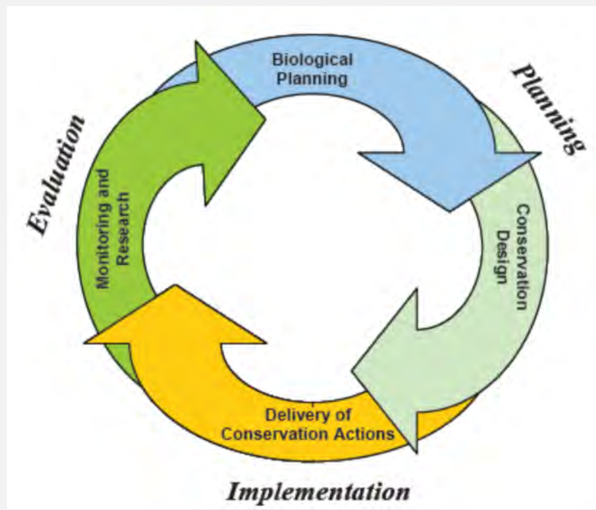
Source: Adapted from CMP 2008

This process of measuring the effectiveness of conservation actions is the key to *adaptive management,* which requires building monitoring efforts into the overall project management cycle (Figure 3). Under an adaptive management approach, project teams state their theory of change behind each action and then collect the information required to evaluate its effectiveness. If the activity provides the expected results, effectiveness measures help communicate that success so others may follow suit. If, on the other hand, the action does not work as hypothesized, then the managers can identify problems and either modify the action, or try alternatives. The key to adaptive management is to learn from successes, informative failures, and useless failures and respond accordingly so programs can become more effective and efficient over time.

Figure 3. Effectiveness Measures Are Implemented in the Context of the Project Cycle

A key premise behind the framework proposed in this report is that effectiveness monitoring and performance reporting are not additional activities added on top of existing project management responsibilities. Instead, as shown in the following diagrams, they should be integrated into the project management cycle. The diagram on the left shows the adaptive management cycle developed by the Conservation Measures Partnership, a forum of key conservation NGOs, funders, and agencies. The cycle on the right shows the Strategic Habitat Conservation Cycle developed by the US Department of the Interior. Although the two cycles use different terms, the steps of planning, implementation, and monitoring in an iterative cyclical fashion are largely equivalent. These cycles represent two ways of implementing Element 5 in SWAPs which requires states to monitor species, habitats, and the effectiveness of conservation actions, and then adapt conservation actions to respond to new information or changing conditions, or in other words, to practice adaptive management.

Open Standards for the Practice of Conservation **Strategic Habitat Conservation**



Source: CMP 2008 & USGS 2006

By developing an appropriate set of effectiveness measures, conservation practitioners will be better able to articulate the value of SWG and potentially SWAPs to policy makers and taxpayers, and ensure positive conservation impacts. This report provides guidance to the states on how to measure the effectiveness of conservation actions funded through SWG and a tool to track and report that effectiveness.

The recommendations provide a cost-efficient mechanism for reporting within states that will also facilitate rolling-up data to regional and national levels. The effectiveness measures could help states meet congressional reporting expectations on the use of SWG and the effectiveness of that program for implementing state-driven conservation. States can proactively demonstrate the benefits of SWG and SWAPs, rather than waiting for Congress and OMB to identify monitoring and reporting standards. The performance measures presented in this framework will facilitate communication about the importance of state fish and wildlife agency work to Congress, partners, and the public who will ultimately decide on continued funding for SWAPs.

1.3 The Effectiveness Measures Working Group

Although state fish and wildlife agencies use adaptive management to assess the effectiveness of the individual actions they implement, in the future, state fish and wildlife agencies may also be required to develop a system that reports on cumulative effectiveness of actions across regions or nationally. The challenge for this project was to develop a framework that can be implemented voluntarily and that minimizes, or potentially even reduces the reporting burden on states, while at the same time improving the overall effectiveness of conservation work and accountability to policy makers and the public.

With this challenge in mind, in September 2009, the Association of Fish and Wildlife Agencies' (AFWA) Teaming With Wildlife (TWW) Committee formed the Effectiveness Measures Working Group (Working Group) comprised of individuals with expertise in effectiveness measures from both state agencies and conservation partner organizations. Foundations of Success (FOS), a nonprofit organization that specializes in developing effectiveness measures for conservation work, was hired to help facilitate the process. The Working Group's charge was to develop and test an effectiveness measures framework for assessing SWG and potentially the broader implementation of SWAPs. This report concludes with a draft set of recommendations to the TWW Committee for consideration at their meeting in March 2011. These recommendations address the following:

- A framework for evaluating the effectiveness of actions funded under SWG and broader SWAPs;
- Specific application of this framework to produce effectiveness measures for the most common actions funded under SWG;
- The Information Technology system required to implement this framework; and
- Suggestions as to how this framework might best be implemented on a voluntary basis by state agencies.


Razorbill Decoys / USFWS

2. Framework for Assessing Effectiveness of Conservation Actions

2.1 Overview of Assessing Effectiveness of Conservation Actions

State fish and wildlife agencies are implementing thousands of specific conservation actions to address threats that affect more than 12,000 species identified as at-risk. Although each conservation situation is unique, there are patterns in the **theory of change** (or results chain) behind all these actions. For example, an agency in the Northeast may promote awareness in boaters of the need to scrub their boat hulls when moving between waterways to minimize the spread of invasive aquatic weeds. An agency in the Northwest may launch a campaign to persuade homeowners to avoid over-fertilizing of lawns to reduce nutrient runoff into an estuary. Although these two actions take place in different ecosystems, are implemented by different agencies, and are countering different threats, they are analogous and their respective theories of change would look very similar. Both actions involve outreach and education that is designed to raise awareness in a specific public sector with the goal of changing behavior. These two conservation actions could be lumped under a "**generic" conservation action** called *Education*, and standard effectiveness measures could be developed that would allow these measures to be rolled up across ecological and sociopolitical boundaries.

This chapter describes a proposed **framework** that states and their partners can use to assess the effectiveness of conservation actions. This framework includes a list of common or generic conservation actions and a **process** for developing results chains, **effectiveness measures,** and data collection **questionnaires.** If this framework is approved and implemented, then it can be applied to the full suite of generic conservation actions that are shared by all states. This chapter outlines the framework and provides recommendations as how to best apply it.

2.2 Expectations of State Agencies Under this Framework

State wildlife agencies will undoubtedly ask: "What does this proposed framework mean for my agency?" The following chapter describes the core of the framework that could be used by states to assess the effectiveness of their conservation actions. The part of the proposed framework which most states will actively use includes: a list of and definitions for generic conservation actions commonly implemented or funded by SWG (Appendix I), and a set of effectiveness measures for each action and specific questionnaires that provide data about these measures (Appendix II).

To illustrate this concept, consider an example in which state agency staff in Minnesota and Wisconsin work to translocate Greater Prairie Chickens from Minnesota to the Buena Vista Wildlife Area in Wisconsin in an effort to increase populations, as well as genetic diversity. This specific action would be classified more generically as "species restoration," based on the definitions in Appendix I. Reporting on effectiveness under this framework might include:

- **Providing action-specific information during the grant application process.** This might include baseline information about the actual state of the prairie chickens, the expected duration of the translocation effort, and the expected population or recovery outcomes.

- **Providing data on progress of the action over the life of the grant.** For this example, some data that would need to be gathered might include:
  - *Plan for Restoring Species and Project Sites* – Is this project being implemented under an overall plan for restoring the species (i.e., Greater Prairie Chicken)? Does this plan define clear biological objectives for the species and for the sites?
  - *Stakeholder Buy-In* – During the reporting period, were there any formal challenges by stakeholders to prevent the release of the target species into the restoration sites? If yes, was the project team able to mediate these challenges?
  - *Target Units of Species Released* – What percent of initial release work across all restoration sites has been completed? How many units (i.e., individuals, breeding pairs, communities) of the species have been reintroduced?
  - *Species Breeding at Restoration Sites* – Are the introduced populations breeding within the recovery site(s)?
  - *Population Viability* – Has the population goal for the target species within the restoration site(s) been achieved?
- **Contributing to "roll up" reports**. To the extent that states need to report data at a state or regional level, they may want to compare data across the same actions within their state or region and then aggregate and report them in a succinct, visually-appealing and powerful manner that would effectively communicate results to policy makers, stakeholders, and the public. Figure 7 in Section 2.3 provides an example of such a report for species restoration.

2.3 The Process

To develop the framework for assessing the effectiveness of conservation actions described in the previous section, the Working Group followed the five-step process described in Chapter 1.2.

The Working Group used this process to pilot-test standardized measures for four generic conservation actions. This framework could be extended to many other conservation actions whether they are funded through SWG or not. This process would not need to be replicated by individual states, but rather a team of state representatives could implement the process on behalf of the broader community, saving considerable time and expense. To illustrate this process and the resulting products, a generic Species Restoration Example has been used.

Franklin Ground Squirrel / Indiana Division of Fish & Wildlife

Step 1. Define the Generic Conservation Action

The Working Group identified 11 categories of generic conservation actions that are most commonly funded with SWG dollars, as well as 2 additional actions that are common components of other actions. This list was developed by first reviewing State Wildlife Action Plans and SWG performance reports to develop an initial list of commonly-mentioned actions. To provide a standard structure, the group then categorized and synthesized these actions following the IUCN-Conservation Measures Partnership's Standard Classification of Conservation Actions (IUCN-CMP 2008). States and USFWS's WSFR Program provided additional input to further refine the list. The list is **not** meant to be exhaustive but rather represents the most common actions and will likely need to be added to over time. The generic actions include:

1. Direct Management of Natural Resources
2. Species Restoration *
3. Creation of New Habitat
4. Acquisition / Easement / Lease *
5. Conservation Area Designation
6. Environmental Review
7. Management Planning
8. Land Use Planning
9. Training & Technical Assistance
10. Data Collection & Analysis *
11. Education *

The two actions that are not stand-alone, but are components of other actions are:

A. Incentives

B. Stakeholder Involvement

A complete list of the generic conservation actions, their associated definitions, and a list of real-world examples can be found in Appendix I. Four of the generic conservation actions (those marked with an asterisk *) were selected for pilot testing. The framework was then extended to the remaining actions listed above.

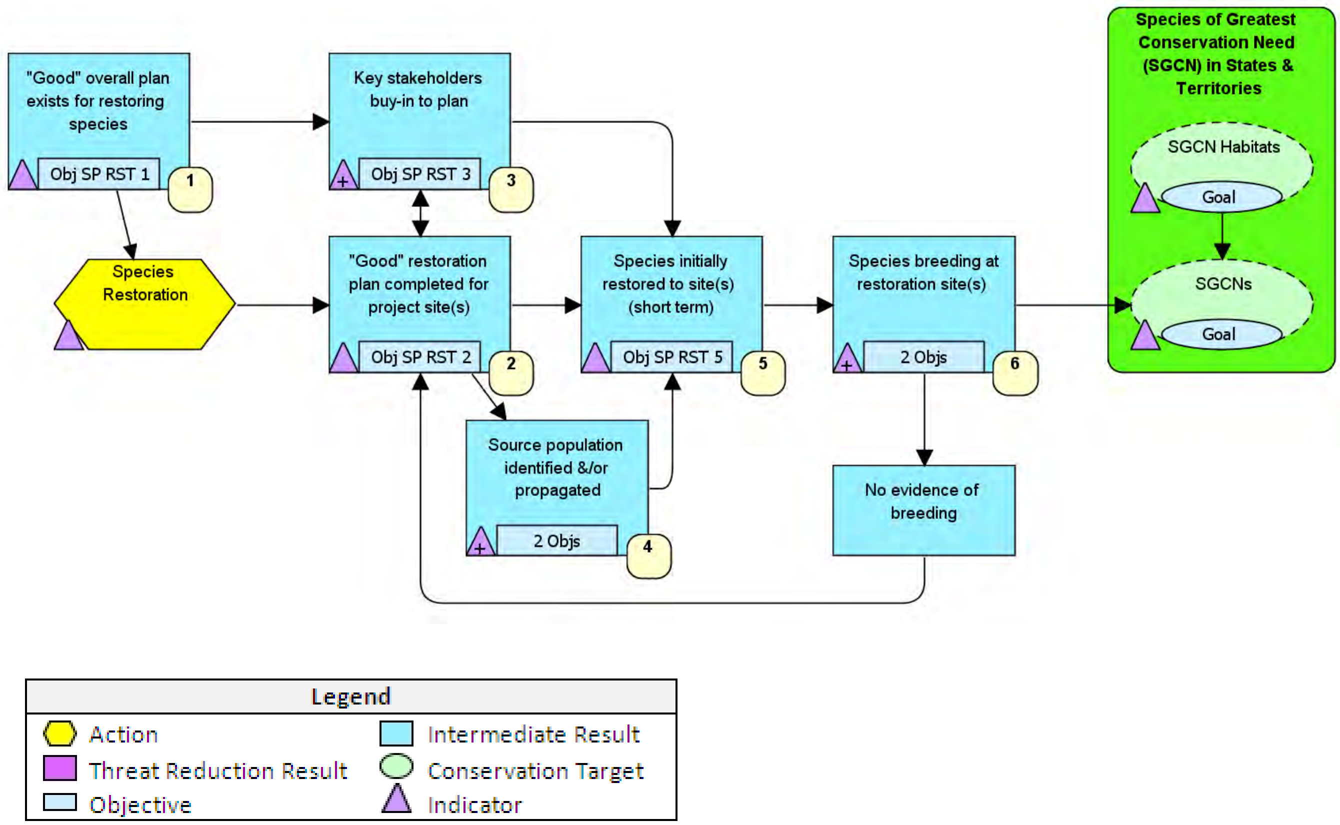
Step 2. Describe Via Results Chains the Theory of Change as to How Each Action Leads to Desired Impacts

Before determining effectiveness measures for any given action, it is first necessary to outline the theory of change behind the action. Results chains are graphical diagrams that map out a series of causal statements that link short, medium, and long-term results between an action and the ultimate desired impact in an if-then fashion. The Working Group evaluated several alternatives for constructing and depicting theories of change and ultimately decided to use Results Chains (FOS 2007) using the Miradi software program (www.Miradi.org). Miradi uses a series of step-by-step interview wizards to guide the development of results chains, associated objectives, and measures to assess the effectiveness of conservation actions.

Figure 4 shows an example of the Species Restoration Results Chain. As outlined on the right-hand side of the results chain, a key precursor for effective Species Restoration involves developing an overall plan for restoring the species (1). The first step involves developing a good restoration plan for the specific project sites (2) and, if needed, assuring that key stakeholders support the plan (3). It is also generally necessary to identify a source population for the restoration effort, either from suitable wild populations or from captive breeding efforts (4). Once the species is restored to the site (5), a key result is that the species is breeding at the restoration sites (6). If there is no evidence that breeding is occurring, then it will be necessary to re-examine the plan and repeat as needed.

The results chain for each generic conservation action went through several iterations, generally starting out in a more detailed and complex form, and then simplified to facilitate understanding and reporting. These generic results chains are included in Appendix II along with a more specific example for each action.

Figure 4. Results Chain for Generic Species Restoration Actions



Step 3. Identify a Limited Set of Effectiveness Measures to Assess Key Points along Each Results Chain and Produce Desired Roll-Up Reports

Once the results chains for each conservation action were developed, the Working Group used the chain and assessments of what data might be realistically available to states to identify effectiveness measures for short- and medium-term results (blue boxes in the results chains). To develop the effectiveness measures, the Working Group found it helpful to first think about *generic objectives* for each result in the chain and then extract the measures from those objectives (**Table 1**).

The following criteria were used in selecting measures:

- **Linked** – tied to key factors in the theory of change laid out in the results chain
- **Measurable** – in either quantitative or qualitative terms
- **Precise** – defined the same way by all agencies
- **Consistent** – unlikely to change over time
- **Sensitive** – changing proportionately in response to actual changes in the condition or item being measured
- **Overarching** – available to be measured at various points throughout the life of a project
- **Achievable** – not onerous for states or their partners to report

Table 1. Objectives, Effectiveness Measures, and Monitoring Questions for Species Restoration Generic Action

Note that labels and results correspond to the results chain in Figure 4

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
SP RST 01	**Generic:** "Good" overall plan exists for restoring the species	Before implementation work starts, a "good" restoration plan exists for the species within a desired region (developing this overall plan will usually not be part of this project).	Presence of plan; Assessment of plan quality against criteria	% of restoration efforts that are based on a "good" plan by taxa and by region	App 1. This project involves: relocation/captive propagation/both. App 2. What species (or other taxonomic units) are expected to benefit from this project? App3. What is the expected duration of the restoration effort in this project? App 4. Is this project being implemented under an overall plan for restoring the species? App 5. Does this overall restoration plan define clear biological objectives required for recovering the species? App 6. Approximately what percentage of the overall species recovery effort is represented by this project? App 7. Does this restoration plan identify: 1) appropriate source(s) of the species, 2) candidate restoration sites, 3) methods for transferring and introducing the species to new sites, 4) monitoring and follow-up methods, and 5) risk assessment and mitigation steps?
SP RST 02	**Generic:** "Good" restoration plan completed for project site(s)	Before implementation work starts, a "good" restoration plan has been developed for the specific project site(s).	Presence of plan; Assessment of plan quality against criteria	None	1. Has the project developed a plan for restoration efforts at the specific project site(s)? 2. Does this restoration plan identify: 1) clear biological objectives, 2) appropriate source(s) of the species, 3) methods for transferring and introducing the species to the sites, 4) monitoring and follow-up methods, 5) a budget and work plan for this work, 6) clear exit criteria for the project (both unsuccessful and successful) , and 7) risk assessment and mitigation steps? 3. What is the "unit" for defining restoration site(s)? 4. How many total site(s) is the project targeting for restoration efforts?

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
SP RST 03	**Generic:** Key stakeholders buy-in to plan	Prior to and following implementation of the plan, all relevant stakeholder groups are either supportive or at least non-hostile towards the restoration.	Actions taken by individuals or organizations that are against the restoration (e.g., formal legal challenges to the plan or hostile acts such as shooting restored animals)	Total number of projects that are being blocked by stakeholders, by taxa and region.	5. During the reporting period, were there any formal challenges by stakeholders to prevent the release of the target species into the restoration sites? 6. If yes, was the project team able to mediate these challenges?
SP RST 04	**Generic:** Source population identified and/or propagated	Prior to implementation of the plan, a suitable source population to meet needs of all restoration sites has been identified. If necessary, before restoration efforts start, sufficient individuals have been propagated to meet needs of all restoration sites.	Evidence of suitable source population being identified. % of total individuals required to meet needs of all sites	% of projects that are able to identify and/or propagate sufficient individuals, by taxa and by region	7. Has the project identified a suitable source of individuals to meet needs of all sites in the restoration effort? 8. If propagating, what percent of total individuals required to meet needs of all sites in the restoration effort have been bred?
SP RST 05	**Generic:** Species initially restored to sites (short-term)	By specified target date, the target number of units* have been introduced to Area(s) YYYY. * Units could be individuals, breeding pairs, communities, pounds of fish fry, or other measures as appropriate.	% of target number of units that are released	% of projects that are able to release sufficient units, by taxa and by region	9. Has the project begun releasing species to restoration site(s)? 10. What percent of initial release work across all restoration sites has been completed? (combines both within site and across sites) 11. What is the "unit" for measuring quantities of species released within restoration site(s)? 12. How many units of the species have been reintroduced?
SP RST 06	**Generic:** Species breeding at restoration sites (medium-term)	Within X years of introduction, the restored population is successfully breeding within the restoration site(s).	% of sites with restored population successfully breeding	% of all projects with restored species successfully breeding, by taxa and by region	13. Are the introduced populations breeding within the recovery site(s)? 14. What is the "unit" for measuring successful reintroduction of the species within restoration site(s)? 15. How many units of the species are present in the recovery sites?
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**Goal:** Within X years of the start of the action, the species of interest have improved viability.	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	16. Are the introduced populations viable within the recovery site(s)? 17. Has the population goal for the target species within the restoration site(s) been achieved? 18. Has this project contributed to any changes regarding the conservation priority status (SGCN priority, Threatened/Endangered, etc.) of the target species in your state?

Step 4. Develop and Test Data Collection Questionnaires for Each Measure

Once the results chains were developed and measures identified, the Working Group created questionnaires to test and evaluate the proposed effectiveness measures using activities funded through SWG. Figure 5 includes some sample questions developed for species restoration and Figure 6 contains general questions that would be asked for all SWG projects. These questionnaires were then pilot-tested with real-world projects drawn from state members of the Working Group (MN, NY, TX, VA, WI) and four additional states (FL, GA, MO, NE). In the second phase of this work, questionnaires were developed for the remaining actions and then peer-reviewed by key state agency staff. These questionnaires are critical, in that as they are incorporated into grant application and reporting processes, they are the only part of the effectiveness measures system that most users will encounter.

Figure 5. Partial Questionnaire for Species Restoration Action

Source Population Identified and/or Propagated

7. Has the project identified a suitable source of individuals to meet needs of all sites in the restoration effort?

- Source(s) identified to provide all of the individuals needed (100%)
- Source(s) identified to provide some of the individuals needed (approximately ____ %)
- Source(s) not yet identified to provide needed number of individuals
- Captive breeding/propagation required to augment source population

If propagating individuals:

8. What percent of total individuals required to meet needs of all sites in the restoration effort have been bred?

____ %

Notes: ____

Species Initially Restored to Sites (Short-Term)

9. Has the project begun releasing species to restoration site(s)?

- Yes
- No

10. What percent of initial release work across all restoration sites has been completed? (combines both within site and across sites)

____ % Notes: ____

11. What is the "unit" for measuring quantities of species released within restoration site(s)?

- Individuals
- Breeding pairs or units
- Communities
- Other (e.g., pounds of fish fry)

Please describe if needed: ____

12. How many units of the species have been reintroduced?

____ total units across all sites Notes: ____

Figure 6. General Questions for All Conservation Actions

The Working Group identified a common set of questions (see below) as critical information to gather on the project level when reporting on a conservation action. These questions are recommended to be consistent across all conservation actions and serve as precursor information that can be captured in the application process of the grant. If this data cannot be captured on the front end due to limitations, then questions should be incorporated as general questions in every report.

Basic Project and Action Info

Project Title *(text field)*

Project Contact *(text field; capture contact information, including position title)*

Project Partners *(text field; capture contact for each partner org)*

Conservation Actions *(pick list of actions)*

General description of project (note: not just the action – max. 1000 characters)

Budget Info

Total Project Budget (grant + match) (*value field)*

Cost of Conservation Action *(value field; one for each action)*

Sources of non-federal match funding (*pick list: Agency general fund, license plate revenue, private funds/NGO contributions, In kind/volunteer work hours, other)*

Basic Result Info

How does the *Conservation Action* address a specific goal/objective within the State Wildlife Action Plan (*pick list of the 8 Elements; descriptor box*)

Threats addressed by this *Conservation Action (pick list – IUCN CMP Taxonomy of threats, level 1 & 2)*

Identify the Primary SGCNs benefitting from this *Conservation Action (pick list of SGCNs within that state: generated from NBII database; include N/A)*

Identify the main habitat types (if any) that this *Conservation Action* addresses *(pick list of habitat types; include N/A*

Step 5. Collect and Analyze Data and Use to Adapt Metrics
When applying the five-step process to any conservation action implemented, after collecting and analyzing monitoring data a project team would then adapt actions and improve the overall effectiveness of its conservation efforts. In the case of the Working Group, there were not specific on-the-ground actions to adapt.

Finally, a key to communicating effectiveness measures is the ability to report the information in a clear, concise, factual, and visually stimulating manner. Policy makers in particular need information that is summarized and can be assimilated and interpreted in as little time as possible. The mock-up report in Figure 7 (enlarged version found in Appendix III) illustrates an example of how the species restoration efforts could be rolled up and communicated to policy makers. The actual data is fictitious, though the group tried to use realistic data and draw on real-world examples. The intent of this mock-up is to provide an example of how state fish and wildlife agencies could communicate results to target audiences such as agency directors, members of Congress or the Office of Management and Budget.

Figure 7. Example of an Effectiveness Report on Species Restoration

Mock-up Example of 2-Page Layout for Reporting on Conservation Actions

Effectiveness of Species Restoration Efforts

What Does This Include?

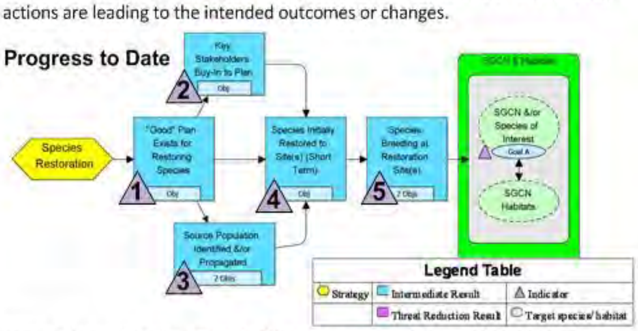
Efforts to reintroduce, relocate, or stock native animals or plants or translocate animals to an area where they are not currently found. Some examples include:

- Translocating/breeding in captivity black-footed ferrets to establish new populations in suitable habitat.
- Restoring mussel assemblages to historically occupied stream stretches

How Do We Measure Effectiveness?

Establishing good effectiveness measures for conservation actions requires being clear about the linkages among conservation actions, changes in threats those actions are designed to address, and the status of the relevant species and habitats. Laying out this "theory of change" isolates and limits the key factors that need to be monitored in order to assess whether our conservation actions are leading to the intended outcomes or changes.

Progress to Date



115 species restoration grants to 28 states were made from 2008-2010. The majority of those led to species breeding at restoration sites.

Effectiveness of Funded Species Restoration Efforts

1 90% of efforts have "good" plans that meet key criteria

2 70% have stakeholder support to move the efforts forward

3 81% have identified or propagated sufficient species to meet restoration needs

4 65% have released sufficient species for initial restoration

5 47% show restored species are breeding successfully

For more info: www.swgdb.org/species-restoration/

Where Do We Go From Here?

While much has been accomplished with funding for species restoration, the support is currently not adequate to meet conservation goals established by states to protect Species of Greatest Conservation Need and their habitats. Consequently, species restoration efforts are falling short. Specifically, it is estimated that states require an additional $11 million dollars to meet their goals for species restoration activities.

Funding Needs for Species Restoration

Stories from the Field

Washington Department of Fish and Wildlife and partners, with SWG support, are helping conserve and restore western pond turtle populations - a state endangered species that has been impacted by habitat loss and non-native predators like large-mouth bass and bullfrogs which eat young turtles.

As part of their recovery strategy, managers implemented a "head start" program for captive bred and wild hatchlings. The young turtles are raised in captivity until they are too large to be eaten by bass and bullfrogs – at which point, the turtles are released into suitable habitats to augment existing or create new populations.

In 2007, Washington achieved goals for restoring at least four self-sustaining populations in the Columbia Gorge. Although efforts to restore this species to Puget Sound recovery areas continue, meeting the Columbia Gorge recovery goals means it is unlikely this species will be extirpated or require protection under the Federal Endangered Species Act

Photos by Kate and Frank Slavens

Questions to Explore

- How can states better engage stakeholders and explain practical benefits of species restoration to improve support?
- Under what conditions does it make sense to do species restoration versus other less labor and cost intensive, like outreach or economic incentives?

2.4 Analysis of Pilot Testing Measures Framework with States

The pilot test involved determining the feasibility and ease with which state agency staff could identify, track, and report on relevant effectiveness measures for select conservation actions. Nine states completed questionnaires on the four selected actions for the pilot phase. The Working Group used the pilot test results to modify existing results chains, measures, and questionnaires, as well as complete the development of materials for the remaining generic conservation actions that are presented in Appendix II.

All states were able to complete the surveys, although the level of difficulty in doing so varied. Most states reported that they had all or most of the data on hand to answer the questions. This included 71% of states for Outreach, 83% for Species Restoration, 60% for Land Acquisition, and 93% for Information and Data Collection. States gathered the data from existing reports, databases, or field interviews. Most states reported that it required one hour or less to gather the information. In those states where it was more difficult to acquire data, the difficulty stemmed from the need to involve multiple people in the process. Collection of financial data was cited as the greatest challenge.

There was a concern among the respondents that adopting this framework would be especially difficult if reporting requirements increase. In addition, concerns were raised that this project could lead to some duplication in databases and that some states would be resistant to making substantial changes to existing state databases to accommodate reporting of effectiveness measures. Pilot states that were part of the Working Group were more likely to indicate that data collection was relatively easy; those that were not part of the working group had more difficulties. About half of the states felt that some training would be needed on effectiveness measures data collection and reporting to help them successfully implement the framework.

Despite these concerns, pilot testers recognized the need for monitoring and reporting and felt that adoption of the effectiveness measures framework would get easier over time, especially if data collection were built into existing grant application and reporting processes. Most respondents felt that the reporting format was feasible and would be a better way to capture progress and accomplishments than the current system. However, it was noted that narratives that are part of the existing grant reporting process should be retained. One of the most frequently mentioned benefits of the process was the ability to summarize data across states in a consistent and standardized way – an aspect pilot testers felt would greatly improve the efficiency of reporting and make it possible to demonstrate the effectiveness of SWG and SWAPs. Another benefit expressed was that the process would clarify objectives and expectations from the outset. Overall the most relevant findings from the pilot testing include the need for 1) consistent measures across states; 2) clear expectations from the start on the level of effort needed for data collection; 3) training on developing and reporting effectiveness measures; and 4) ensuring that database entry and reporting are not duplicative.

2.5 Using the Framework to Promote Improved Project Management

Although the primary purpose of the Working Group was to develop effectiveness measures for conservation actions funded by SWG or implemented as part of SWAPs, the team also recognized the potential for this approach to generally improve project management with state agencies. If agency projects and programs use the effectiveness measures framework outlined in this report and the broader *Open Standards* on which they are based to define the context in which they are working, lay out their assumptions, and collect specific data to test these assumptions, they should be able to determine whether these actions are working to achieve the desired results. If the actions are not working as predicted, hopefully project managers can determine how to appropriately adapt their strategies. Furthermore, if managers share their results with other project leaders doing similar work in other states or regions, then these results can be collectively analyzed to determine the conditions under which the action is likely to work.

This kind of adaptive management would require managers to not merely report on the effectiveness measures for their specific actions, but also to take the underlying theories of change and adapt them to their specific circumstances. Getting managers to do this work would likely require additional training and support but could have huge potential payoffs in not just measuring the effectiveness of actions, but actually improving effectiveness over time.

2.6 Recommendations for Assessing the Effectiveness of Conservation Actions

The Effectiveness Measures Working Group offers the following recommendations for assessing the effectiveness of SWG-funded and SWAP-implemented conservation actions. It's understood that it is ultimately the choice of each state to decide whether to adopt these recommendations; they are strictly voluntary.

Recommendations: The Working Group recommends that the Teaming With Wildlife Committee:

- **Adopt the proposed effectiveness measures framework to improve accountability and project management of State Wildlife Grants.** If states want to be able to compare, roll-up, and report on the effectiveness of conservation actions, then states (or a subset of states representing the broader community) will have to 1) agree on specific generic conservation actions, 2) develop specific measures and data collection questionnaires for each action, and 3) collect and share data for all instances of that type of action being implemented. The Working Group believes that the framework and measures presented in this document meet these needs and can both serve accountability functions, and increase the potential for learning and improving conservation actions. We recommend that the Committee adopt this framework for SWG.
- **Integrate the framework into grant application and reporting processes.** State agency staff and resources are already stretched thin. If it is to be successfully implemented, the effectiveness measures framework will have to become part of the routine work of the agencies, replacing rather than adding to existing reporting requirements. Working Group members working in concert with staff from the USFWS Wildlife and Sport Fish Restoration Program and state federal aid staff should examine current grant making and reporting processes and make recommendations as to how these processes could be changed to accommodate the effectiveness measures framework and to streamline the inclusion of effectiveness data in grant making and reporting processes. As outlined in greater detail in Chapter 3, states may need to invest in new or change existing IT systems to collect and share data. Members of the Working Group will continue collaborating with the USFWS and other stakeholders to provide input into the design of the Wildlife TRACS reporting tool and other relevant tools to ensure that they meet the needs articulated in this report.
- **Extend the framework as needed for other generic conservation actions.** The Working Group has developed effectiveness measures for 11 of the most common conservation actions funded by State Wildlife Grants. The process used to develop these measures should be extended as needed for any additional actions for which it is necessary to track effectiveness. This work could be done by one or more teams on behalf of the broader community.

In addition to the above recommendations, the Working Group recommends that only essential data be collected for reporting to minimize the burden on states. Furthermore, the Working Group recommends that reporting occur over the long term to capture results that require longer timeframes. This may require that there be a standardized reporting interval and a mechanism to ensure reporting responsibilities are recognized and maintained as personnel leave or assume different job duties within an agency.

3. Information Technology Needs

3.1 Overview of Information Technology (IT) Needs and Issues

Through report language in SWG appropriations, Congress has specifically instructed the US Fish and Wildlife Service to work with states to adopt common mapping, data, and measurement standards to facilitate national evaluation and reporting. In order to track and report on the effectiveness of SWG-funded conservation actions, appropriate data needs to be collected and aggregated from state and national level databases.

Databases will need to track results from specific management *actions* undertaken as part of individual *projects* and/or *grants*, as well as provide a consistent means for reporting these data at a local, regional, state, or national level in a meaningful way. For example, a state agency may be interested in tracking the effectiveness of its land protection actions to improve the status of SGCN by tracking the number of priority acres placed under easement, while at a national level the USFWS may be interested in learning what percentage of priority acres, in all states, have been protected using State Wildlife Grant funding. If each state were recording both total acres targeted and total acres protected in a similar manner in an accessible database, this information could be 'rolled-up' across states to capture information on SWG effectiveness at regional or national scales. The effectiveness data that should be captured and aggregated will need to include both quantitative indicators (e.g., number of acres protected, population estimates, financial records) as well as more qualitative assessments (e.g., a story or project narrative) that can meet the needs of different audiences.

Federal, state, and tribal agencies as well as national and regional conservation organizations have developed a variety of databases and other related Information Technology (IT) tools that support at least some of the data collection and storage needs for tracking and reporting on the effectiveness of conservation actions. At the start of the Working Group's efforts in late 2009, however, no single database existed that would enable states to meet all of the IT needs to support the framework for measuring the effectiveness of conservation actions outlined in previous sections of this report. To this end, the Working Group reviewed the existing IT tools and provided guidance as to how states might select the tools that would make most sense for their overall IT needs, focusing in particular on databases that can aggregate, store, and manage information about wildlife conservation and management actions. The Working Group established criteria for the ideal database, reviewed how each candidate database performed against these criteria, and then developed recommendations about how states can work both individually and within larger partnerships to develop and deploy the best set of tools for their state's needs.

Over the past year, it has become apparent that the Wildlife TRACS system being developed by the USFWS specifically for SWG is the obvious system to use to support the effectiveness measures being proposed in this report. The USFWS and the Project Advisory Group have been supportive of the Working Group and are looking for its guidance on how to incorporate effectiveness measures into the TRACS system. It will be important for AFWA and members of the Working Group who are involved in the development of TRACS to continue providing that guidance and support during the development of TRACS.

3.2 Evaluation of Existing IT Tools

Three fundamental principles guided our efforts to develop criteria and evaluate existing IT tools:

- There is a core set of data fields and functions that characterize the ideal database for assessing the effectiveness of wildlife conservation and management actions.

- There are many existing databases that already perform some of the required tasks, but none currently meet all the characteristics of a database for tracking the effectiveness of wildlife conservation and management actions.
- The most cost-effective approach for tracking the effectiveness of actions will be to use a suite of tools, taking advantage of their existing strengths, and to cooperate in advancing the interoperability and functionality of these tools to create a robust network that easily shares data and reduces the need for redundant data entry.

Characteristics of the Ideal Database

The Working Group developed criteria for the ideal database through an iterative process. Our starting point was the NEAFWA Performance Monitoring Framework, *Appendix 10: Proposed Data Fields for Strategy Effectiveness Database*. These were then refined based on the needs and priorities that emerged from the Working Group. A full set of the criteria recommended by this working group can be found in Appendix V of this report.

The five types of criteria used to evaluate the existing databases include:

Key data fields that cover the range of information required to report on the effectiveness of wildlife conservation and management actions (e.g., actions, projects, conservation targets, viability, threats/stressors, work plan tools, budget tools, and project status).
Spatial data characteristics that are important for conveying mapped information (e.g., capability for spatial analysis, base maps, spatial import/export capability, and graphical diagrams such as results chains).
System design and administration characteristics (e.g., ease of use, privacy control, user access control, data quality control, and data import/export).
Business model characteristics (e.g., licensing structure, hosting model, and number of states currently using the system).
Use of standard structures and terms common within the conservation community (e.g., standard taxonomies for plants and animals, and standards adopted by the Conservation Measures Partnership).

Existing Data Management Tools

The Working Group reviewed eight existing or emerging data management tools most widely used by states or their conservation partners. This list is a subset of the many tools currently in use. In particular, several state agencies have implemented state-specific data management tools that are not covered here. However, one of the Working Group's desired outcomes is for more states to adopt common tools, or to design their own systems for full interoperability and data sharing. Thus, by highlighting tools in use across multiple states, the Working Group hopes to encourage their future adoption by others, or alternatively, the development of state-specific tools that are explicitly designed to be fully interoperable with multi-state norms.

This section summarizes the purpose of each data management tool and the strengths of each for measuring effectiveness of wildlife conservation and management actions. Additional information about the strengths and weaknesses of each tool relative to the characteristics of the ideal database can be found in Appendix V.

A key way in which data management tools differ is in their units of analysis – what constitutes a record or row in the database. For instance, some are organized around species or ecosystems. Others are organized to track projects, actions, or specific grants. In general, data management tools that focus on projects and actions are the most appropriate for evaluating and reporting on the effectiveness of conservation actions. But tools that have species or habitats as their main unit of information provide an essential link between project databases and the impact of all cumulative actions on the status of the species of greatest conservation need and their habitats.

The data management tools reviewed also represent the trade-offs inherent between power and simplicity. On the one hand, there are tools that are very easy to use. They are designed to be intuitive and useful to the lay person without any training. These tools are particularly suited to being implemented by large numbers of people who may use the system intermittently. But the focus on simplicity does impose constraints on the user's ability to customize the inputs, outputs, and the user interface. Other tools are very powerful, offering the ability to manage complex spatial data sets and relationships between information elements, as well as a high degree of user flexibility for reporting and analysis. The consequence of this complexity is that these tools require users to have more expertise and training, and sometimes even require specialists to operate them, thus limiting the range of people who can have direct access to the source information.

Finally, it is worth noting that this assessment of existing data management tools generally focuses on their current capabilities. Yet all of these are "living systems" that continuously evolve to meet emerging needs in their intended user communities, and all aspire to be useful to state fish and wildlife agencies working to implement their SWAPs. The developers of the Conservation Registry, Miradi, Wildlife TRACS, and Biotics/NatureServe Explorer, in particular, have been deeply engaged with AFWA to keep abreast of state requirements and plan for future enhancements.

Database Systems that Use Projects as the Main Unit of Analysis
(Tools are listed in alphabetical order. Full descriptions of each tool are included in Appendix V.)

- **ConPro** (conpro.tnc.org) – ConPro is an online database originally developed by the Nature Conservancy to track its conservation projects. ConPro is working with the Conservation Measures Partnership and Miradi to open up the system to non-TNC users. This will include the ability for states to create custom portals for tracking conservation projects, as well as the ability to set granular data access controls.
- **Conservation Registry** (www.conservationregistry.org) – The Registry is an online application that states can use to share information and knowledge including text that describes each conservation project, the actions associated with the project, the status of the actions (e.g., "in progress"), and supplement the data with hot links and reference materials. The tool is maintained by Defenders of Wildlife (www.defenders.org), and there are no limitations on who can use the Registry.
- **HabITS** – HabITS is a centrally-hosted, geo-spatial database for the USFWS Partners for Fish and Wildlife and Coastal Programs to track agreements, projects, and sites. HabITS also includes work plan and budgeting tools that track staff days and financial contributions. At this time, access to the system is limited to the Partners for Fish and Wildlife Program with a high level of privacy protection, but some level of public access is being considered for the future. HabITS will likely form a core of the emerging Wildlife TRACS system.
- **Miradi** (www.miradi.org) – Miradi is a project management, desktop software application designed to help program managers organize and track project activity through conceptual models and results chains (for example, all of the results chains diagrams in this report were produced using Miradi). Among all the software evaluated, Miradi has the most highly developed set of tools for documenting and tracking indicators of project performance. It does not include spatial GIS data, but that is a planned enhancement for the future.
- **Wildlife TRACS** (www.fws.ekosystem.us) – Wildlife TRACS is a new, online database under development by the USFWS and piloted by the Washington Department of Fish and Wildlife. Wildlife TRACS is the only data management tool that is explicitly being designed to facilitate WSFR/USFWS tracking and reporting on federal assistance grants, including SWG. The design team includes representatives from state fish and wildlife agencies, AFWA, and many of the organizations that maintain the other data management tools listed here

(Conservation Registry, HabITS, Miradi, Biotics). It's anticipated that there will be some degree of interoperability among these systems.

Other Important Systems

- **Biotics 4** (www.natureserve.org/prodServices/biotics.jsp) – Biotics 4 is a desktop application designed to integrate into the workflow of state natural resource agencies. By using national standards to track changes in the status of conservation targets (species or ecosystems), Biotics fulfills a critical long-term requirement for measuring effectiveness. The system is currently deployed in 46 US states and Puerto Rico, as well as Canada and Latin America. The remaining states all use fully compatible and interoperable systems.
- **DataBasin** (http://databasin.org) – This is an online tool for sharing and visualizing spatial data. DataBasin's larger objective is to create a vibrant, online community of conservation practitioners who self-organize into interest groups that share and improve spatial data. Although DataBasin is not currently set up to deliver data via web services, it should be a valuable source of quality spatial data that states can integrate into their SWAP analyses.
- **NatureServe Explorer Web Service** (http://services.natureserve.org/index.jsp) – This tool provides free and open access to virtually all of the data maintained in the Biotics 4 data system, except for sensitive spatial data. This web service provides direct access to data on the status, distribution, range, taxonomy (including synonyms), habitat preferences, threats, and management needs of over 53,000 species of the United States for incorporation into state-based data systems or other tools such as Wildlife TRACS.

Creating a Robust "IT Ecosystem"

As stated above, no single database currently exists that would enable states to meet all of the IT needs to support the framework for measuring the effectiveness of conservation actions outlined in previous sections of this report. Instead, there is an "IT Ecosystem" in which multiple databases and other tools fill different niches required by diverse agencies and organizations. The key is to ensure that the various components fit and link together to create a robust overall IT Ecosystem. In particular, we need to make sure that these different tools seamlessly hand-off information to one another. For example, projects that are managed locally in Miradi Software might then automatically upload their information to Wildlife TRACS, ConPro, or the Conservation Registry. These databases could then also pull in information about conservation targets from Biotics, and perhaps threat information from a map layer within Data Basin. They could then also export this information to www.grants.gov. There are many social, economic, and logistical issues that will need to be overcome in order to realize this vision and advance the conservation and stewardship of our fish and wildlife heritage, but the vision is technically feasible and will reduce costs and workload in the future.

3.3 Considerations for IT Needs

Effective tracking and reporting of conservation actions will depend on the continued role of states in measuring SWG effectiveness and developing appropriate IT tools as described in this report. The Working Group suggested that the following be considerations be made in the context of IT system development:

- **Use common mapping, data, and measurement standards wherever possible.** Each state has its own unique requirements that drive its information technology needs. However, to facilitate data sharing and roll-up of effectiveness measures as requested by Congress, states with existing IT systems should incorporate standard data structures and terms into their own systems. States needing to develop new systems should consider adopting one or more of the tools described in this report that meet these standards. In particular, states should consider working with and adopting Wildlife TRACS as it becomes available.

- **Work with the US Fish and Wildlife Service to ensure that Wildlife TRACS can collect and share effectiveness measures as outlined in this report.** The fish and wildlife conservation community has a unique opportunity to promote and influence the development of Wildlife TRACS to support effectiveness measures collection, data integration from existing tools, and reporting to meet various audiences' needs. Members of the Working Group should continue to collaborate with the US Fish and Wildlife Service and its contractors to ensure that Wildlife TRACS meets the data collection and sharing needs articulated in this report. In addition, states should directly give input into the design of Wildlife TRACS, and address gaps in compatibility to make their current data systems interoperable with Wildlife TRACS.
- **Participate in development of IT systems that share data via linked networks.** To meet all of the IT requirements for tracking and reporting the effectiveness measures framework outlined in this report while minimizing redundant data entry, state fish and wildlife agencies should:
    - Establish data management practices that encourage participation in data sharing networks,
    - Support active participation of their information managers in groups that promote interoperability such as the Organization of Fish and Wildlife Information Managers (OFWIM), the Conservation Measures Partnership, and the state natural heritage data network, and
    - Collaborate with developers of relevant tools such as Wildlife TRACS, Biotics, Miradi, and the Conservation Registry to ensure that their tools meet state needs.

4. Extending the Framework to Assess Overall SWAP Effectiveness

4.1 Assessing Overall SWAP Effectiveness

When the State Wildlife Grants program was created, Congress required that eight elements be addressed within each Wildlife Action Plan. States used a variety of tools and techniques in drafting their SWAPs, and the plans represent 56 different approaches to meeting a state's conservation priorities. As 2015 approaches, when all SWAPS must be updated, it seems an opportune time to assess the SWAPs to determine which aspects of the plans have been most effective at preventing species from becoming endangered. Such an effort could provide action plan coordinators and agency personnel with valuable insights. It would also provide Congress and the US Fish and Wildlife Service with data to help ensure these plans continue to be relevant.

As is the case with any evaluation or assessment, the methods that could be used to undertake this work vary in terms of their precision and cost. Depending on the audience and budget, this assessment could be done as a rapid self-assessment by one or more states or USFWS. Alternatively, it could be done as an extensive external third-party evaluation on behalf of one or more of the above groups. In all cases, however, the assessment would require laying out the core theory of change behind SWAPs as well as the indicators that could be used to assess whether this theory holds.

Although it was far beyond the charge of the Working Group to complete or even start such an assessment, the group did lay out the basic theory of change behind SWAPs and present some options for how such an assessment might be done. It will be up to AFWA, the states, and the USFWS to determine if and how these recommendations might be carried forward.

4.2 Proposed Results Chain and Indicators for Assessing SWAP Effectiveness

As outlined in the previous sections of this report, the basic approach for assessing the effectiveness of a given action involves laying out the theory of change in a results chain, and then determining the appropriate effectiveness indicators to monitor. This methodology can be extended to assess SWAP effectiveness by treating the development and implementation of SWAPs as one comprehensive action.

As shown on the right hand side of Figure 8, the ultimate goal of SWAPs is to improve the conservation of wildlife and their habitats in the 56 states and territories. To achieve this ultimate goal, SWAPs are designed to improve the capacity of state wildlife agencies and their partners to take action to restore degraded species populations and habitats and to counter threats to wildlife. One main pathway (Path A) by which the SWAPs lead to better conservation is through increased funding available for conservation work through SWG and other sources of funds. Based solely on this pathway, the net impact of the SWAP program is the "sum of the effectiveness" of these funded actions.

Increased funding is not, however, the sole path by which SWAPs can improve conservation in states. Perhaps the simplest is Path B, which assumes that if states implement SWAPs, they will be able to be more strategic in the actions they take and fund to support wildlife conservation. Under Path C, as they implement their SWAPs, they improve the policy environment which in turn creates more funding for conservation work. Following Path D, SWAPs also enable states to better coordinate the work done by other state agencies and other actors – for example, ensuring that roads built by transportation departments take into account wildlife needs. And finally, following Path E, SWAPs enable the development of more effective coalitions of agencies and organizations, thus enhancing the ability to do better conservation.

Figure 8. Overall Results Chain and Indicators for State Wildlife Action Plan Effectiveness

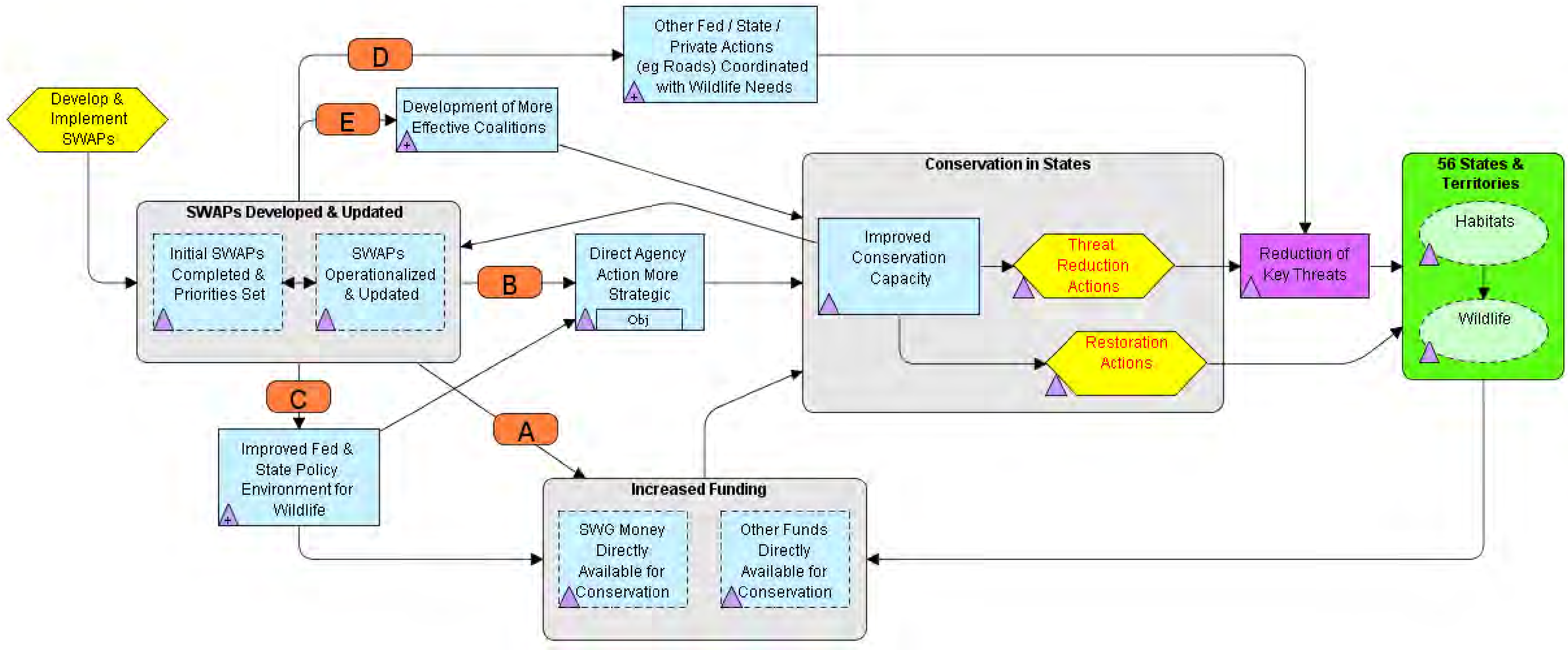


Table 2. Key Indicators for Results Chain in Figure 8

Measure	Objective	Details
1. # "good" plans completed	Initial SWAPs Completed & Priorities Set	Need to define criteria for "good"
2. Evidence that SWAPs are Living Docs	SWAPs Operationalized & Updated	- priorities and "battle plan" (1 = no prioritization; 4 = very clear priorities) - folks refer to it in the state / incorporated into and reported on other plans - measures being collected and used
A1. Amt of SWG $$ (absolute and change)	SWG Money Directly Available for Conservation Work	
A2. $$ Available (total and change)	Other Funds Directly Available for Conservation Work	
B1. Evidence that work plans support SWAP priorities	Direct Agency Action More Strategic	Sample agency and organizational work plans in relation to SWAP priorities.
C1. Evidence of changes in Policies and Procedures and Regulations	Improved Fed & State Policy Environment for Wildlife	
C2. Improved Leadership Buy in	Improved Fed & State Policy Environment for Wildlife	
D1. % of other agency activities that "contravene" SWAP priorities	Other Fed / State / Private Actions Coordinated with Wildlife Needs	- Dept 1 (e.g., Transportation) - Dept 2 (e.g., Urban Planning)
D2. Assessment of "cooperation" by other agencies	Other Fed / State / Private Actions Coordinated with Wildlife Needs	Do agencies at least consult with SWAP before road building? Are SWAPs cited in development plans or EIAs?
E1. #s of new coalitions or coalitions that cite SWAPs	Development of More Effective Coalitions	
E2. Evidence as aggregation device...	Development of More Effective Coalitions	Are SWAPs an aggregation device for NGOs and agencies to work together???
E3. Evidence that SWAPS feeding into NGO work	Development of More Effective Coalitions	
F1. Capacity of Conservation Actors	Improved Conservation Capacity	
F2. # of / $'s Spent on Different Actions	Threat Reduction Actions	
F3. # of / $'s Spent on Different Restoration	Restoration Actions	
F4. Threat Status	Reduction of Key Threats	
F5. Habitat Conservation	Habitats	
F6. Wildlife Conservation	Wildlife	

Based on this chain, there are a number of indicators that could be collected to assess progress. For example, along Path B, an evaluator might assess a sample of state projects to see what percentage conforms to SWAP. Obviously, this work would have to take into account the differing level of investment that states have for their work. Table 2 lists key indicators that could potentially be used to track progress along each of these paths.

4.3 Recommendations for Assessing Overall SWAP Effectiveness

As stated previously, it is beyond the charge of this Working Group to decide whether AFWA, WSFR, or other key players should undertake an evaluation of the effectiveness of SWAPs. However, we do make the following recommendation:

- **Form a Working Group to Assess and Recommend Improvements for SWAPs.** To ensure State Wildlife Action Plans remain relevant and effective, a Working Group should be convened in the future to identify best practices and to make recommendations on improving the plans. The Working Group should complete its work prior to the 10-year anniversary of the plans in 2015.


Iowa Dept of Natural Resources

5. Summary Recommendations and Proposed Next Steps

5.1 Summary of Working Group Recommendations

The Working Group recommends that the TWW Committee adopt the following recommendations:

- **Approve the Proposed Effectiveness Measures Framework for SWG.** The framework and effectiveness measures described in this report are the result of more than a thousand hours of labor by the Working Group, state fish and wildlife agency staff, and others during the last 18 months. Initial draft measures were tested by nine pilot states, reviewed by State Wildlife Action Plan Coordinators, and distributed for review to states and partners. Drafts of the measures were also made available for review by the Office of Management and Budget and congressional appropriations staff. The resulting measures represent the best collective thinking on effectiveness measures that should stand the test of time and have applicability beyond SWG.
- **Integrate SWG Effectiveness Measures into the USFWS Wildlife TRACS Reporting and Tracking Tool.** The USFWS began work on a new reporting and data tracking system concurrent with the effectiveness measures project. Wildlife TRACS is being designed to make full use of the effectiveness measures developed by the Working Group and after an evaluation of potential information technology systems, TRACS was deemed the best system available to track and report on effectiveness of SWG, as outlined in this report.
- **Explore Options for Integrating Effectiveness Measures into the Grant Application and Reporting Process.** The Wildlife TRACS Project Advisory Group is exploring ways to streamline the grant making and reporting process for SWG. To ensure that the framework can be successfully implemented, it is important that data collection and reporting not add substantially to existing grant making and reporting processes. Consideration should be given as to how best to incorporate effectiveness measures into these processes to ensure the utmost efficiency in data collection and reporting.
- **Form a Working Group to Assess and Recommend Improvements for SWAPs.** To ensure State Wildlife Action Plans remain relevant and effective, a Working Group should be convened in the future to identify best practices and to make recommendations on improving the plans. The Working Group should complete its work prior to the 10-year anniversary of the plans in 2015.

5.2 Proposed Next Steps

If the recommendations in this report are approved, then the Working Group proposes the following steps be taken.

- **Continue Coordinating with USFWS on Development of Wildlife TRACS.** Members of the Working Group who are also members of the Wildlife TRACS Project Advisory Group will continue working to develop the Wildlife TRACS reporting tool to ensure the effectiveness measures framework can be integrated into this system. They will also work to make changes to federal grant making processes to facilitate the efficient collection and reporting of effectiveness measures data.
- **Conduct Communication & Outreach Efforts.** Although the Working Group regularly communicated with the TWW Committee, agency directors, action plan coordinators and others, outreach will need to continue throughout the implementation of the framework. Outreach will be conducted principally by AFWA and by the USFWS as part of communication related to Wildlife TRACS.

- **Develop Training Materials and Coaches.** Based on the pilot test, there is a need for training to raise awareness and knowledge about results chains and effectiveness measures as they relate to the overall project cycles. AFWA and its partners should consider potential collaboration with ongoing related training efforts through the National Conservation Training Center and the Conservation Measures Partnership.

APPENDIX I. COMMON GENERIC CONSERVATION ACTIONS FUNDED BY SWG

The following 11 generic conservation actions were identified by the Working Group as most commonly funded by SWG. In addition, the list contains two additional actions that are often taken as components of other actions. This list was developed by first reviewing State Wildlife Action Plans and SWG performance reports to develop an initial list of commonly-mentioned actions. To provide a standard structure, the group then categorized and synthesized these actions following the IUCN-Conservation Measures Partnership's Standard Classification of Conservation Actions (IUCN-CMP 2008). States and USFWS's WSFR Program provided additional input to further refine the list. The list is **not** meant to be exhaustive, but rather represents the most common actions and will likely need to be added to over time.

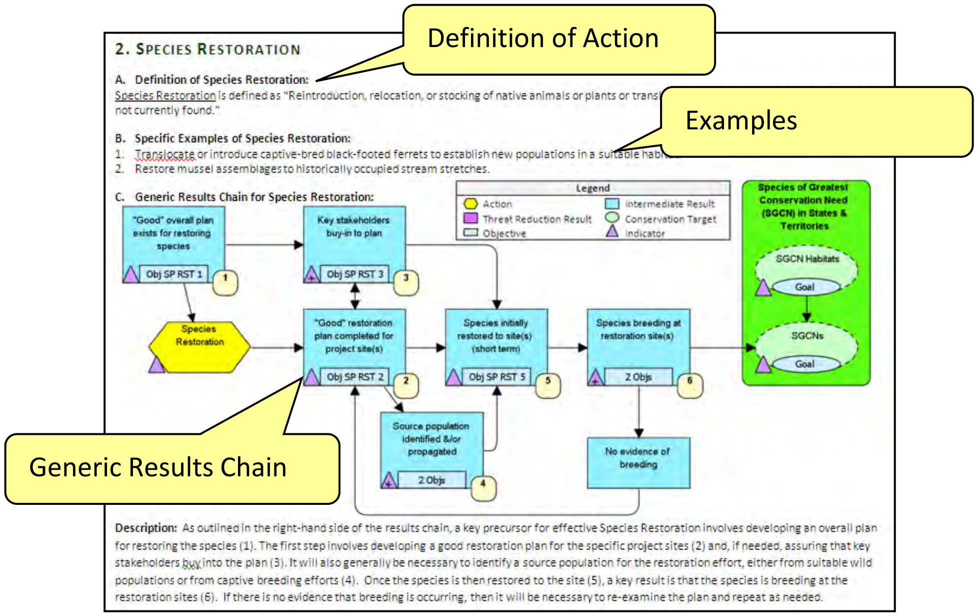
Conservation Action	Draft Definition	Examples
1. Direct management of natural resources	Stewardship of terrestrial and aquatic species, habitats and/or natural processes to maintain populations or restore ecological functions.	• Conduct controlled burns • Manage invasive species • Remove dams and other barriers
2. Species restoration	Reintroduction, relocation, stocking of native animals or plants, or translocation of animals to an area where they are not currently found.	• Translocate/breed in captivity Black-footed Ferrets to establish new populations in suitable habitat • Restore mussel assemblages to historically occupied stream stretches
3. Creation of new habitat	The creation or establishment of *new* habitats, including necessary natural processes, habitat structures, and biotic components to mitigate loss of ecological functions elsewhere.	• Establish prairie communities where crop land currently exists • The creation of new breeding habitat for Gopher Frog reintroduction and due to a climate adaptation strategy and recovery plan
4. Acquisition / Easement / Lease	Protection of land or water real property or rights through fee title acquisition, permanent easement, lease, contract, or a related means.	• Purchase land in a corridor connecting a Wildlife Management Area and a National Wildlife Refuge • A perpetual easement restricting land conversion and development is placed on a remnant tall grass prairie • A 20-year term contract is placed on a privately-owned Pennsylvania wet meadow for protection and recovery of the Bog Turtle
5. Conservation area designation	Designation of a site or landscape as having unique and important value to wildlife with or without legal protections.	• Designate an area as an Important Bird Area • Designate an area as an Important Reptile/Amphibian Area • Add an area to a State Natural Area Registry

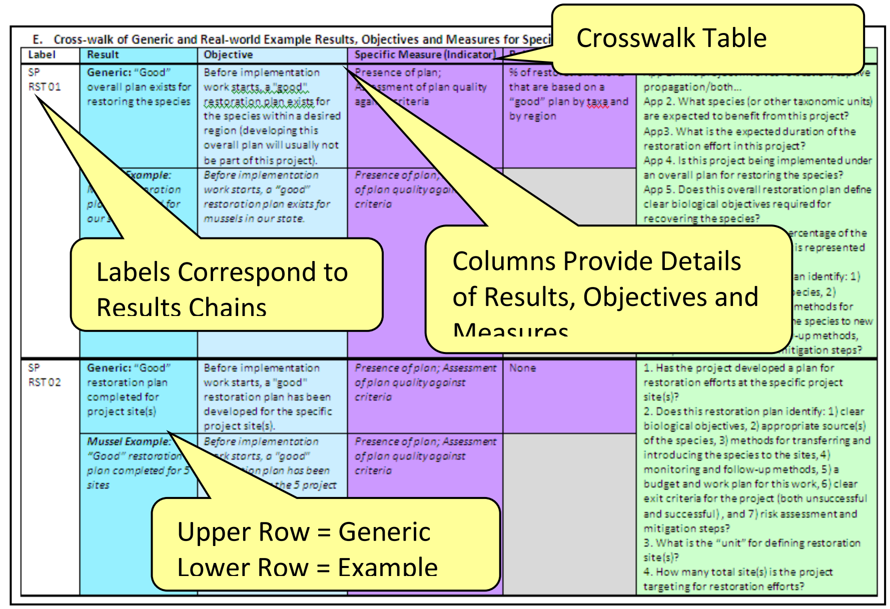
Conservation Action	Draft Definition	Examples
6. Environmental review	Review of agency and private sector policies, projects, and plans (primarily related to development and potential adverse impacts to natural resources) to help ensure potential impacts to fish and wildlife are avoided, minimized and/or compensated/mitigated.	• Review of proposed new landfill siting alternatives to recommend which alternative(s) will least impact natural resources immediately (direct) and over time (indirect, cumulative), and where mitigation activities and dollars would be best spent to compensate for unavoidable resource impacts • Review new highway route alternatives and make recommendations for resource protection from planning through implementation • Review of new road salt application policy to ensure timing, periodicity, and intensity to avoid or limit potential impacts to natural resources
7. Management planning	Development of management plans for species, habitats, and natural processes.	• Develop a management plan for migration corridors • Develop a management plan for Longleaf Pine habitat • Develop a management plan for endangered mussels
8. Land use planning	Leading or participating in land use planning for rural, urban, or agricultural lands.	• Develop county-wide zoning plans • Participate in workgroup regarding low impact development siting • Develop city plan for implementing best management practices for stormwater management
9. Training & technical assistance	Training is defined as "Skills development for professionals, key stakeholders, or others to facilitate needed management activities and techniques." It does not include training that is minor or a routine component of implementing another action. It does include certification or apprenticeship models. It is not the same as information delivery (e.g., education or outreach), although training could lead to an education or outreach conservation action for threat reduction. Technical Assistance (TA) is defined as "Tangible, practical support (e.g., skills, knowledge, recommendations) delivered by experts to professionals or key stakeholders for the purpose of helping them implement specific conservation actions."	• Provide training for agency staff in reptile and amphibian assessment techniques • Provide classroom training in elements of prescribed fire qualifications (e.g., planning, tool familiarity, weather) to resource professionals who will eventually take "next steps" to become site-based Fire Operators and leaders (e.g., Crew Leaders, Burn Bosses) • Provide qualified prescribed fire operators with "apprenticeship" in field skills (e.g., leading crews, ignition, fire management, safety and emergency response) leading toward Fire Leader (Burn Boss) certification or qualification • Provide technical assistance in successful techniques to assess (e.g., field surveys, boundary document reading, conservation value rapid assessment), write successful terms and conditions, and monitor (timeframes, techniques, etc.) a conservation easement • Provide technical assistance in the form of one-on-one engineering consultation for dam removal

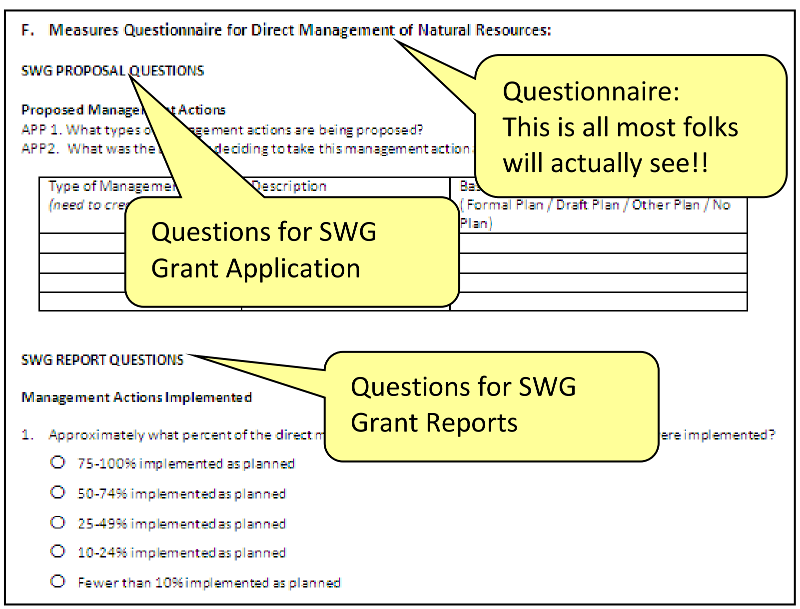
Conservation Action	Draft Definition	Examples
10. Data collection & analysis	Collecting data about species and habitats and the threats to them to fill information needs; includes compilation, management, synthesis, analysis, and reporting of spatial and nonspatial data.	• Gather data on the Shenandoah salamander to define current distribution, survey methodologies and understand habitat use, and threats • Conduct surveys & genetic assessments of three North American minnow SGCNs to determine baseline population data to assist in the establishment of conservation units
11.Education	Actions or efforts to increase knowledge or understanding and encourage practices in support of SGCN conservation through instruction or distribution of materials or to provide general information in response to inquiries from the public or partners about SGCN conservation programs, actions, or activities. Includes both formal (e.g., classroom) and non-formal education efforts.	• Implement a timber rattlesnake educational program that includes developing educational materials, conducting workshops on conservation efforts, and conducting habitat management demonstration tours to NGO's interested in implementing timber rattlesnake conservation projects • Conduct outreach to landowners to implement land management practices to benefit species • Providing decision makers with data about pollution impacts on at-risk aquatic species to help them set water quality standards for key water bodies
A. Incentives	Development and delivery of economic incentives to private landowners to influence responsible stewardship of land/water and specific species.	• Tax breaks • Stewardship payments to landowners (doing the right thing, continue to do the right thing) • Management infrastructure & practices incentives (e.g., $ to build a fence, infrastructure, delay hayfield) • Restoration incentives (e.g., $ to restore wetland) • Regulatory streamlining • Technical assistance
B. Stakeholder Involvement	Engaging state and federal agencies, tribal entities, the NGO community and other partners to achieve shared objectives and broader coordination across overlapping areas.	• Establish decision-making processes with state agencies • Outreach with tribal governments • Convene an advisory committee to assist with implementation of a State Wildlife Action Plan

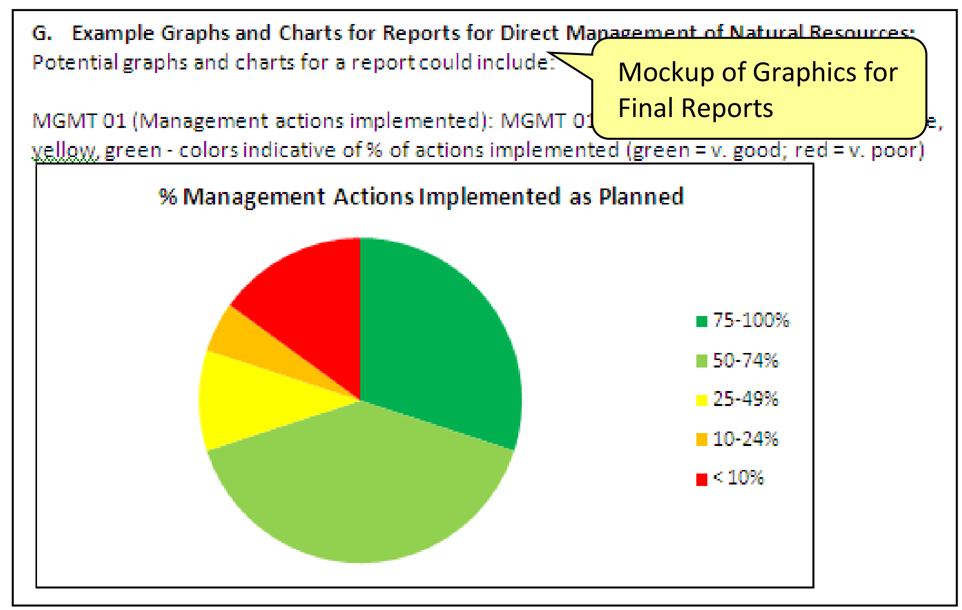
Appendix II. Effectiveness Measures for Generic Actions

This appendix contains the bulk of the work completed by the Working Group. For each of the 11+2 actions defined in Appendix 1, we provide a ***definition of the action***, one or more ***examples***, "generic" and "example" ***results chains***, a "crosswalk table" that provides details for the ***results***, ***objectives***, and ***measures*** shown in each results chain, and a ***questionnaire*** that translates the measures into survey-type questions that could be integrated in application and reporting forms in Wildlife TRACS and other systems. For a few actions, we also provide ***mockups of graphics for final reports***.









1. Direct Management of Natural Resources

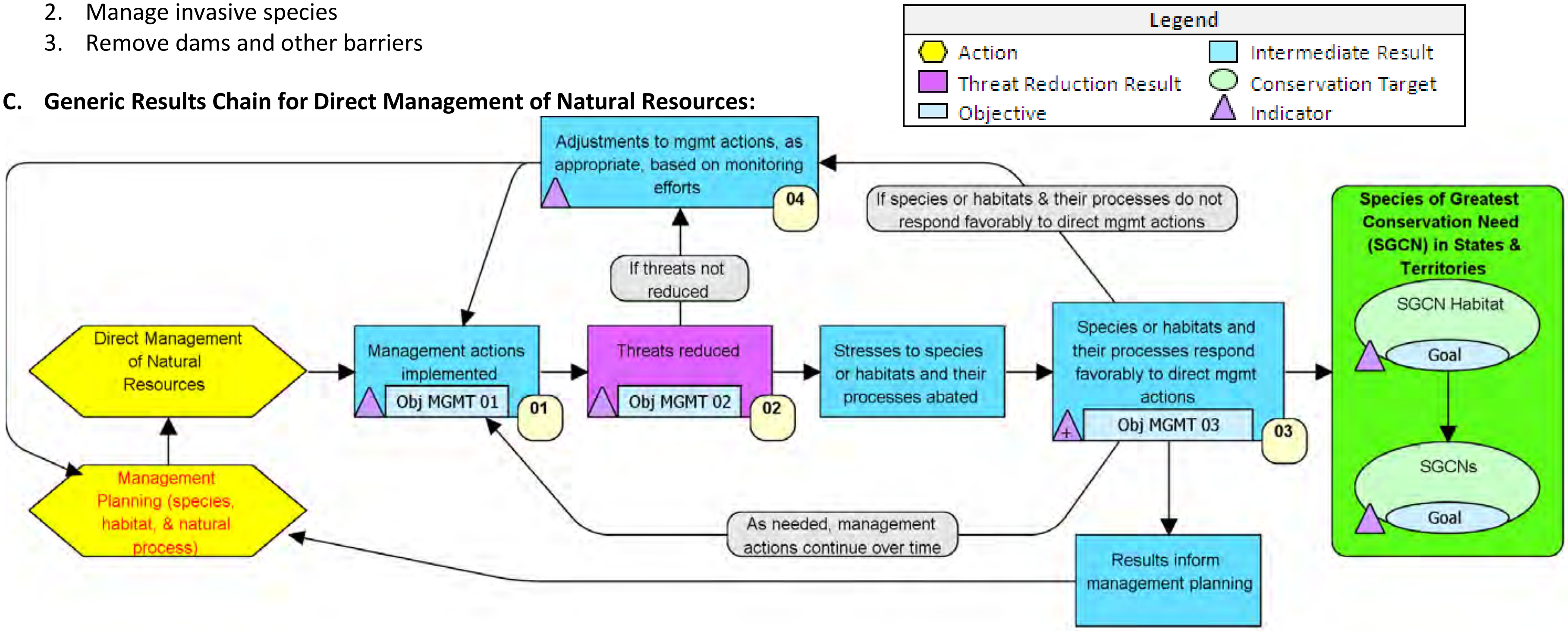
A. Definition of Direct Management of Natural Resources:

Direct Management of Natural Resources is defined as "Stewardship of terrestrial and aquatic species, habitats and/or natural processes to maintain populations or restore ecological functions." *Includes the restoration of degraded species and habitats that are at the site but not the reintroductions of species or creation of new habitat.*

B. Specific Examples of Direct Management of Natural Resources:

1. Conduct controlled burns
2. Manage invasive species
3. Remove dams and other barriers

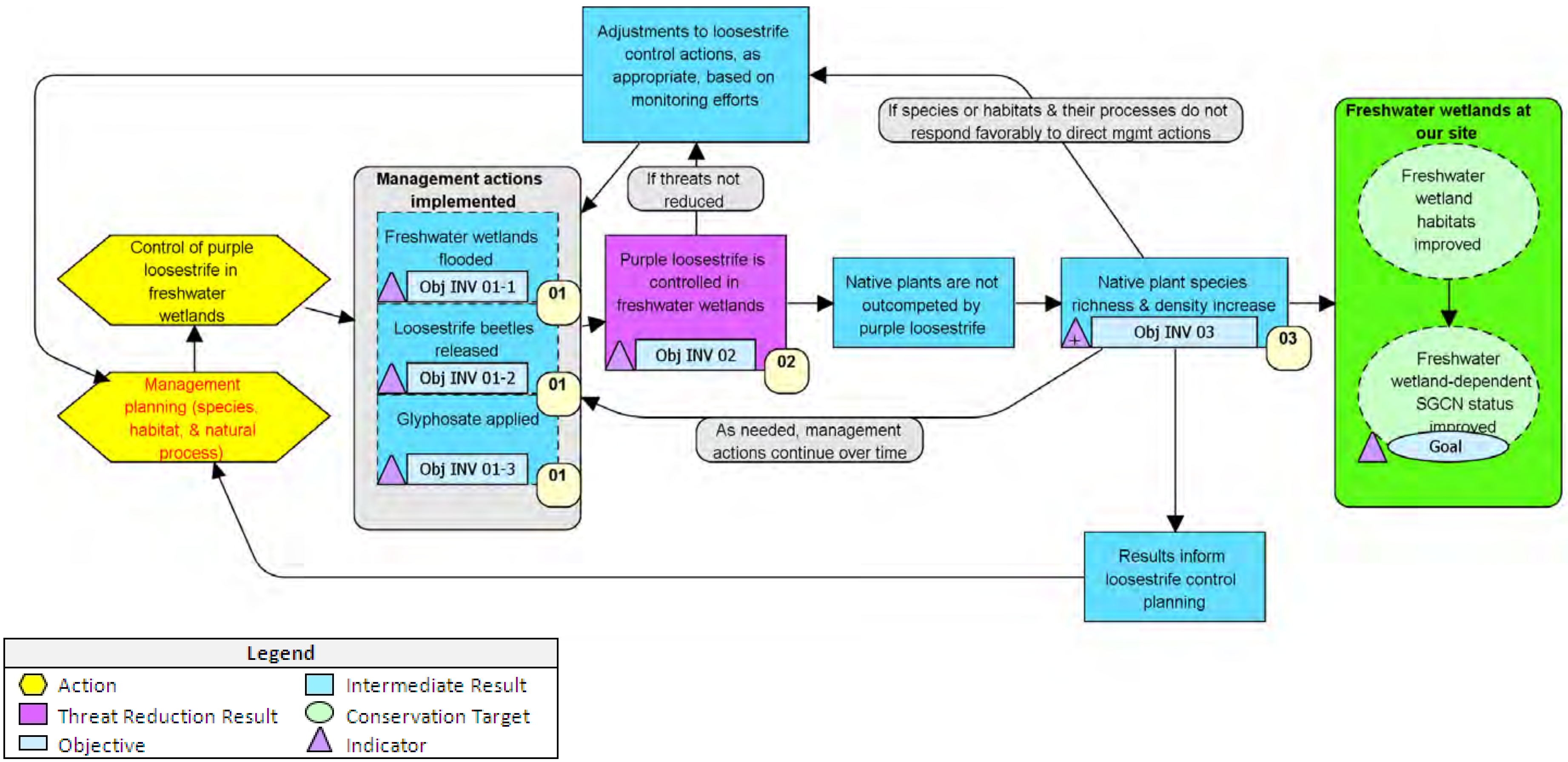
C. Generic Results Chain for Direct Management of Natural Resources:



Description: Direct management is one of the most common and fundamental conservation actions used by states to manage species of greatest conservation need (SGCN) and their habitats. Before implementing a direct management action, it's assumed that a management plan has been completed (yellow hexagon in red text). That plan informs the direct management actions that should occur. Ideally, all management actions should be implemented, but that is not always possible. Part of the monitoring (see Cross-Walk table in Section E) of implementation includes identifying the percentage of management actions that are being implemented over a predetermined time span. Upon implementation of direct management (01), threats will either be reduced or not reduced (02). In the latter case, adjustments in the management action or in planning will be needed (04). If threats are reduced, then the stressors to species or their habitats/processes will be abated. If threats are reduced then the next expected result is that species or habitats and their processes have responded favorably to the direct management action (03) (e.g., the degree to which the targets responded to management; the degree to which the targets responded as expected to management). At this point in the results chain, there are three potential pathways. If the targets (SGCN species/habitats/processes) respond favorably to direct management and are more secure, then there is no response requiring an adjustment in management (04), and lastly the results are used to inform future management. Finally, the chain also reflects that many management actions continue over time, so there would be a feedback loop between Result 03 and Result 01.

D. Example Results Chain for Direct Management of Natural Resources:

This fictitious example is based on a case of controlling invasive Purple Loosestrife plants in freshwater wetlands.



E. Cross-walk of Generic and Example Results, Objectives and Measures for Direct Management of Natural Resources:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
MGMT 01	**Generic:** Management actions implemented	Within X months/years of receiving funding, at least X% of mgmt actions are being implemented as planned	% mgmt actions implemented as planned	% of actions done by plan % initiatives that fall into each category of implementation status	APPLICATION APP1. What types of management actions are being proposed? APP2. What was the basis for deciding to take this management action at this site? REPORT 1. Approximately what percent of the direct management actions in the original grant application were implemented?
	Loosestrife Example: *Freshwater wetlands flooded*	*Within 1 year of receiving funding, 100% of wetlands targeted for flooding were flooded*	*% of wetlands targeted for flooding that were flooded*		
	Loosestrife Example: *Loosestrife beetles released*	*Within 2 years of receiving funding, at least 75% of freshwater wetlands targeted for loosestrife beetle release have established beetle populations*	*% of freshwater wetlands targeted for loosestrife beetle release that have established beetle populations*		
	Loosestrife Example: *Glyphosate applied*	*Within 1 year of receiving funding, at least 50% of freshwater wetlands targeted for chemical control have received glyphosate applications*	*% of freshwater wetlands targeted for chemical control that have received glyphosate applications*		
MGMT 02	**Generic:** Threats reduced	Within X years of the start of the action, the desired threat reduction is seen	Evidence that direct management action is reducing key threats	% of initiatives that show the expected reduction in key threats being addressed by direct management actions	2. What threat(s) were you hoping to address through the management action(s) and do you have evidence that the action(s) are leading toward reductions in any of these threats? 3. Additional comments or anecdotes (optional)
	Loosestrife Example: *Purple Loosestrife is controlled in freshwater wetlands*	*Within 3 years of receiving funding for the Purple Loosestrife control program, purple loosestrife stem density is decreased by at least 75% (as compared to 2011 levels) in targeted freshwater wetlands*	*Stem density of Purple Loosestrife*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
MGMT 03	**Generic:** Species or habitats/processes respond favorably	Within X months/years of implementing direct management actions, species or habitats and their processes respond as expected from direct management leading to fulfillment of stated objectives	a. Degree to which target SGCNs respond as expected from direct management actions b. Degree to which target habitats/processes respond as expected from direct management actions	a. % of initiatives in which target SGCNs at least partially benefit b. % of initiatives in which target habitats/processes at least partially benefit	4. Did you achieve your objectives regarding target SGCNs response to the direct management actions? 5. Did you achieve your objectives regarding target habitats/processes responses to the direct management actions? 6. Additional comments or anecdotes (optional)
	Loosestrife Example: *Native plant species richness & density increase*	*Within 3 years of implementing purple loosestrife control actions, native plant species richness increases by at least 15 species and density increases by at least 50%*	a. *# of species of native plants* b. *Stem density of native plants*		
MGMT 04	**Generic:** Adjustments to mgmt actions, as appropriate, based on monitoring efforts	Note: No objective or indicator because neither tell the reviewer if the team made the *right* choice. Important, however, to ask questions to help teams think about using monitoring results to adjust	N/A	N/A	7. What action (if any) did your project team take to address the fact that you were not seeing desired threat reduction or response in species or habitats/processes? Please explain your rationale for adjusting or abandoning your management actions. 8. Please provide any narratives, case studies, or additional comments you may have related to your work in direct management of natural resources (optional)
	Loosestrife Example: *Adjustments to loosestrife control actions, as appropriate, based on monitoring efforts*	*N/A*	*N/A*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	Goal: Within X years of the start of the action, the species of interests have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Loosestrife Example: *Freshwater wetland-dependent SGCN status improved*	*Goal:* Within 3 years of implementing Purple Loosestrife control actions, Bog Turtle populations are documented as stable or increasing in at least 40% of the targeted wetlands	Trend in Bog Turtle populations by freshwater wetland		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	<u>Goal:</u> Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Loosestrife Example: *Freshwater wetland habitats improved*	*None set because very similar to objective set for native plant species richness and density*	*N/A*		

F. Measures Questionnaire for Direct Management of Natural Resources:

SWG PROPOSAL QUESTIONS

Proposed Management Actions
APP 1. What types of management actions are being proposed?
APP2. What was the basis for deciding to take this management action at this site?

Type of Management Action *(need to create pick list)*	Description	Basis for Action (Formal Plan / Draft Plan / Other Plan / No Plan)

SWG REPORT QUESTIONS

Management Actions Implemented
1. Approximately what percent of the direct management actions in the original grant application were implemented?

- ○ 75-100% implemented as planned
- ○ 50-74% implemented as planned
- ○ 25-49% implemented as planned
- ○ 10-24% implemented as planned
- ○ Fewer than 10% implemented as planned

Type of Management Action ***(populate from APP 1)***	**Description** ***(populate from APP 1)***	**% Completed**

Threat Reduction
2. What threat(s) were you hoping to address through the management action(s), and do you have evidence that the designation(s) are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org. *Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.*

Direct Threat	Check if relevant	Evidence of reduction?	Please explain
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	

7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	
11 Climate Change & Severe Weather	☐	y/n/don't know	

3. Additional comments or anecdotes (optional)

Evidence of Expected Response

4. Did you achieve your objectives regarding target SGCNs response to the direct management actions?

- ○ Most or all SGCN responded to the desired level (comments, optional)
- ○ Most or all SGCN responded but not to the level desired (comments, optional)
- ○ Some SGCN responded fully or partially but not all responded (comments, optional)
- ○ SGCN did not respond as expected (please explain ____________________)
- ○ Don't know (please explain____________________)
- ○ Not applicable (main focus of action was on habitats/processes)

Programming notes: Depending upon response, bring up an additional field for comments (optional) or please explain, as indicated above. For roll-up, SGCNs that at least partially benefit should fall into one of the first 3 categories.

5. Did you achieve your objectives regarding target habitats/processes responses to the direct management actions?

- ○ Most or all habitats/processes responded to the desired level (comments, optional)
- ○ Most or all habitats/processes responded but not to the level desired (comments, optional)
- ○ Some habitats/processes responded fully or partially but not all responded (comments, optional)
- ○ Habitats/processes did not respond as expected (please explain ____________________)
- ○ Don't know (please explain____________________)
- ○ Not applicable (main focus of action was on SGCNs, not their habitats or processes)

Programming notes: Depending upon response, bring up an additional field for comments (optional) or please explain, as indicated above. For roll-up, habitats/processes that at least partially benefit should fall into one of the first 3 categories.

6. Additional comments or anecdotes (optional)

Adjustments to Actions

Programming note: Only show this question if answer to questions 4 and 5 were not the first or last option

7. What action (if any) did your project team take to address the fact that you were not seeing desired threat reduction or response in species or habitats/processes?

   ○ Adjusted our suite of management actions or implementation schedule

   ○ Abandoned the direct management action

   ○ Other (please specify ____________________)

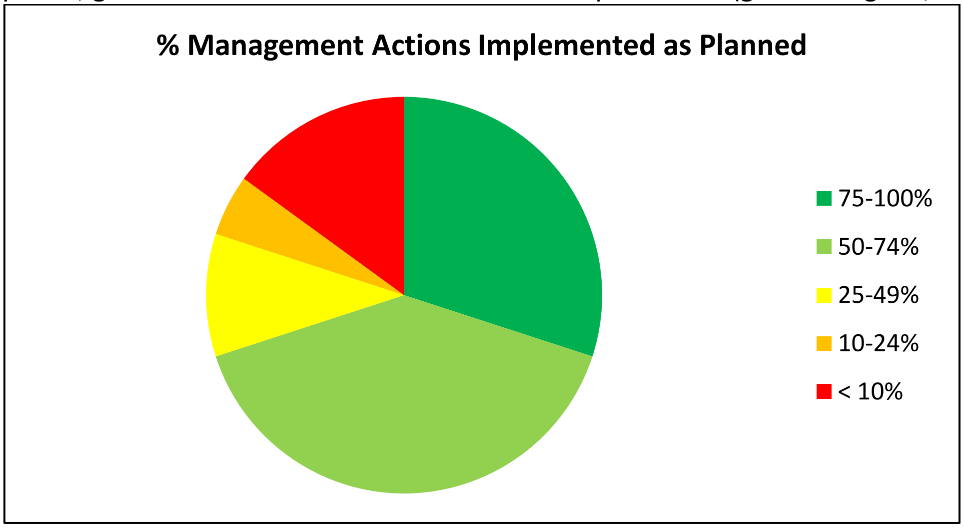
   Please explain your rationale for adjusting or abandoning your management actions:

Additional Information

8. Please provide any narratives, case studies, or additional comments you may have related to your work in direct management of natural resources (optional)

G. Example Graphs and Charts for Reports for Direct Management of Natural Resources:
Potential graphs and charts for a report could include:

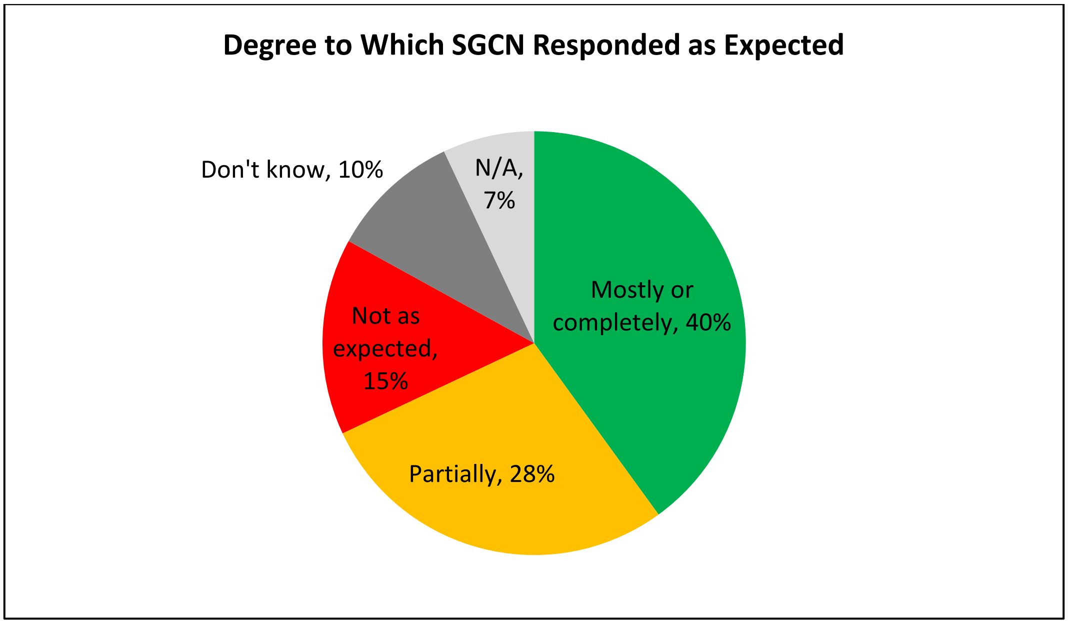
MGMT 01 (Management actions implemented): MGMT 01: Pie chart - colors with red, orange, yellow, green - colors indicative of % of actions implemented (green = v. good; red = v. poor)

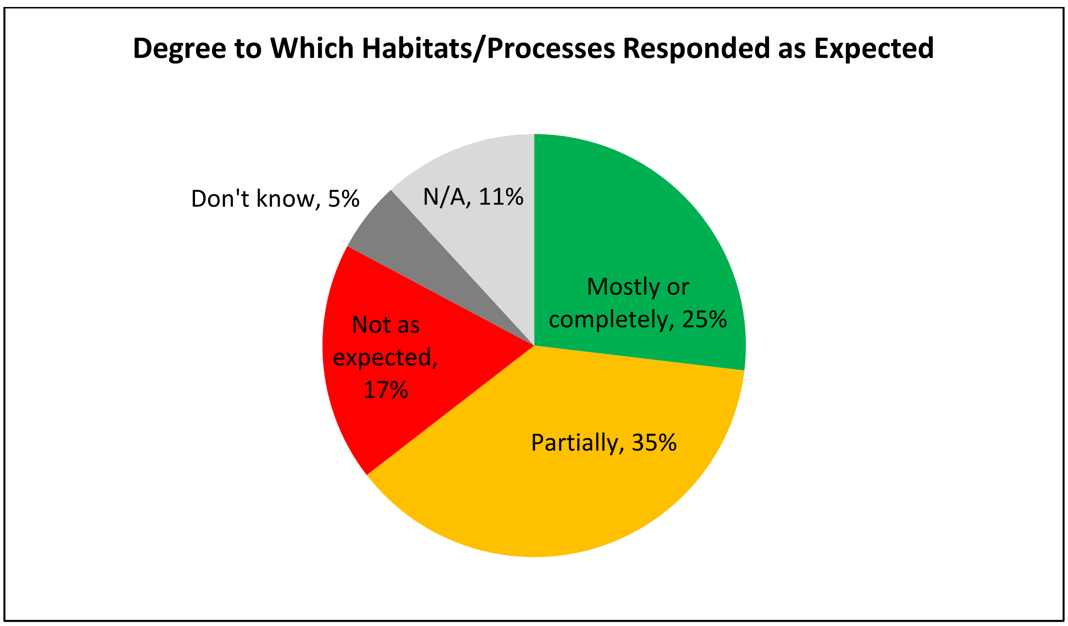


MGMT 02 (Threats reduced): Table or histogram with IUCN-CMP threat categories & # being addressed through mgmt actions, do not report on evidence of threat reduction. Note, this figure could also be shown as the total number of initiatives, rather than as percents within that total number.

ASSOCIATION of FISH & WILDLIFE AGENCIES

MGMT 03 (Species or habitats and their processes respond favorably to direct management actions): Pie chart or histogram showing % of initiatives by benefit category (if pie chart, collapse the two partially benefits categories into one)





2. Species Restoration

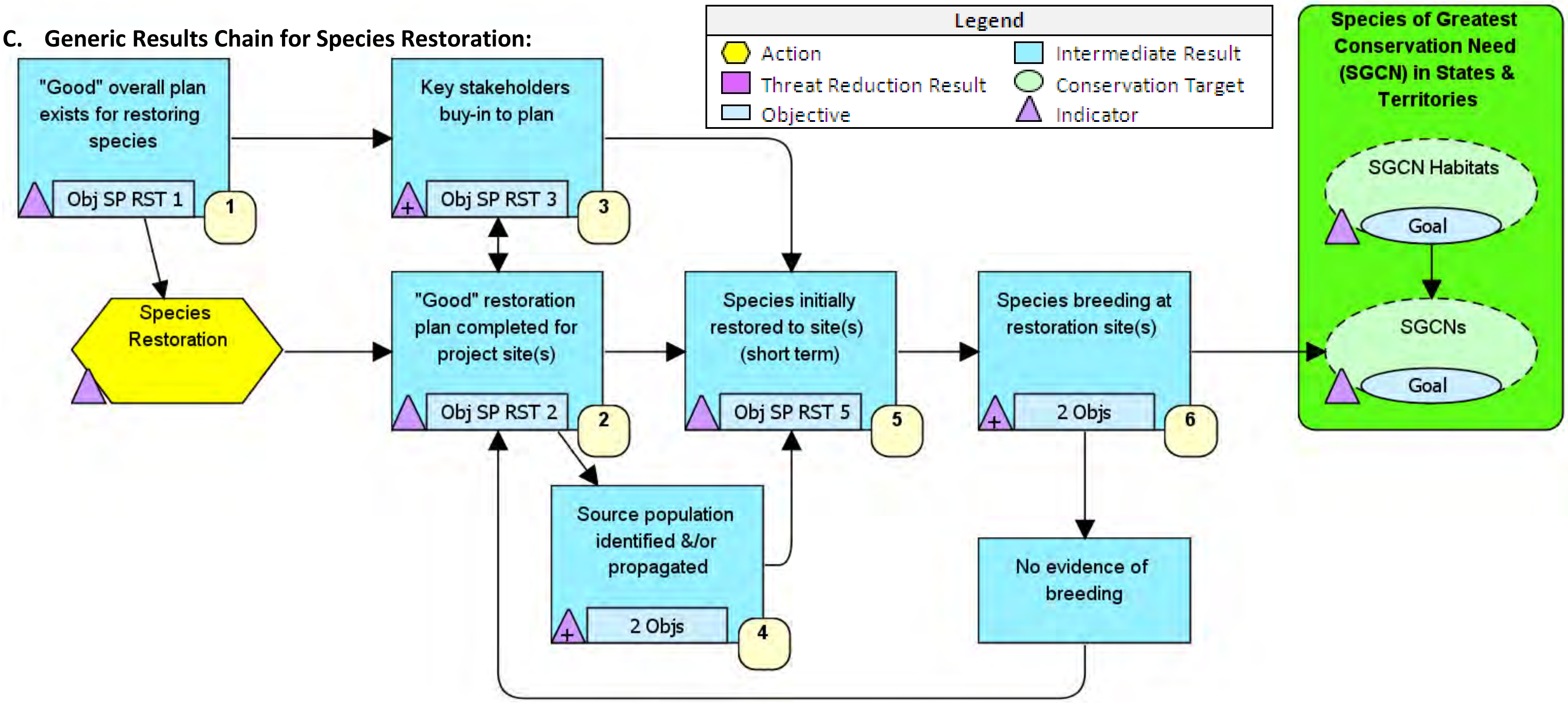
A. Definition of Species Restoration:

Species Restoration is defined as "Reintroduction, relocation, or stocking of native animals or plants or translocation of animals to an area where they are not currently found."

B. Specific Examples of Species Restoration:

1. Translocate or introduce captive-bred Black-footed Ferrets to establish new populations in a suitable habitat.
2. Restore mussel assemblages to historically occupied stream stretches.

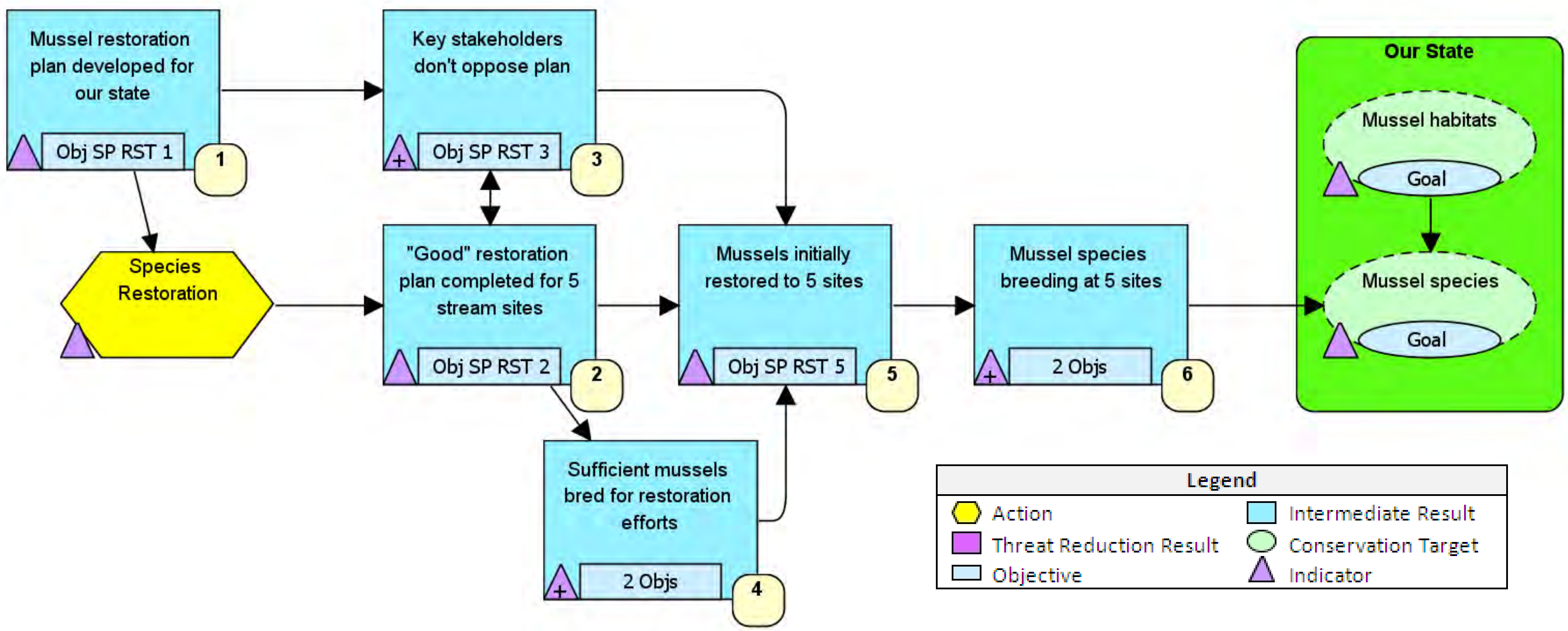
C. Generic Results Chain for Species Restoration:



Description: As outlined in the right-hand side of the results chain, a key precursor for effective Species Restoration involves developing an overall plan for restoring the species (1). The first step involves developing a good restoration plan for the specific project sites (2) and, if needed, assuring that key stakeholders buy into the plan (3). It will also generally be necessary to identify a source population for the restoration effort, either from suitable wild populations or from captive breeding efforts (4). Once the species is then restored to the site (5), a key result is that the species is breeding at the restoration sites (6). If there is no evidence that breeding is occurring, then it will be necessary to re-examine the plan and repeat as needed.

D. Example Results Chain for Species Restoration:

This fictitious example is based on a case of restoring endangered mussel species by captive breeding and then restoring to 5 stream sites. The species restoration obviously has to be combined with other conservation efforts to make sure the habitat is sufficiently conserved to support the mussels.



E. Cross-walk of Generic and Real-world Example Results, Objectives and Measures for Species Restoration:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
SP RST 01	**Generic:** "Good" overall plan exists for restoring the species	Before implementation work starts, a "good" restoration plan exists for the species within a desired region (developing this overall plan will usually not be part of this project).	Presence of plan; Assessment of plan quality against criteria	% of restoration efforts that are based on a "good" plan by taxa and by region	App 1. This project involves relocation/captive propagation/both… App 2. What species (or other taxonomic units) are expected to benefit from this project? App3. What is the expected duration of the restoration effort in this project? App 4. Is this project being implemented under an overall plan for restoring the species? App 5. Does this overall restoration plan define clear biological objectives required for recovering the species? App 6. Approximately what percentage of the overall species recovery effort is represented by this project? App 7. Does this restoration plan identify: 1) appropriate source(s) of the species, 2) candidate restoration sites, 3) methods for transferring and introducing the species to new sites, 4) monitoring and follow-up methods, and 5) risk assessment and mitigation steps?
	Mussel Example: *Mussel restoration plan developed for our state*	*Before implementation work starts, a "good" restoration plan exists for mussels in our state.*	*Presence of plan; Assessment of plan quality against criteria*		
SP RST 02	**Generic:** "Good" restoration plan completed for project site(s)	Before implementation work starts, a "good" restoration plan has been developed for the specific project site(s).	*Presence of plan; Assessment of plan quality against criteria*	None	1. Has the project developed a plan for restoration efforts at the specific project site(s)? 2. Does this restoration plan identify: 1) clear biological objectives, 2) appropriate source(s) of the species, 3) methods for transferring and introducing the species to the sites, 4) monitoring and follow-up methods, 5) a budget and work plan for this work, 6) clear exit criteria for the project (both unsuccessful and successful) , and 7) risk assessment and mitigation steps? 3. What is the "unit" for defining restoration site(s)? 4. How many total site(s) is the project targeting for restoration efforts?
	Mussel Example: *"Good" restoration plan completed for 5 sites*	*Before implementation work starts, a "good" restoration plan has been developed for the 5 project site(s).*	*Presence of plan; Assessment of plan quality against criteria*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
SP RST 03	**Generic:** Key stakeholders buy-in to plan	Prior to and following implementation of the plan, all relevant stakeholder groups are either supportive or at least non-hostile towards the restoration.	Actions taken by individuals or organizations that are against the restoration (e.g., formal legal challenges to the plan or hostile acts such as shooting restored animals)	Total number of projects that are being blocked by stakeholders, by taxa and region.	5. During the reporting period, were there any formal challenges by stakeholders to prevent the release of the target species into the restoration sites? 6. If yes, was the project team able to mediate these challenges?
	***Mussel Example:** Key stakeholders don't oppose plan*	*Prior to and following implementation of the plan, landowners and stream user groups are either supportive or at least non-hostile towards the restoration.*	*Actions taken by individuals or organizations that are against the restoration (e.g., formal legal challenges to the plan or hostile acts such as shooting restored animals)*		
SP RST 04	**Generic:** Source population identified and/or propagated	Prior to implementation of the plan, a suitable source population to meet needs of all restoration sites has been identified. If necessary, before restoration efforts start, sufficient individuals have been propagated to meet needs of all restoration sites.	Evidence of suitable source population being identified. % of total individuals required to meet needs of all sites	% of projects that are able to identify and/or propagate sufficient individuals, by taxa and by region	7. Has the project identified a suitable source of individuals to meet needs of all sites in the restoration effort? 8. If propagating, what percent of total individuals required to meet needs of all sites in the restoration effort have been bred?
	***Mussel Example:** Sufficient mussels bred for restoration efforts*	*Prior to implementation of the plan, a suitable source population to meet needs of all 5 restoration sites has been identified. Before restoration efforts start, sufficient mussels have been propagated to meet needs of all 5 restoration sites.*	*Evidence of suitable source population being identified. % of total mussels required to meet needs of all sites*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
SP RST 05	**Generic:** Species initially restored to sites (short-term)	By specified target date, the target number of units* have been introduced to Area(s) YYYY. * Units could be individuals, breeding pairs, communities, pounds of fish fry, or other measures as appropriate.	% of target number of units that are released	% of projects that are able to release sufficient units, by taxa and by region	9. Has the project begun releasing species to restoration site(s)? 10. What percent of initial release work across all restoration sites has been completed? (combines both within site and across sites) 11. What is the "unit" for measuring quantities of species released within restoration site(s)? 12. How many units of the species have been reintroduced?
	Mussel Example: *Mussels initially restored to 5 sites*	*Within 2 years, more than 10,000 individuals of each species have been restored to each site.*	*% of 10,000 individuals that are released*		
SP RST 06	**Generic:** Species breeding at restoration sites (medium-term)	Within X years of introduction, the restored population is successfully breeding within the restoration site(s).	% of sites with restored population successfully breeding	% of all projects with restored species successfully breeding, by taxa and by region	13. Are the introduced populations breeding within the recovery site(s)? 14. What is the "unit" for measuring successful reintroduction of the species within restoration site(s)? 15. How many units of the species are present in the recovery sites?
	Mussel Example: *Mussel species breeding at 5 sites*	*Within 4 years, the mussel species are breeding at each of the 5 sites*	*% of 5 sites with evidence of breeding*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**Goal:** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	16. Are the introduced populations viable within the recovery site(s)? 17. Has the population goal for the target species within the restoration site(s) been achieved? 18. Has this project contributed to any changes regarding the conservation priority status (SGCN priority, Threatened/Endangered, etc.) of the target species in your state?
	Mussel Example: *Viability of Mussel Population*	***Goal:*** *Within 5 years, viable populations of mussels have doubled from 5 to 10 sites*	*Number of viable populations*		

F. Measures Questionnaire for Species Restoration

SWG PROPOSAL QUESTIONS

APP 1. **This project involves…:**

- ☐ Relocation of wild animals from an occupied habitat to one or more restoration sites.
- ☐ Captive propagation of animals to be released into one or more restoration sites.
- ☐ Both relocation of wild animals and release of captive raised animals into one or more restoration sites.
- ☐ Other (Describe:)

Notes:

APP 2. What species (or other taxonomic units) are expected to benefit from this project?
(Repeat up to 5; if more than 5 then please combine as higher level units – e.g. mussel assemblage)

Genus: Species: Other Units:

Notes:

APP 3. What is the expected duration of the restoration effort in this project?

Years

Overall Management Plan

APP 4. Is this project being implemented under an overall plan for restoring the species?

- ☐ Formal Recovery Plan Plan's title:
- ☐ Draft Recovery Plan
- ☐ Other Restoration Plan Explain:
- ☐ No Plan

APP 5. Does this overall restoration plan define clear biological objectives (number of populations/sites) required for recovering the species?

○ Yes ○ No

APP 6. Approximately what percentage of the overall species recovery effort is represented by this project?

% in our state % nationally Notes:

APP 7. Does this restoration plan identify: 1) appropriate source(s) of the species, 2) candidate restoration sites, 3) methods for transferring and introducing the species to new sites, 4) monitoring and follow-up methods, and 5) risk assessment and mitigation steps?

- Plan addresses all or almost all criteria
- Plan addresses most criteria
- Plan addresses some criteria
- Plan address few or no criteria

Notes:

SWG PERFORMANCE REPORTING QUESTIONS
Basic Action Information

What is the time frame that this report covers?

Start Date: End Date:

In what stage in the restoration process is this project currently? (check the most “advanced option” reached)

- Overall Planning for Restoring the Species
- Planning for Specific Project Site(s)
- Source Population Development
- Species Actively Being Restored to Site(s)
- Active Restoration Complete; Monitoring and Follow-Up

Restoration Plan

1. Has the project developed a plan for restoration efforts at the specific project site(s)?

- Yes
- No

2. Does this restoration plan identify: 1) clear biological objectives, 2) appropriate source(s) of the species, 3) methods for transferring and introducing the species to the sites, 4) monitoring and follow-up methods, 5) a budget and work plan for this work, 6) clear exit criteria for the project (both unsuccessful and successful) , and 7) risk assessment and mitigation steps?

- Plan addresses all or almost all criteria
- Plan addresses most criteria
- Plan addresses some criteria
- Plan address few or no criteria

Notes:

3. What is the “unit” for defining restoration site(s)?

- Defined geographic locations
- Populations of animals
- Other

Describe if needed:

4. How many total site(s) is the project targeting for restoration efforts?

Number of sites: Describe if needed:

Key Stakeholders Buy-In to Plan

5. During the reporting period, were there any formal challenges by stakeholders to prevent the release of the target species into the restoration sites?

- Yes
- No

6. If yes, was the project team able to mediate these challenges?

- Complete
- Most
- Some
- Few or none

Source Population Identified and/or Propagated

7. Has the project identified a suitable source of individuals to meet needs of all sites in the restoration effort?

- Source(s) identified to provide all of the individuals needed (100%)
- Source(s) identified to provide some of the individuals needed (approximately %)
- Source(s) not yet identified to provide needed number of individuals
- Captive breeding/propagation required to augment source population

If propagating individuals:

8. What percent of total individuals required to meet needs of all sites in the restoration effort have been bred?

%

Notes:

Species Initially Restored to Sites (Short-Term)

9. Has the project begun releasing species to restoration site(s)?

- Yes
- No

10. What percent of initial release work across all restoration sites has been completed? (combines both within site and across sites)

% Notes:

11. What is the "unit" for measuring quantities of species released within restoration site(s)?

- Individuals
- Breeding pairs or units
- Communities
- Other (e.g., pounds of fish fry)

Please describe if needed:

12. How many units of the species have been reintroduced? *[repeat for up to five species]*

total units across all sites Notes:

Species Recruitment (Medium-Term)

13. Are the introduced populations breeding within the recovery site(s)?

- Yes, at all sites
- Yes, but only at some sites (% of sites)
- No documentation of breeding occurring
  - Too early to expect breeding
  - Problems with restored population(s)
- Insufficient monitoring in place

Notes:

14. What is the "unit" for measuring successful reintroduction of the species within restoration site(s)?

- Individuals
- Breeding pairs or units
- Populations
- Spatial coverage (eg miles of stream)
- Other

Describe if needed:

15. How many units of the species are present in the recovery sites?

total units across all sites Notes:

Viable Populations (Long-Term)

16. Are the introduced populations viable within the recovery site(s)?

- ○ Yes, at all sites
- ○ Yes, but only at some sites (____ % of sites)
- ○ No documentation of viability
  - ☐ Too early to expect viability
  - ☐ Problems with restored population(s)
- ☐ Insufficient monitoring in place

17. Has the population goal for the target species within the restoration site(s) been achieved?

- ○ Yes, at all sites for all species
- ○ Yes, but only at some sites or for some species
- ○ No

Notes: ____

18. Has this project contributed to any changes regarding the conservation priority status (e.g., SGCN priority, Threatened/Endangered, etc.) of the target species in your state? (Check all that apply)

- ☐ No change to SGCN priority, State ESA priority, or Federal ESA priority
- ☐ Remove from state ESA list
- ☐ Remove from Federal ESA list
- ☐ Change to lower SGCN priority within the Wildlife Action Plan
- ☐ Change to higher SGCN priority with the Wildlife Action Plan
- ☐ Change to higher priority within state ESA list
- ☐ Change to higher priority within Federal ESA list

Notes: ____

3. Creation of New Habitat

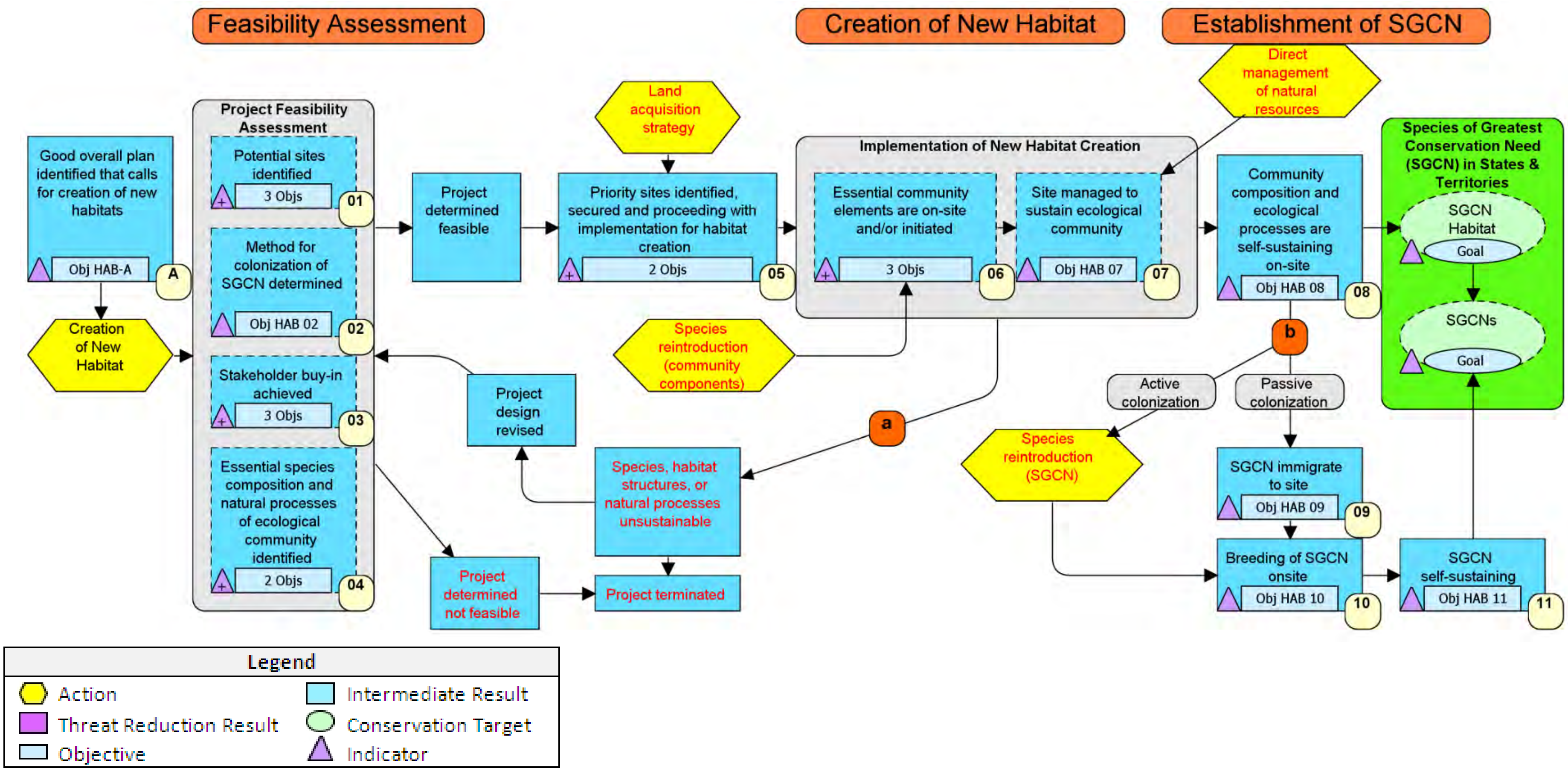
A. Definition of Creation of New Habitat:

<u>Creation of New Habitat</u> is defined as "The creation or establishment of *new* habitats, including necessary natural processes, habitat structures, and biotic components, to mitigate loss of ecological functions elsewhere."

B. Specific Examples of Creation of New Habitat:

1. Establish prairie communities where crop land currently exists
2. The creation of new breeding habitat for Gopher Frog reintroduction and due to a climate adaptation strategy and recovery plan

C. Generic Results Chain for Creation of New Habitat:



ASSOCIATION of FISH & WILDLIFE AGENCIES

Description: The ultimate goal of the New Habitat Creation Results Chain is the conservation of SGCN and their habitats. This results chain contains the following three major components:

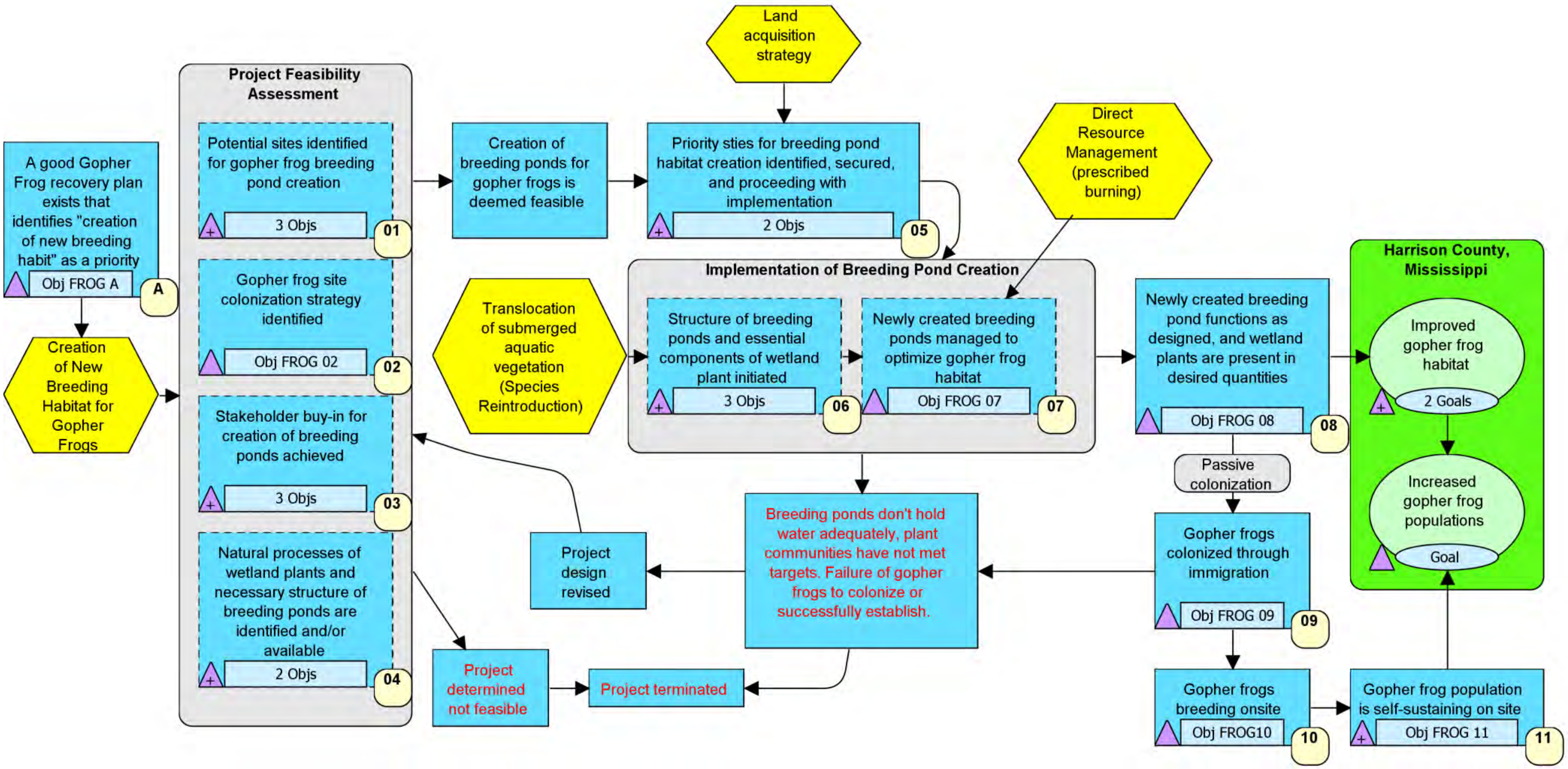
- Project feasibility assessment
- Implementation of new habitat creation
- Establishment of species of greatest conservation need (SGCN)

Although these three components comprise the bulk of the results chain, several other results are necessary to connect the conservation action to the conservation goal. The initial project feasibility assessment (results 01-04) includes several elements: the identification of potential sites (01), an economic and biological risk assessment for each site (01), selection of an SGCN site colonization strategy (02), obtaining stakeholder buy-in (03), and identifying variables by which success will be measured (04). The project feasibility assessment will inform whether a project should go forward or whether it is not feasible and should be terminated. If the project is determined feasible (05), then the chain assumes that sites would be secured (which may require a land acquisition strategy) prior to implementation (06). Implementation efforts focus on the community level and aim to establish ecological processes and necessary communities (e.g., acquiring native prairie seed) (07). If applicable, implementation also ensures that structural components of the new habitat are in place (e.g., construction of artificial wetland depressions). If these are in place, then it is assumed that the site will be managed to sustain the ecological community (08). Ideally, this means that new habitats have been developed and management plans are being implemented on site.

If implementation has occurred successfully, then it is expected that species composition and processes would be self-sustaining (09). This can be assessed via the indicators and associated thresholds established earlier in the project (Result 04). Evaluation of these indicators will help determine whether the implementation efforts were successful. If these efforts failed (Pathway a), and the basic structure/habitat is unsuitable, adaptive management must occur, and the results chain returns to the “Project Feasibility Assessment” step or the “Project Terminated” step. If implementation is successful (Pathway b), SGCN either colonize naturally (10), or the reintroduction/translocation results chain is used to effectively establish SGCN in the newly created habitat. If Pathway B is successful, breeding of SGCN occurs at the site (11) and, if breeding occurs to meet identified thresholds, then it is assumed that the SGCN populations are now self-sustaining (12), and the conservation of SGCNs and their habitats is achieved.

D. Example Results Chain for Creation of New Habitat:

This fictitious example is based on an effort to create new breeding habitat for Gopher Frogs in Harrison County, Mississippi.



Legend	
Action	Intermediate Result
Threat Reduction Result	Conservation Target
Objective	Indicator

E. Cross-walk of Generic and Example Results, Objectives and Measures for Creation of New Habitat:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
HAB A	**Generic:** Good overall plan identified for SGCN that calls for creation of new habitats	Before strategy initiated, a "good" management plan exists that identifies that new habitat creation is needed	Presence of a plan that identifies new habitat creation as a conservation action	% of new habitat creation initiatives in which a plan exists that calls for the creation of new habitats	App1. Did a previous conservation and management plan for the target SGCN identify “Creation of New Habitat” as a necessary conservation action?
	Gopher Frog Example: *A good Gopher Frog recovery plan exists that identifies "creation of new breeding habit" as a priority*	*Before the new habitat creation strategy is initiated, a “good” management plan for Gopher Frogs exists that identifies the need for creation of new breeding ponds*	*Presence of a management plan for Gopher Frogs that identifies the creation of new breeding ponds*		
HAB 01-1	**Generic:** Potential sites identified	By {target date}, a list of X potential sites for consideration has been create	a. Presence of a list of potential sites b. Total number of potential sites	c. % of plans in which potential site list exists d. No roll-up	1. List all potential sites for new habitat creation:
	Gopher Frog Example: *Potential sites identified for Gopher Frog breeding pond creation*	*Within 1 month of project initiation, a list of 6 potential breeding pond sites for consideration has been created*	*a. Presence of a list of potential Gopher Frog sites* *b. Total number of potential Gopher Frog sites*		
HAB 01-2	**Generic:** Potential sites identified	By {target date}, a written biological risk assessment for all potential sites has been completed	% of potential sites with biological risk assessment	% of total plans with biological risk assessments completed	2. For each potential site, please identify the level of completion for the following assessments: a. Written Biological Assessment b. Written Economic Assessment c. Site-specific Budget Please indicate barriers to assessment completion (for each assessment for each site)
	Gopher Frog Example: *Potential sites identified for Gopher Frog breeding pond creation*	*Within 4 months of project initiation, a written biological risk assessment for all breeding pond sites has been completed*	*#/% of potential Gopher Frog sites with biological risk assessment*		

ASSOCIATION of FISH & WILDLIFE AGENCIES

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
HAB 01-3	**Generic:** Potential sites identified	By {target date}, a written economic assessment and budget for all potential sites for consideration has been completed	% of potential sites with economic assessment & budget completed	% of total plans with economic assessments completed	See above
	Gopher Frog Example: *Potential sites identified for Gopher Frog breeding pond creation*	*Within 5 months of project initiation, a written economic assessment has been completed for each breeding pond site*	*#/% of potential gopher frog sites with economic assessment & budget completed*		
HAB 02	**Generic:** Method for colonization of SGCN determined	By {target date} site colonization method for SGCN has been decided	Presence of site colonization method	% plans that have a colonization method indicated; of that, breakdown of methods employed	3. Identify the appropriate method for colonization of SGCN across all potential sites
	Gopher Frog Example: *Gopher Frog site colonization strategy identified*	*Within 6 months of project initiation, a site colonization method for Gopher Frogs has been decided*	*Evidence of site colonization method for gopher frog*		
HAB 03-1	**Generic:** Stakeholder buy-in achieved	By {target date}, at least X# stakeholder groups have been identified, and at least Y% have received communication about new habitat creation initiative and expectations	a. # stakeholders/ stakeholder groups identified b. % stakeholders with whom communication has been achieved and expectations shared	# of stakeholders/ stakeholder groups across all projects	4. This project identified the following stakeholders:: ○ Internal/Agency Partners ○ Community members at large ○ Financial contributor/ capital commitment holder ○ Special interest group ○ Other: 5. How many stakeholders were identified for this project? 6. Of the X#* stakeholders identified, how many were you able to communicate with?
	Gopher Frog Example *Stakeholder buy-in for creation of breeding ponds achieved*	*Within 6 months of gopher frog project onset, 4 major stakeholder groups have been identified, and at least 75% have received communication*	*a. # stakeholder groups identified* *b. % stakeholders with whom communication about creation of breeding ponds has been achieved and expectations shared*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
HAB 03-2	**Generic:** Stakeholder buy-in achieved	By {target date}, of those who have received communications, at least X% have agreed to participate	% of contacted stakeholders who agree to participate	% projects in which X% of contacted stakeholders agree to participate	7. Of the X#* stakeholders you communicated with, how many agreed to participate in your action?
	Gopher Frog Example: *Stakeholder buy-in for creation of breeding ponds achieved*	*Within 2 months of communication with stakeholder groups, 100% have agreed to participate (e.g. support) creation of breeding ponds*	*% of stakeholders contacted who have agreed to participate in the creation of breeding ponds*		
HAB 03-3	**Generic:** Stakeholder buy-in achieved	By {target date}, of participating stakeholders, at least X% have fulfilled their commitments to the project	% of participating stakeholders who fulfill commitments	% projects in which X% participating stakeholders fulfill commitments	8. For the X#* participating stakeholders, how many fulfilled their commitments to your project? 9. Were participating stakeholders recognized for their involvement? If yes, please describe
	Gopher Frog Example: *Stakeholder buy-in for creation of breeding ponds achieved*	*Within 6 months of agreeing to participate, 100% of those stakeholders have fulfilled their commitments to efforts to support the creation of breeding ponds*	*% of those stakeholders who have fulfilled their commitments to efforts to create breeding ponds*		
HAB 04-1	**Generic:** Essential species composition and natural processes of ecological community identified	By {target date}, indicators with quantifiable thresholds for success have been defined that determine whether community and ecological processes have been established and sustained	Presence of defined indicators with thresholds of success	% projects that have documented indicators with thresholds of success	10. Have indicators with quantifiable thresholds been identified that will later be used to determine that community and ecological process have been established? If yes, please list
	Gopher Frog Example: *Natural processes of wetland plants and necessary structure of breeding*	*Within 3 months of initiating the project feasibility assessment, indicators with quantifiable thresholds for success have*	*Presence of defined indicators with thresholds of success*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
	ponds are identified and/or available	*been defined that determine whether a wetland community has been established and sustained*			
HAB 04-2	**Generic:** Essential species composition and natural processes of ecological community identified	By {target date}, X% of indicators with quantifiable thresholds have been peer reviewed	% of indicators with quantifiable thresholds that have been peer reviewed	% of new habitat creation actions in which they have peer reviewed the desired #/% of indicators with quantifiable thresholds (by category, as well)	11. Has a peer review process occurred for all indicators and quantifiable thresholds for success? 12. After completion of the Project Feasibility Study, has this project been deemed feasible for implementation? If no, why?
	Gopher Frog Example: *Natural processes of wetland plants and necessary structure of breeding ponds are identified and/or available*	*Within 3 months of project initiation, 100% of the indicators with quantifiable thresholds have been peer reviewed by the gopher frog recovery team*	*% of indicators with quantifiable thresholds that reviewed by the Gopher Frog recovery team*		
HAB 05-1	**Generic:** Priority sites identified, secured and proceeding with implementation for habitat creation	By {target date}, X% of suitable potential sites are secured	% of suitable sites that are secured	% of projects with X% (grouped in categories) of suitable sites secured	13. Please indicate status of each potential site in regards to project implementation a. Was this site deemed suitable for project implementation? If "No," please indicate why b. Has this site been secured and made available for the use of this project? If "No," please indicate why:
	Gopher Frog Example: *Priority sties for breeding pond habitat creation identified, secured, and proceeding with implementation*	*Within 6 months of the completion of the feasibility assessment, 100% of suitable breeding pond sites are secured*	*% of secured breeding pond sites that are proceeding with implementation*		
HAB 05-2	**Generic:** Priority sites identified, secured and proceeding with implementation for habitat creation	By {target date}, X% of secured sites are proceeding with implementation	% of secured sites in which implementation occurs	% of projects with X% (grouped in categories) of secured sites in which implementation has occurred	c. Is project implementation occurring on this site? If "No," please indicate why
	Gopher Frog Example: *Priority sties for breeding*	*Within 3 months of securing sites, a minimum of 50% of secured breeding pond sites*	*% of secured sites in which implementation occurs*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
	pond habitat creation identified, secured, and proceeding with implementation	*are proceeding with implementation*			
HAB 06-1	**Generic:** Essential community elements are on-site and/or initiated	By {target date}, essential species necessary for community creation have been introduced	Presence of essential species for target community composition	% projects with essential species for target community composition introduced	14. Have the essential species necessary for community creation been introduced on site?
	Gopher Frog Example: *Structure of breeding ponds and essential components of wetland plant initiated*	*Within 1.5 years of project implementation, essential species necessary for community creation including submerged aquatic vegetation/wetland plant species have been introduced*	*Presence of essential species necessary for community creation including submerged aquatic vegetation/wetland plant species*		
HAB 06-2	**Generic:** Essential community elements are on-site and/or initiated	By {target date}, habitat structure necessary for community creation have been created	Presence of habitat structures	% projects with habitat structure created	15. Have habitat structures necessary for community creation been created on site? (i.e., ponds, woody debris, etc.)
	Gopher Frog Example: *Structure of breeding ponds and essential components of wetland plant initiated*	*Within 2 years of project implementation breeding ponds and their associated habitat structures have been created*	*Presence of breeding ponds and associated habitat structures*		
HAB 06-3	**Generic:** Essential community elements are on-site and/or initiated	By {target date}, natural processes necessary for community creation have been initiated	Evidence that natural processes have been initiated	% projects with natural processes initiated	16. Have natural processes necessary for community creation been initiated? (i.e., adequate stream flows, fire regimes, etc.)
	Gopher Frog Example: *Structure of breeding ponds and essential components of wetland plant initiated*	*Within 2 years of project implementation, prescribed fire regimes for breeding pond habitat have been initiated*	*Evidence that prescribed fire has been used to manage new breeding habitat*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
HAB 07	**Generic:** Site managed to sustain ecological community	By {target date}, a management plan is implemented	Evidence of management plan implementation	% of new habitat creation initiatives that have a management plan in implementation (report by categories)	17. Is a management plan currently being implemented?
	Gopher Frog Example: *Newly created breeding ponds managed to optimize gopher frog habitat*	*Within 2 years of project initiation, a management plan for breeding pond habitats is implemented*	*Evidence of implementation of a management plan for breeding pond habitats*		
HAB 08	**Generic:** Essential species composition and ecological processes are self-sustaining on-site	Within X years since the introduction of community elements, the thresholds of success previously identified in the project feasibility study have been attained.	Evidence of thresholds attained	%of projects in which community viability has been achieved (by category)	18. At the time of this survey, have the thresholds for indicators of community viability been attained?
	Gopher Frog Example: *Newly created breeding pond functions as designed, and wetland plants are present in desired quantities*	*Within 5 years of project initiation, a minimum of 75% of the thresholds of success for breeding pond community viability indicators identified in the project feasibility study have been attained.*	*% of the thresholds of success for breeding pond community viability indicators identified in the project feasibility study that have been attained.*		
HAB 09	**Generic:** SGCN immigrate to site	By {target date}, XX SGCN individuals have immigrated to the site	# SGCN individuals that have immigrated to the site	% of total projects where immigration has occurred	19. Are target SGCN present on-site? If "Yes," indicate number of individuals present
	Gopher Frog Example: *Gopher Frogs colonized through immigration*	*Within 2 years of the creation of the breeding pond habitat, at least 100 Gopher Frogs have immigrated to the site*	*# of Gopher Frogs that have immigrated to the site*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
HAB 10	**Generic:** Breeding of SGCN onsite	Within XX years of colonization, SGCN is successfully breeding within the new habitat	Evidence of breeding happening at site(s)	a. % of new habitat creation initiatives in which breeding of SGCN is evident b. % of sites in which breeding of SGCN is evident	20. Are target SGCN breeding within the site?
	Gopher Frog Example: *Gopher Frogs breeding onsite*	*Within 2 years of colonization, there is evidence of successful breeding within the new pond*	*Evidence that Gopher Frog tadpoles are successfully metamorphosing and emerging from the breeding habitat*		
HAB 11	**Generic:** SGCN self-sustaining on-site	By {target date}, a "viable" population of SGCN exists at the new habitat	Evidence a "viable" population of SGCN exists at the new habitat	% of new habitat creation initiatives with viable populations of targeted SGCN	21. Are the immigrated populations viable within the site?
	Gopher Frog Example: *Gopher Frog population is self-sustaining on site.*	*Within 10 years of breeding habitat creation, a viable population of Gopher Frogs (> 100 individuals) breeds on site, producing egg masses that successfully hatch and tadpoles that metamorphose in breeding ponds and return to their natal pond to breed when they reach maturity*	*a. % of egg masses that successfully hatch* *b. # of individuals that breed on site* *c. % tadpoles that metamorphose in breeding ponds* *d. % tadpoles return to their natal pond to breed when they reach reproductive maturity*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**Goal:** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	**N/A**
	Gopher Frog Example: *Increased Gopher Frog populations*	***Goal:*** *Within 10 years of pond construction, a population of at least 100 individual Gopher Frogs utilizes the breeding pond*	*# of Gopher Frogs that are utilizing the breeding pond*		

F. Measures Questionnaire for Creation of New Habitat:
Project Feasibility – Assessment

App 1. Did a previous conservation and management plan for the target SGCN identify "Creation of New Habitat" as a necessary conservation action?

○ Yes, a plan exists that identifies "Creation of New Habitat" as a necessary action

○ No, a plan currently does not specifically identify "Creation of New Habitat" as a necessary action for SGCN conservation & management

Plan name, if applicable: [ ]

Programming note: This is an application question

1. List all potential sites for new habitat creation:

Site 1: [ ]

☐ Add another potential site

Programming Note: Allow practitioner to identify as many sites as he deems appropriate. Ask the following question for each site. Auto-fill from previously-identified sites.

2. For each potential site, please identify the level of completion for the following assessments:

Potential Site	Written Biological Assessment	Written Economic Assessment	Site-specific Budget
Site 1 *(programming note: auto populate from response above)*	☐ Fully Complete ☐ Assessment in progress If not fully complete: ☐ < 50% complete ☐ ≥ 50% complete	☐ Fully Complete ☐ Assessment in progress If not fully complete: ☐ < 50% complete ☐ ≥ 50% complete	☐ Fully Complete ☐ Assessment in progress If not fully complete: ☐ < 50% complete ☐ ≥ 50% complete
	Please indicate barriers to assessment completion (*note: show this cell if completion is below 50%)* ☐ Insufficient time ☐ Insufficient funding ☐ Change in site prioritization ☐ Inability to access site ☐ Other: ______________	Please indicate barriers to assessment completion (*note: if completion <50%)* ☐ Insufficient time ☐ Insufficient funding ☐ Change in site prioritization ☐ Inability to access site ☐ Other: ______________	Please indicate barriers to assessment completion (*note: if completion is< 50%)* ☐ Insufficient time ☐ Insufficient funding ☐ Change in site prioritization ☐ Inability to access appropriate cost details ☐ Other: ______________
Site 2… etc.	*Same as above*	*Same as above*	*Same as above*

3. Identify the appropriate method for colonization of SGCN across all potential sites (check all that apply):

☐ Species Introduction from propagated population

☐ Species Translocation from source population

☐ Species immigration

☐ No colonization method determined

Project Feasibility - Stakeholder Involvement

4. This project identified the following stakeholders :

   - ○ Internal/Agency Partners
   - ○ Community members at large
   - ○ Financial contributor/ capital commitment holder
   - ○ Special interest group
   - ○ Other ____________________

5. How many stakeholders were identified for this project? [ ]

6. Of the X#* stakeholders identified, how many were you able to communicate with? [ ]
   **Programming note: Auto populate X# with number from Question 6*

7. Of the X#* stakeholders you communicated with, how many agreed to participate in your action? [ ]
   **Programming note: Auto populate X# with number from Question 7*

8. For the X#* participating stakeholders, how many fulfilled their commitments to your project? [ ]
   **Programming note: Auto populate X# with number from Question 8*

9. Were participating stakeholders recognized for their involvement?

   - ○ Yes
   - ○ No

   If "Yes," please describe: [ ]

Project Feasibility - Indicators of Success

10. Have Indicators with quantifiable thresholds been identified that will later be used to determine that community and ecological process have been established?

    - ○ Yes, Indicators with quantifiable thresholds have been developed
    - ○ No, Indicators have been developed, but quantifiable thresholds have not been determined.
    - ○ No, Indicators with quantifiable thresholds have not been developed for community and ecological process establishment

    If Yes, please list indicator(s): [ ] (*optional*)

    ☐ Add another Indicator

(Programming note: If YES, answer questions 11 - 13)

11. Has a peer review process occurred for all indicators and quantifiable thresholds for success?

    - ○ Yes, indicators/thresholds have been peer reviewed both internally (within the agency) and externally
    - ○ Yes, Indicators/thresholds have been peer reviewed internally
    - ○ Yes, Indicators/thresholds have been peer reviewed externally
    - ○ No, indicators/thresholds have not been peer reviewed

A "Threshold for Success" is a minimum target goal set prior to project implementation for a given indicator that is necessary for achieving a successful and self-sustaining ecological community and its associated processes. For the previously identified set of indicators, answer the following questions:

12. After completion of the Project Feasibility Study, has this project been deemed feasible for implementation?
    (Programming note: Mandatory)

    - ○ Yes, project is feasible for implementation
    - ○ No, project deemed infeasible based on results of the study

If no, please explain why this project was deemed infeasible *(Note: consider adding a pick list, TBD)*

Project Implementation – Site Status

13. Please indicate status of each potential site in regards to project implementation:

Potential Site	Was this site deemed suitable for project implementation?	Has this site been secured and made available for the use of this project?	Is project implementation occurring on this site?
Site 1 *(programming note: auto populate from response in Question 2)*	○ Yes, site deemed suitable for project implementation ○ No, site deemed inappropriate for project implementation If "No," please indicate why: ☐ Land unavailable for procurement ☐ Unable to support/sustain biological, ecological, or structural functions ☐ Site is cost-prohibitive ☐ Stakeholder objections ☐ Colonization method inappropriate for this site ☐ Other: ___________	(*NOTE: if "Yes" to previous question, show this column)* ○ Yes, site is secured for this project ○ No, site has not yet been secured If "No," please indicate why: ☐ secured by agency but currently unavailable for this project ☐ inadequate funding for procuring site ☐ insufficient time has passed to procure site ☐ Other:______________	(*NOTE: if "Yes" to previous question, show this column)* ○ Yes, project implementation occurring ○ No, project implementation not yet occurring If "No," please indicate why: ☐ Insufficient time ☐ Insufficient funding ☐ Environmental barriers (e.g., weather, difficult terrain or access, etc.) ☐ Lack of appropriate staff resources ☐ Other:____________
Etc…			

Programming note: tally from each column to show total number of sites selected for implementation, total number of selected sites secured, and total number of secured sites in which project implementation is occurring. If at least one site has project implementation occurring, proceed with questionnaire. If NO sites have project implementation occurring, stop questionnaire.

Project Implementation – Essential Elements

14. Have the essential species necessary for community creation been introduced on site? (i.e., aquatic vegetation, food sources, etc.)

○ Yes, essential species introduced

○ Yes, species introduction has been initiated, but is not yet complete due to:
- ☐ Insufficient time ☐ Insufficient funding
- ☐ Inability to secure source population for essential species
- ☐ Other: ___________________________________

○ No (*check all that apply*):
- ☐ Insufficient time ☐ Insufficient funding
- ☐ Inability to secure source population for essential species
- ☐ Other: ___________________________________

15. Have habitat structures necessary for community creation been created on site? (i.e., ponds, woody debris, etc.)

- ○ Yes, habitat structures created
- ○ Yes, habitat structure creation has been initiated, but is not yet complete due to:
  - ☐ Insufficient time ☐ Insufficient funding
  - ☐ Inability to secure source population for essential species
  - ☐ Other: ______________________________________
- ○ No (*check all that apply*):
  - ☐ Insufficient time ☐ Insufficient funding
  - ☐ Other: ______________________________________

16. Have natural processes necessary for community creation been initiated? (i.e., adequate stream flows, fire regimes, etc.)

- ○ Yes, natural processes initiated
- ○ Yes, natural processes have been initiated, but have not yet been completed due to:
  - ☐ Insufficient time ☐ Insufficient funding
  - ☐ Inability to secure source population for essential species
  - ☐ Other: ______________________________________
- ○ No (*check all that apply*):
  - ☐ Insufficient time ☐ Insufficient funding
  - ☐ Other: ______________________________________

Management & Monitoring

17. Is a management plan currently being implemented?

- ○ Yes, implementation of management plan occurring
- ○ No, management plan does not exist or is not finalized
- ○ No, too soon to implement management plan
- ○ No, insufficient resources to implement management plan
- ○ No, other: ___________________________

18. At the time of this survey, have the thresholds for indicators of community viability (stated in question 10) been attained?

- ○ Thresholds met/attained for all of the community viability indicators (100%)
- ○ Thresholds met/attained for most of the community viability indicators (75-99%)
- ○ Thresholds met/attained for some of the community viability indicators (30-75%)
- ○ Thresholds met/attained for few or none of the community viability indicators (< 30%)
- ○ It is too soon to determine if thresholds have been met/attained

Establishment of Species of Greatest Conservation Need – *Passive Colonization Only*

(*Note: If active colonization, complete the questionnaire for Species Reintroduction)*

19. Are target SGCN present on-site?

- ○ No, too soon to measure colonization
- ○ Insufficient monitoring is in place to determine if SGCN are present on-site
- ○ Yes, target SGCN is present on site

  If "Yes," indicate number of individuals present: ☐

  PROGRAMMING NOTE: During the initial information gathering stage, we assume there will be a question, "What are the primary target SGCN ?" for each project. For each indicated SGCN for a project, autopopulate additional subsets for this question, so the PI can indicate # of individals present for each SGCN (if these data are available). Do the same for Questions 20 and 21.

20. Are target SGCN breeding within the site?

- ○ Yes
- ○ No documentation of breeding occurring
  - ☐ Too early to expect breeding
  - ☐ Problems with immigrated population
  - ☐ Insufficient monitoring in place

21. Are the immigrated populations viable within the site?

- ○ Yes
- ○ No documentation of breeding occurring
  - ☐ Too early to expect breeding
  - ☐ Problems with immigrated population
  - ☐ Insufficient monitoring in place

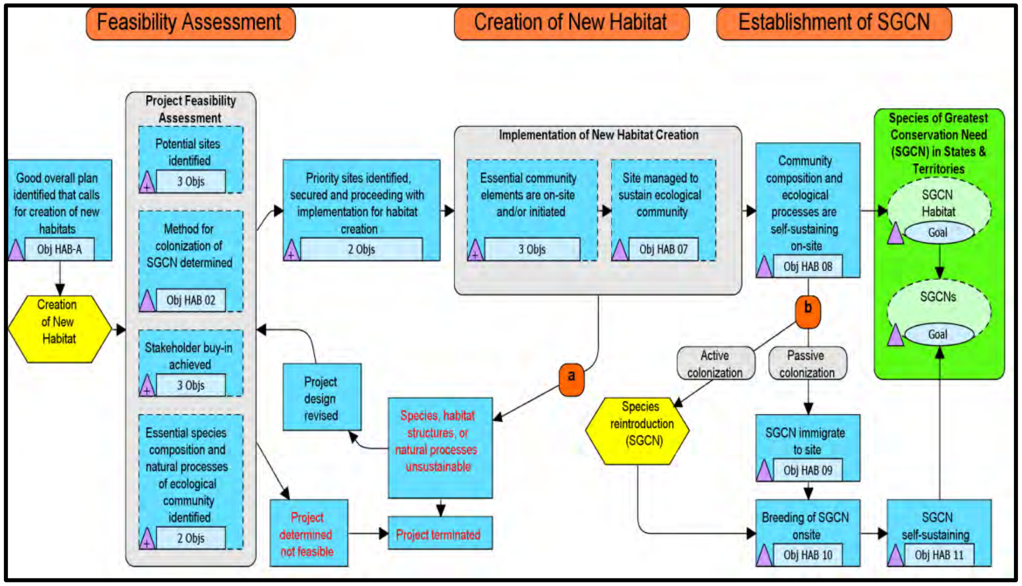
G. Example Graphs and Charts for Reports for Creation of New Habitat:

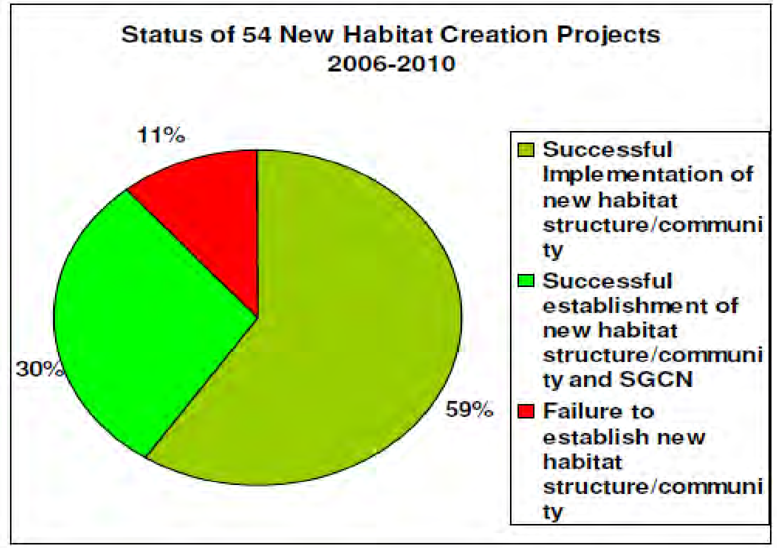
Effectiveness of Creation of New Habitat

Creation of New Habitat is the creation or establishment of new habitats or natural processes to mitigate loss of ecological functions elsewhere. Some examples include:

- Creating new breeding ponds for amphibian SGCN
- Creating prairie habitat where there are no remnant prairie plants
- Creating new wetlands for mitigation purposed (e.g., highway construction)

Progress to Date: Results Chain for Creation of New Habitat
In total, 54 *Creation of New Habitat* grants have been issues to 19 states from 2006-2010. Within four years of project termination, 30% of *Creation of New Habitat* projects resulted in new viable populations of SGCN, insufficient time has passed to determine success of 59% of *Creation of New Habitat* projects, and 11% of projects failed at the implementation stage.





Where Do We Go From Here?

New habitats created using SWG funding have resulted in self-sustaining populations of SGCN in 16 states. With existing threats to SGCN exacerbated by global climate change, new habitat creation is becoming increasingly warranted as a conservation action. In light of these current and future threats to SGCN, existing habitat creation projects have allowed the conservation community to determine the most efficient and economic methods for this conservation action. States will continue to monitor these projects for success/failure, and implement new habitat creation projects as funding allows.

Currently states would require an additional $9 million dollars to implement existing plans for *Creation of New Habitat*.

4. ACQUISITION / EASEMENT / LEASE

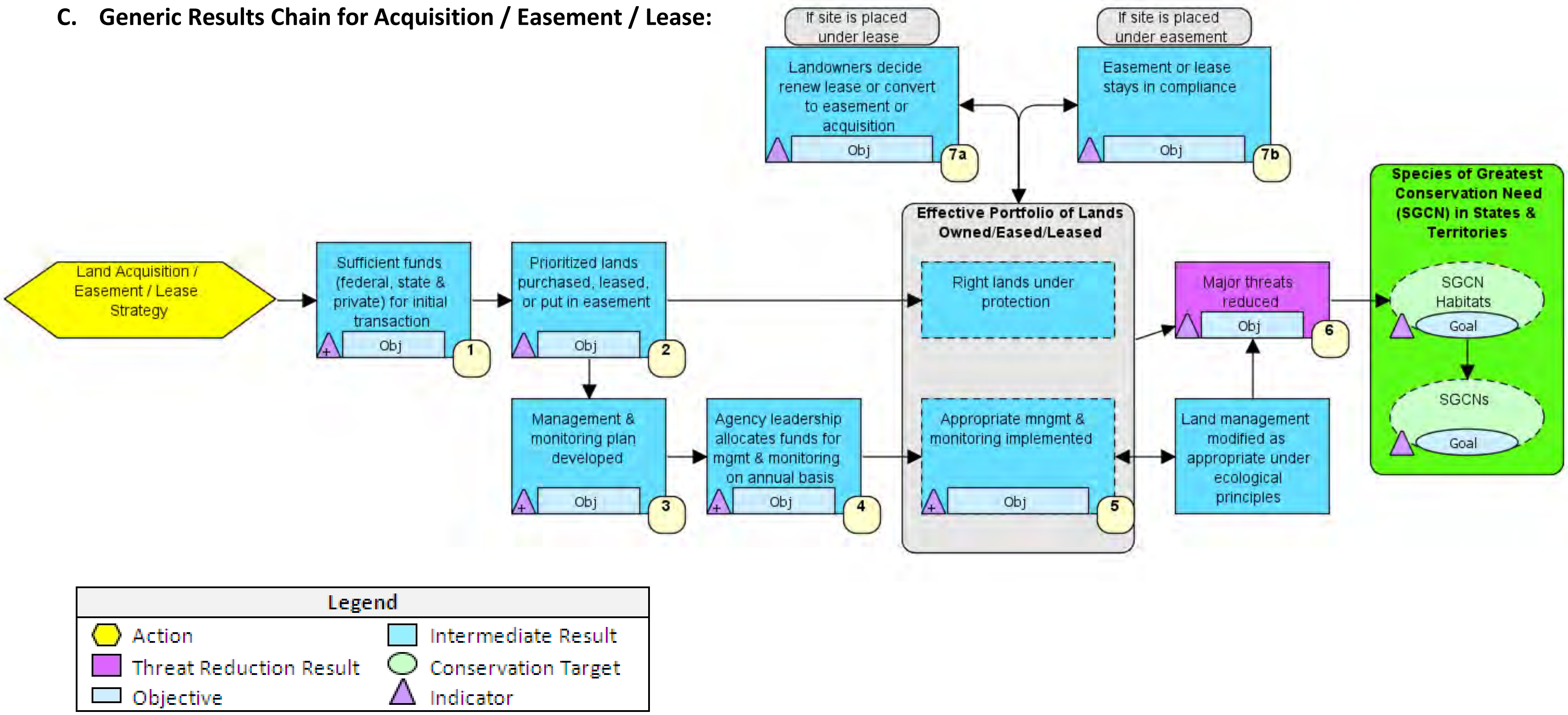
A. Definition of Acquisition / Easement / Lease:

Acquisition/Easement/Lease is defined as "Protection of land or water real property or rights through fee title acquisition, permanent easement, lease, contract, or a related means."

B. Specific Examples of Acquisition / Easement / Lease:

1. Purchase of land in a corridor connecting a Wildlife Management Area and a National Wildlife Refuge.
2. A perpetual easement restricting land conversion and development is placed on a remnant tall grass prairie.
3. A 20-year term contract is placed on a privately-owned Pennsylvania wet meadow for protection and recovery of the Bog Turtle.

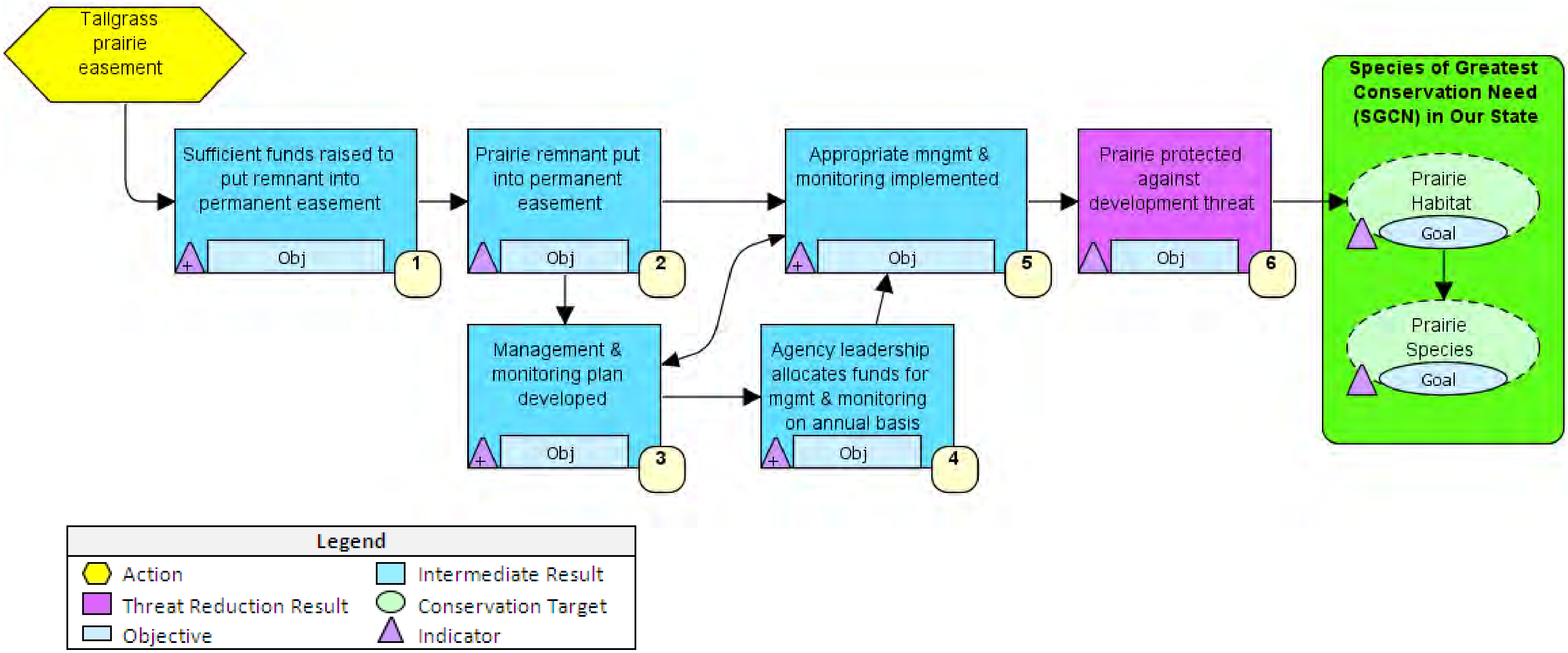
C. Generic Results Chain for Acquisition / Easement / Lease:



ASSOCIATION of FISH & WILDLIFE AGENCIES

Description: As outlined on the right-hand side of the results chain, Land Protection depends on getting sufficient funds in place for the initial transaction (1) and then purchasing, leasing, or obtaining an easement for the prioritized lands (2). The agency then needs to develop a management and monitoring plan (3) and allocate funds to implement it (4). The agency then needs to implement the management and monitoring work (5), thus mitigating the threats to the land (6). If the site is leased, over time the landowners need to renew the lease or convert to a more permanent form of protection (7a). If the site is placed under easement, the easement needs to stay in compliance (7b).

D. Example Results Chain for Acquisition / Easement / Lease:
This fictitious example is based on a case of obtaining an easement for a remnant tract of tall grass prairie.



E. Cross-walk of Generic and Real-world Example Results, Objectives, and Measures for Acquisition / Easement / Lease:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
LND AQ 1	**Generic:** Sufficient funds (federal, state & private) for initial transaction	At least X % of needed transaction cost comes from non-federal partnership with SWG	Amount received/needed for initial transaction	%/# of acquisitions that acquired X % of needed transaction cost with non-federal partnership	App 1. Was the site identified as a priority in the State Wildlife Action Plan? a. If NO, why? App 2. Type of land protection strategy App3. How many acres (or other units) are being prioritized for purchase, lease, or easement? App4. What is the total proposed cost (dollar amount) of the initial transaction for purchase, lease or easement? App5. What are the proposed sources of funds for this effort, including this grant? *The following questions repeat in report:* 1. What was the total cost (dollar amount) of the initial transaction for purchase, lease or easement? 2. What were the sources of funds for this effort, including this grant?
	Prairie Example: *Sufficient funds raised to put remnant into permanent easement*	*At least 50% of easement fees come from non-federal partnership with SWG*	*Amount needed/received for initial transaction of permanent easement*		
LND AQ 2	**Generic:** Prioritized land is purchased, leased, or put in easement	Priority site is purchased, leased, or put in an easement within X months/year of site being identified	# acres prioritized for purchase, lease or easement # acres purchased, leased, or put in easement	% of prioritized land purchased, leased, or put into easement	3. How many acres (or other units) were: a. Prioritized for purchase, lease or easement both by dominant habitat type and total b. Actually purchased, leased, or put under easement? 4. If lease or easement a. Date of transaction b. Length of contract c. Date of expiration
	Prairie Example: *Prairie remnant is put into permanent easement*	*Prairie easement is put into place within 12 months of being identified*	*# prairie acres put in easement within 12 months of prioritization*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
LND AQ 3	**Generic:** Management and monitoring plan developed	Within X months of priority site being identified, clear management and monitoring plans have been developed	Existence of a management and monitoring plan that outlines steps required to achieve desired conservation results	% of protected land with management and monitoring plans that outline steps required to achieve desired conservation results	5. Was a management plan created that outlines steps required leading to desired conservation results (e.g., SGCN populations and habitat conditions)? 6. Who is responsible for implementing this management plan? 7. Was a monitoring plan created? 8. Who is responsible for implementing this monitoring plan?
	Prairie Example: *Management and monitoring plan developed*	*Within 12 months of priority site being identified, clear management and monitoring plans have been developed*	*Existence of a management and monitoring plan that outlines steps required to achieve desired conservation results*		
LND AQ 4	**Generic:** Agency leadership allocates funds for management & monitoring on annual basis	At least X % of funds requested for annual management & monitoring are being allocated by agency leadership	Amount of funding requested for management & monitoring annually; Amount of funding that that was allocated by Agency leadership for management and monitoring annually	% of requested funding that was allocated by agency leadership to be spent on management and monitoring annually	9. How much funding was requested and finally allocated for managing this lease, easement, or acquisition? 10. How much funding was requested and finally allocated for monitoring this lease, easement, or acquisition?
	Prairie Example: *Agency leadership allocates funds for management & monitoring on annual basis*	At least $20,000 per year is allocated for management and monitoring of the site	Amount of funding requested for management & monitoring annually; Amount of funding that that was spent on management and monitoring annually		
LND AQ 5	**Generic:** Appropriate management and monitoring implemented	Within X months/years of land acquisition/lease/ easement, agency is implementing appropriate management and monitoring plans at that site	Evidence of management plan being implemented	% of land acquisition actions in which management plans are being implemented	11. What is the extent that the management plan is being implemented? 12. If the management plan is being implemented, are the actions achieving the desired goals identified in the plan? 13. If management plan is not achieving desired goals, why not? 14. If the management is not having the desired effect, are management plans being updated to reflect new information? 15. Is there a monitoring plan in a place that includes either a species or habitat monitoring component? 16. What is the extent to which the monitoring plan is being implemented?
	Prairie Example: *Appropriate management and monitoring plan implemented*	*Within 1 year after the easement, agency is implementing appropriate management and monitoring plans at the site*	*Evidence of management plan being implemented*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
LND AQ 6	**Generic:** Major threats reduced	Within X years of completing the acquisition, the desired threat reduction is seen	Evidence that management plan is reducing key threats	% of initiatives that show a reduction in key threats being addressed by management plan	17. What threat(s) were you hoping to address through your management plan(s), and do you have evidence that the plan(s) are leading toward reductions in any of these threats? 18. Additional comments or anecdotes (optional) 19. Do you have any suggestions to improve the planning process?
	Prairie Example: *Prairie protected against development threat*	*Within 2 years, the development threat has been mitigated*	*Assessment of development threat*		
LND AQ 7a	**Generic:** Landowners decide to renew lease or convert to easement or acquisition	At the time of lease renewal, landowner decides to either: a) renew lease; b) convert least to easement; or c) offer leased land up for acquisition	Evidence of lease renewal or conversion to easement or acquisition	% of protected lands at the time of renewal that are: a) renewed; b) converted from lease to easement or c) converted to acquisition	20. For lease strategies: a. Has the lease contract expired? b. If the lease contract has expired has the agency attempted to renew the agreement? c. If landowner has renewed was the agreement: lease or convert to easement/acquisition? d. If landowner has not renewed agreement, why not?
	Prairie Example: *(not part of this example)*				
LND AQ 7b	**Generic:** Easement or lease stays in compliance	Each year after the easement or lease is established the easement is shown to be in compliance	Evidence of lease compliance per year	% of easements or leases in compliance	21. What proportion of years since the easement/lease contract beginning has the landowner remained in compliance? 22. During the past three years, has the agency had to initiate legal action to compel a landowner to comply with the terms of this easement/lease agreement?
	Prairie Example: *(not part of this example)*				

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**<u>Goal:</u>** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Prairie Example: *Prairie-dependent SGCN status improved*	***<u>Goal:</u>*** *Within 3 years of the easement, key prairie species have improved viablity*	*Viability of prairie species*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	**<u>Goal:</u>** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Prairie Example: *Prairie habitat improved*	*Within 3 years of the easement, the prairie habitat viability has improved*	*Viability of prairie habitat*		

F. Measures Questionnaire for Acquisition / Easement / Lease:

SWG PROPOSAL QUESTIONS

App1. Was the site(s) identified as a priority in the State Wildlife Action Plan?

- ○ YES
- ○ NO
- ○ Not Applicable

App1a. IF NO, Why not?

- ☐ State Wildlife Action Plan did not identify priority sites
- ☐ Site is meeting an emerging need not identified in State Wildlife Action Plan
- ☐ Other (please describe in the space below)

Comments

App2. Please identify the type of Land Protection Strategy:

- ○ Fee Title Acquisition
- ○ Perpetual Conservation Easement
- ○ Term Conservation Easement
- ○ Lease/agreement/contract
- ○ Other

If "other," please describe:

App3. How many acres (or other units) are being prioritized for purchase, lease, or easement?

App4. What is the total proposed cost (dollar amount) of the initial transaction for purchase, lease or easement?

App5. What are the proposed sources of funds for this effort, including this grant?

Funding Source	Amount	% of Total	Comment
This grant			

SWG PERFORMANCE REPORTING QUESTIONS
Site Identification and Procurement

1. What was the total cost (dollar amount) of the initial transaction for purchase, lease or easement?

2. What were the sources of funds for this effort, including this grant?

Funding Source	Amount	% of Total	Comment
This grant			
Other			

3. How many acres (or other units):

a. Were prioritized for purchase, lease, or easement both by dominant habitat type and total?

Total Units

b. Were actually purchased, leased, or put under easement both by dominant habitat type and total?

Total Units

Habitat Type	Unit (e.g. acres)	Prioritized	Actual	Comment

4. If lease or easement:
a. Date of transaction (numerical value)

b. Length of contract (numerical value)

c. Date of expiration (numerical value)

5. Was a management plan created that outlines steps required leading to desired conservation results (e.g., SGCN populations and habitat conditions)?

- YES
- NO (please explain below)
- Unknown

If "NO" or "Unknown," please explain:

ASSOCIATION of FISH & WILDLIFE AGENCIES

6. Who is responsible for implementing this management plan?

- Wildlife Agency
- Landowner
- Other (please specify)

7. Was a monitoring plan created?

- YES
- NO (please explain below)
- Unknown

If "NO" or "Unknown," please explain:

8. Who is responsible for implementing this management plan?

- Wildlife Agency
- Landowner
- Other (please specify)

9. How much funding was requested and finally allocated for managing this lease, easement, or acquisition?

Amount requested Amount allocated

10. How much funding was requested and finally allocated for monitoring this lease, easement, or acquisition?

Amount requested Amount allocated

11. What is the extent to which the management plan is being implemented?

- Fully
- Mostly
- Partially
- Not at all

If "Mostly," "Partially" or "Not at all," why?

12. If the management plan is being implemented, are the actions achieving the desired goals based on the plan(s)?

- Fully
- Mostly (explain below)
- Partially (explain below)
- Not at all

If "Mostly," "Partially" or "Not at all," please explain:

13. If "Not at all," why not?

- Not enough time has passed
- Management actions weren't appropriate
- Funding requested for management wasn't adequate
- Weather or unpredictable hazards impeded management activity
- Unknown
- Other (please specify below)

Comments:

14. If management is not having the desired effect, have management plans been updated to reflect new information?

YES NO (please explain below) Unknown

If "No," please explain:

15. Is there a monitoring plan in place that includes either a species or habitat monitoring component?

- YES
- NO (please explain below)
- Unknown

If "No" or "unknown," why not?

16. What is the extent to which the monitoring plan is being implemented?

- Fully
- Mostly
- Partially
- Not at all (please explain below)

If "mostly," "partially" or "not at all," why not?

Threat Reduction

17. What threat(s) were you hoping to address through the designation of conservation areas, and do you have evidence that the designation(s) are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org.

Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.

Direct Threat	Check if relevant	Evidence of reduction?	Please explain
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	
7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	
11 Climate Change & Severe Weather	☐	y/n/don't know	

18. Additional comments or anecdotes (optional)

19. Do you have any suggestions to improve the planning process?

20. For lease strategies:

20a. Has the original lease agreement expired?

- ○ YES
- ○ NO

20b. If "YES," when the lease agreement expired, did the agency attempt to renew this agreement?

- ○ YES
- ○ NO
- ○ Unknown

20c. If "YES," was the lease agreement officially renewed?

- YES
- NO
- Unknown

20d. If the lease agreement was not renewed, please explain why:

- Economic - lease fee insufficient
- Changing ownership - new owner not interested
- Landowner unhappy with the lease terms or process
- Lease converted to a permanent easement
- Property acquired by agency or partner
- Property no longer meets conservation goals
- Poor relationship between the landowner and the agency
- Management objectives have been met
- Other (please specify below)

Comment:

21. What proportion of years since the easement/lease contract beginning has the landowner remained in compliance?

- Fully compliant (96-100% of years under contract)
- Mostly compliant (76-95% of years under contract)
- Somewhat compliant (46-75% of the years under contract)
- Rarely compliant (26-45% of the years under contract)
- No evidence of compliance (less than 25%)
- Unknown

If "somewhat," "Rarely," "No-evidence" or "Unknown," please explain:

22. During the past three years, has the agency had to initiate legal action to compel a landowner to comply with the terms of this easement/lease agreement?

- YES
- NO
- Unknown

Please explain if necessary:

5. Conservation Area Designation

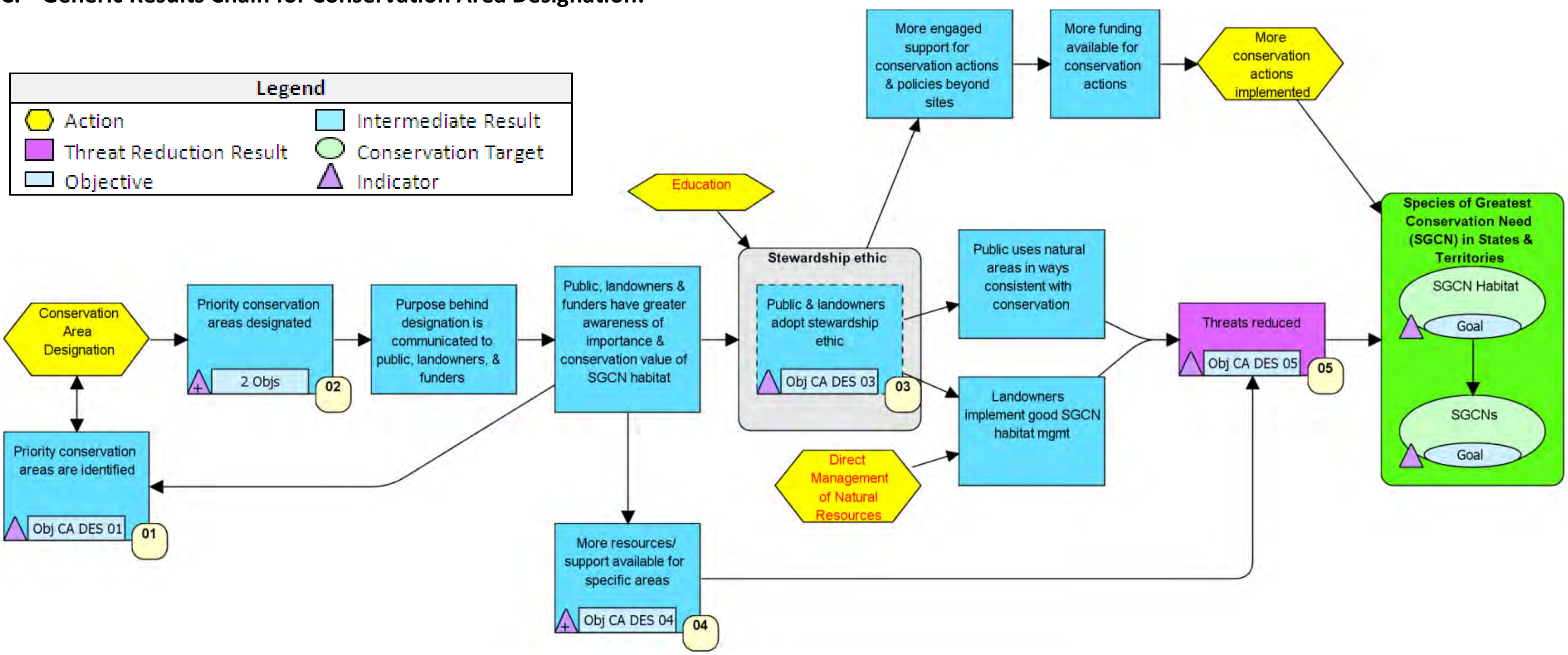
A. Definition of Conservation Area Designation:

Conservation Area Designation is defined as "Designation of a site or landscape as having unique and important value to wildlife with or without legal protections."

B. Specific Examples of Conservation Area Designation:

1. Designate an area as an Important Bird Area.
2. Designate an area as an Important Reptile/Amphibian Area.
3. Add an area to a State Natural Area Registry.

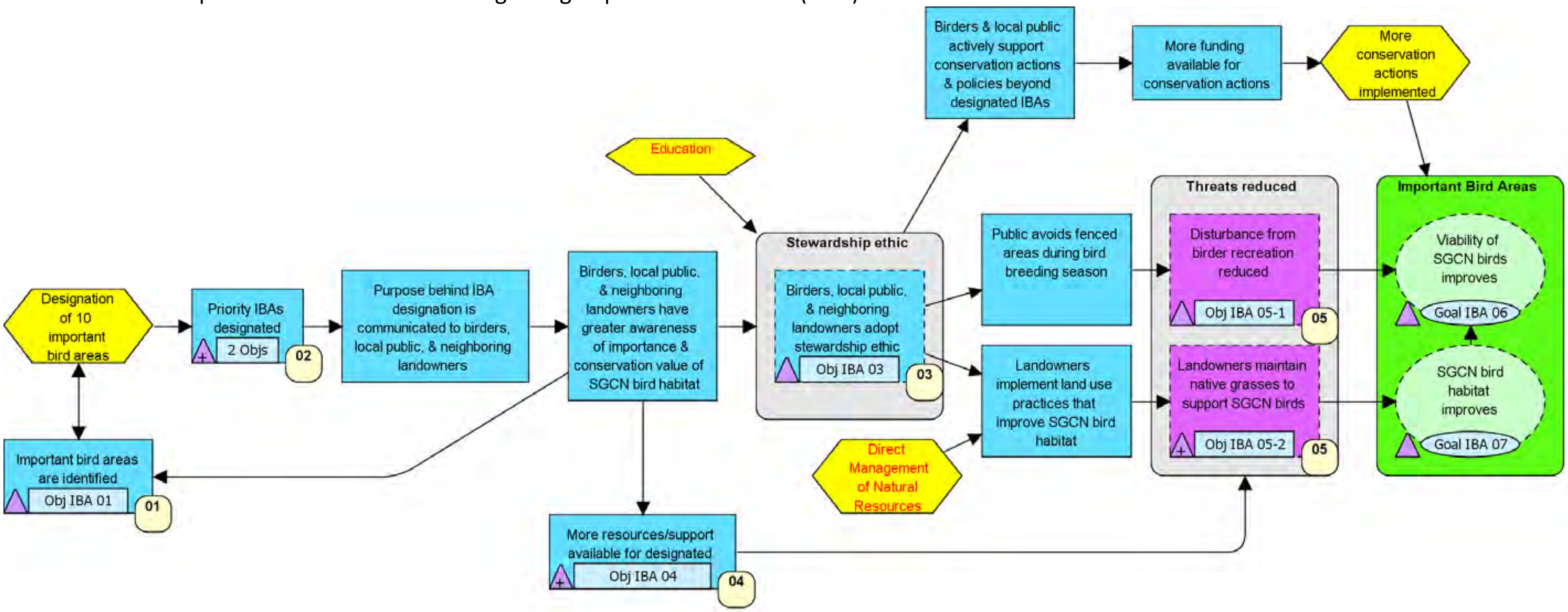
C. Generic Results Chain for Conservation Area Designation:



Description: State agencies and their partners use the formal designation of conservation areas to identify places with high value as wildlife habitat and to promote a stewardship ethic among landowners and other key stakeholders that value or use the sites for recreation. The results chain begins with a rigorous process for identifying these priority areas that involves quality data and stakeholder participation (01). It is assumed that this would be part of the SWG review process – in other words, a conservation areas designation initiative that did not undertake a rigorous process would not be awarded SWG funding. If an initiative does receive funding, then the results chain shows that the first expected result is that the priority areas would be designated (02) and would cover a desired spatial extent and benefit key SGCN. The project team then engages local stakeholders—most importantly landowners within the designated areas—to raise awareness of the important wildlife and habitat values. Ideally the landowners would be part of the original stakeholder participation in identifying the priority conservation areas. But even if they are not, outreach with landowners is critical at this stage to achieve the desired results. The successful communication of wildlife and habitat values should result in an increased stewardship ethic among target populations (03), that leads to compatible public uses and good habitat management within the designated areas. Over time, these results are expected to help reduce threats to the SGCN within the designated conservation areas (05) and achieve population and habitat goals. Ancillary benefits, depicted in the chains below and above the main chain, include increases in resources/support for specific conservation areas (04) and more active engagement by target audiences in supporting conservation action and policies beyond the designated conservation areas. Well known examples of conservation designations include State Natural Areas Registries, Important Bird Areas, TNC's ecoregional portfolio, and the priority conservation zones identified in some states' Wildlife Action Plans.

D. Example Results Chain for Conservation Area Designation:

This fictitious example is based on a case of designating Important Bird Areas (IBAs).



Legend	
Action	Intermediate Result
Threat Reduction Result	Conservation Target
Objective	Indicator

Association of Fish & Wildlife Agencies

E. Cross-walk of Generic and Example Results, Objectives and Measures for Conservation Area Designation:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
CA DES 01	**Generic:** Priority conservation areas identified	Prior to designation, a rigorous process is in place for identifying priority conservation areas	Existence of rigorous process for identifying priority conservation areas	None – should be part of application and review process	App1. Which of the following did you consider in identifying your priority conservation areas? a. Geospatial SGCN data b. Consistent designation criteria c. Process underwent an expert review d. Process gathered stakeholder input *Note: these are suggested questions for the SWG application process.*
	IBA Example: *Important bird areas identified*	*Prior to designation, a rigorous process is in place for identifying important bird areas*	*Existence of rigorous process for identifying important areas*		
CA DES 02-1	**Generic:** Priority conservation areas designated	Within X years of initiating the process, at least X# or % of priority conservation areas designated	# of priority conservation areas designated	% of initiatives that have met their designation # objective	1. How many priority conservation areas were designated?
	IBA Example: *Priority IBAs designated*	*Within 2 years of initiating the Important Bird Area designation process, at least 8 IBAs are designated*	*# of important areas designated*		
CA DES 02-2	**Generic:** Priority conservation areas designated	Within X years of initiating the process, at least X# of SGCNs and X# acres are covered by the designations	a. # acres encompassed within designated conservation areas b. # of SGCNs encompassed within designated conservation areas	a. % of initiatives that have met their acreage objective b. % of initiatives that have met their SGCN coverage objective	2. How many acres are encompassed within designated conservation areas? 3. How many SGCNS are encompassed within designated conservation areas?
	IBA Example: *Priority IBAs designated*	*Within 2 years of initiating the Important Bird Area designation process, at least 15 SGCN birds and 4,000 acres are covered by the IBAs*	a. *# acres encompassed within important bird areas* b. *# of SGCN birds encompassed within the Important Bird Areas*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
CA DES 03	**Generic:** Public & landowners adopt stewardship ethic	Within X years of the designation, the trend in stewardship ethic within the designated conservation area increases	Trend in stewardship ethic within designated conservation area	% of initiatives that show an increase in the trend in stewardship ethic within designated conservation area	4. What is the general trend for stewardship ethic across all of the designated conservation area(s)? If stable, declining, or mixed results, please indicate why 5. What is the basis for your answer above? 6. To what degree do you feel the primary driver behind the trend was the designation of the conservation area(s)? 7. Additional comments or anecdotes (optional)
	IBA Example: *Birders, local public, & neighboring landowners adopt stewardship ethic*	*Within 5 years of the IBA designation, the trend in stewardship ethic across the IBAs increases*	*Trend in stewardship ethic across designated IBAs*		
CA DES 04	**Generic:** More resources/ support available for specific areas	Within X years of designation, there is an increase in funding, human resources, and/or programs that benefit the designated conservation areas	Evidence of increase in: a. Funding b. Human resources c. Programs	% of initiatives that show evidence of increase in: a. Funding b. Human resources c. Programs	8. Since the designation of the conservation area, have you seen an increase in the following resources? a. Funding b. Human resources c. Programs 9. Additional comments or anecdotes (optional)
	IBA Example: *More resources/support available for designated IBAs*	*Within 5 years of IBAs' designation, donations and volunteer hours for IBA management from the birding community increase relative to 2011 levels*	*Evidence of increase in:* *a. Donations from birding community for designated IBAs* *b. Volunteer hours from birding community*		
CA DES 05	**Generic:** Threats reduced	Within X years of the designation of the conservation area, the desired threat reduction is seen	Evidence that conservation area designation is reducing key threats	% of initiatives that show a reduction in key threats being addressed by conservation area designation	10. What threat(s) were you hoping to address through the designation of conservation areas, and do you have evidence that the designation(s) are leading toward reductions in any of these threats? If you did not see the threat reductions you expected, please indicate why 11. Additional comments or anecdotes (optional)
	IBA Example: *Disturbance from birder recreation reduced*	*Within 7 years, incidences of disturbance to nesting birds in IBAs decrease by at least 75%, as compared to 2011 levels*	*# of incidences of disturbance to nesting birds in IBAs*		
	IBA Example: *Landowners maintain native grasses to support SGCN birds*	*Within 7 years, at least 50 landholders across the IBAS are maintaining a total of at least 1000 acres of grasslands with native grass species to support SGCN birds*	*a. # of acres of native grass habitat maintained* *b. # of landholders within the IBAs that are maintaining native grasses*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
N/A - Conser-vation targets	**Generic: Viability of SGCN improved**	**<u>Goal:</u>** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	IBA Example: *Viability of SGCN birds improves*	***<u>Goal:</u>*** *Within 10 years of the designation of IBAs, SGCN bird breeding pairs within designated IBAs have increased at least 10% over 2011 numbers based on breeding season grassland bird point counts*	*# of SGCN breeding bird pairs within designated IBAs*		
N/A - Conser-vation targets	**Generic: Viability of SGCN habitats improved**	**<u>Goal:</u>** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	IBA Example: *SGCN bird habitat improves*	***<u>Goal:</u>*** *Within 10 years of the designation of IBAs, at least 1,000 acres of SGCN bird habitat within designated IBAs is being maintained by landowners in a condition of high ecological integrity, as measured against an appropriate native grassland reference site*	*# of acres of SGCN bird habitat maintained in a condition of high ecological integrity*		

F. Measures Questionnaire for Conservation Area Designation:

Identification of Priority Conservation Areas

APP1. Which of the following did you consider in identifying your priority conservation areas?

Element	Yes	No	Don't Know
Geospatial SGCN data	○	○	○
Consistent designation criteria	○	○	○
Process underwent an expert review	○	○	○
Process gathered stakeholder input	○	○	○

Note: This should be an application question, not a monitoring question.

Designation of Priority Conservation Areas

Considering the entire scope of your initiative to designate conservation areas, please answer the following questions

1. How many priority conservation areas were designated? ☐ areas
2. How many acres are encompassed within designated conservation areas? ☐ acres
3. How many SGCNS are encompassed within designated conservation areas? ☐ SGCNs

Trend in Stewardship Ethic

4. What is the general trend for stewardship ethic across all of the designated conservation area(s)? (Improving, Stable, Declining)

   ○ Improving

   ○ Stable

   ○ Declining

   ○ Mixed results across multiple area designations

   ○ Don't know

   If stable, declining, or mixed results, please indicate why *(check all that apply)*:

   ☐ Insufficient time has passed to expect an improving trend in stewardship
   ☐ Stewardship ethic was already very good
   ☐ Other factors (e.g., economic, political, social conditions) were too strong to overcome
   ☐ Other: ______________________________________
   ☐ Don't know

5. What is the basis for your estimate on stewardship ethic trends?

   ○ Professional judgment

   ○ Attitude survey or similar data collection effort

   ○ Other (Please specify _________________)

6. To what degree do you feel the primary driver behind the stewardship trend was the designation of the conservation area(s)?

   ○ Mostly or completely

   ○ Partly

   ○ Not very much

○ Not at all

○ Don't know

7. Additional comments or anecdotes (optional)

Resources/ Support Available to Designated Conservation Areas

8. Since the designation of the conservation area, have you seen an increase in the following resources?

Resource	Yes	No	Don't Know
Funding	○	○	○
Human resources	○	○	○
Programs	○	○	○

9. Additional comments or anecdotes (optional)

Threat Reduction

10. What threat(s) were you hoping to address through the designation of conservation areas, and do you have evidence that the designation(s) are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org. *Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.*

Direct Threat	Check if relevant	Evidence of reduction?	Please explain
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	
7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	
11 Climate Change & Severe Weather	☐	y/n/don't know	

If you did not see the threat reductions you expected, please indicate why *(check all that apply)*:

☐ Insufficient time has passed to expect a reduction in threats

☐ Insufficient funding was available to adequately support conservation areas

☐ Other factors (e.g., economic, political, social conditions) were too strong to overcome

☐ Other: ______________________________________

☐ Don’t know

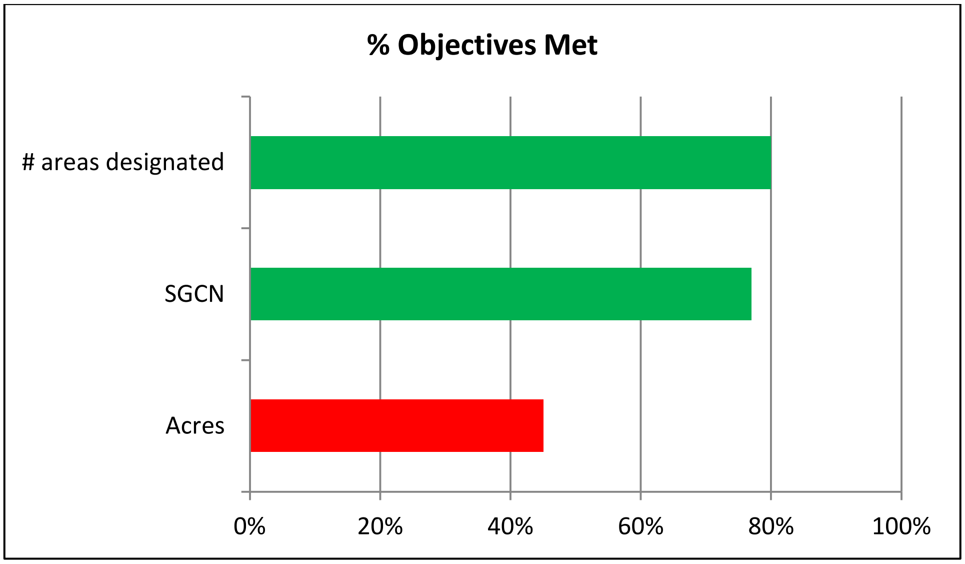
11. Additional comments or anecdotes (optional)

Additional Information

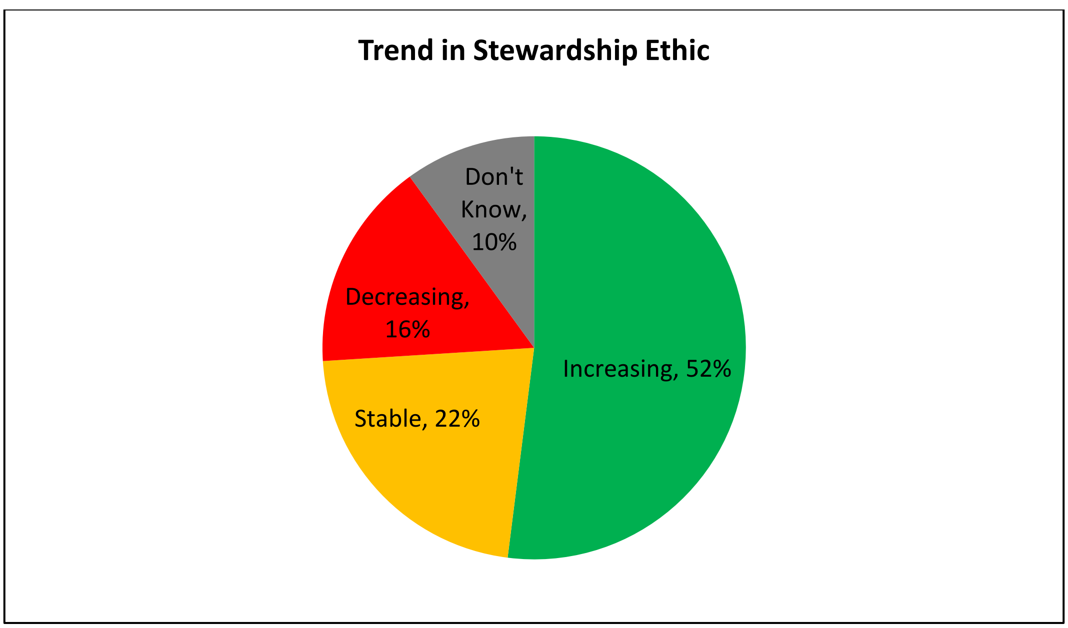
12. Please provide any narratives, case studies, or additional comments you may have related to your conservation area designation initiative (optional)

G. Example Graphs and Charts for Reports Conservation Area Designation:
Potential graphs and charts for a report could include:

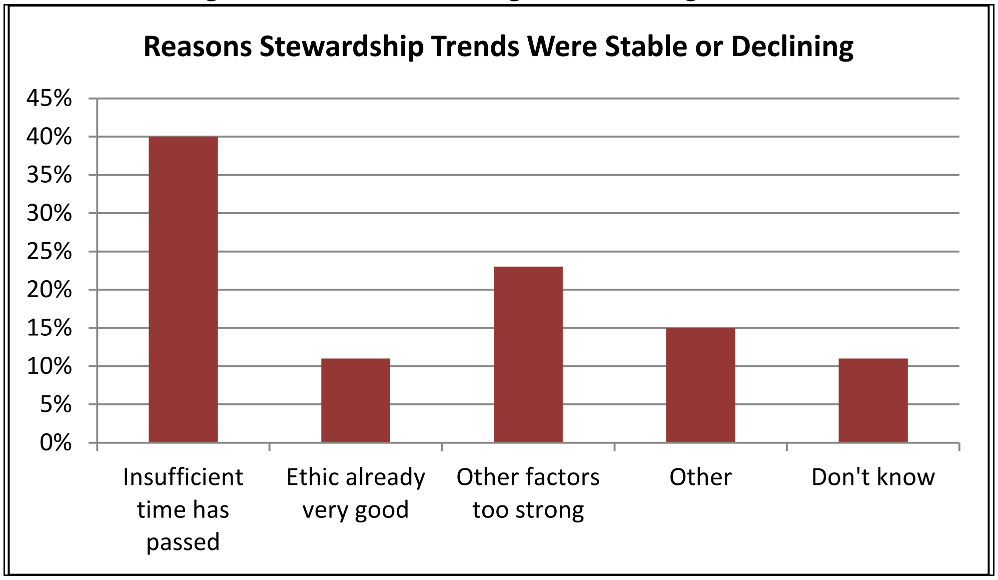
CA DES 02 (Priority conservation areas designated): Bar graph that shows 3 indicators of % objectives met for acres, SGCN, and # areas designated; Could use red (<50%), yellow (51-75%), green (76% - 100%) categories to show how well they are doing



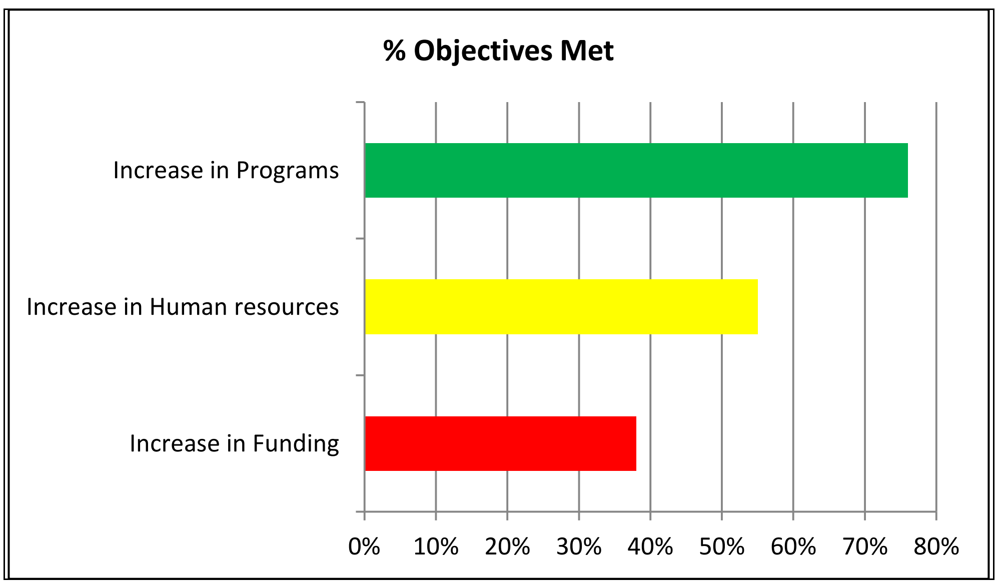
CA DES 03 (Public & landowners adopt stewardship ethic): Pie chart that shows increasing, stable, decreasing trends. Note: Consider timeframe...only show those responses where they have NOT indicated that it is too early to be able to have met their objectives



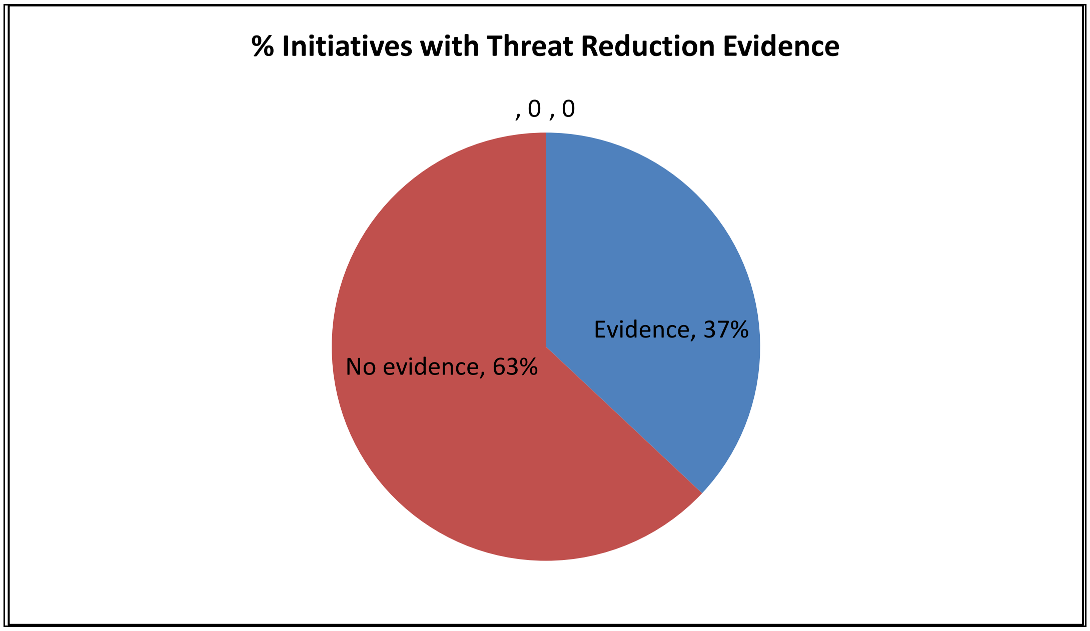
Bar chart showing main reasons accounting for decreasing or stable trends:

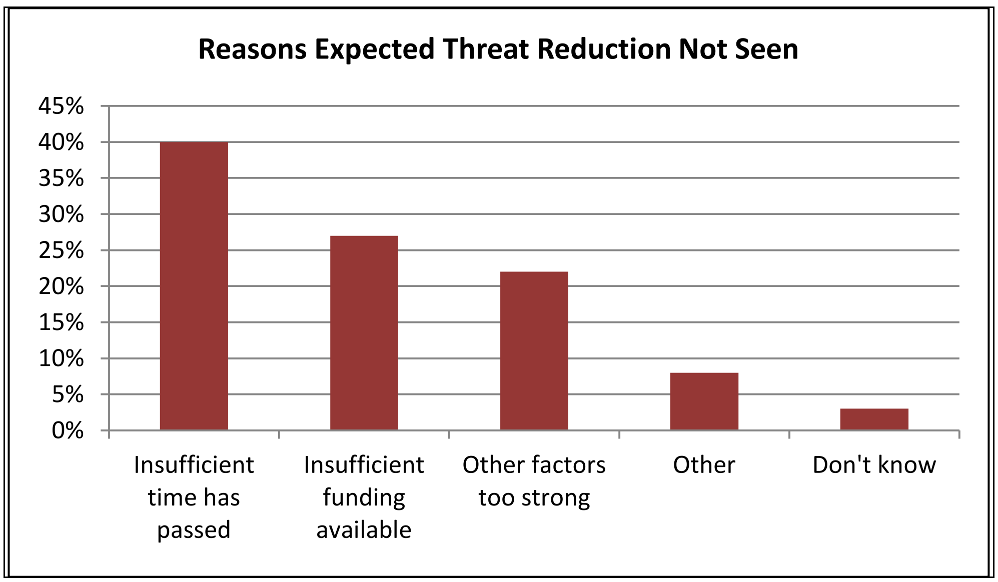


CA DES 04 (More resources/ support available for specific areas): Bar graph that shows 3 indicators of % objectives met for funding, human resources, programs; Could use red (<50%), yellow (51-75%), green (76% - 100%) categories to show how well they are doing



CADES 05 (Threats reduced): Pie chart showing % of initiatives with threat reduction evidence vs. not





6. Environmental Review

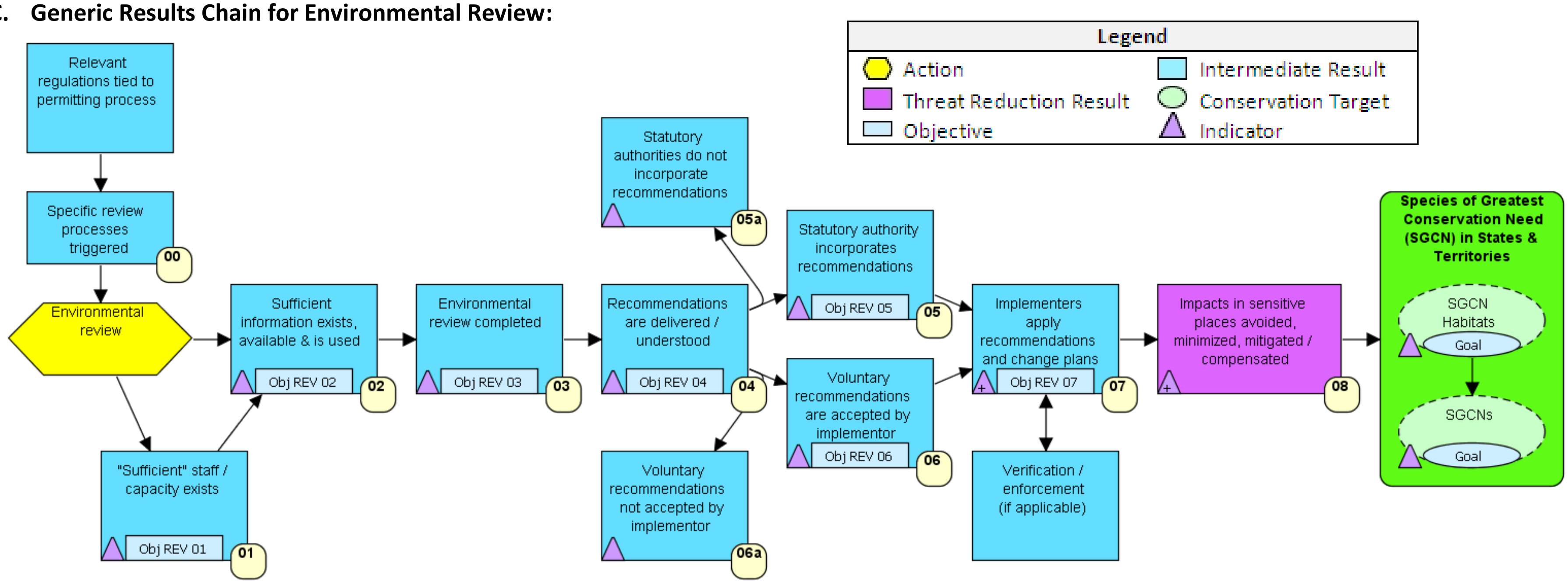
A. Definition of Environmental Review:

Environmental Review is defined as "Review of agency and private sector policies, projects and plans (primarily related to development and potential adverse impacts to natural resources) to help ensure potential impacts to fish and wildlife are avoided, minimized and/or compensated/mitigated."

B. Specific Examples of Environmental Review:

1. Review of proposed new landfill siting alternatives to recommend which alternative(s) will least impact natural resources immediately (direct) and over time (indirect, cumulative); and where mitigation activities and dollars would be best spent to compensate for unavoidable resource impacts.
2. Review new highway route alternatives and make recommendations for resource protection from planning through implementation.
3. Review of new road salt application policy to ensure timing, periodicity, and intensity avoid or limit potential impacts to natural resources.

C. Generic Results Chain for Environmental Review:

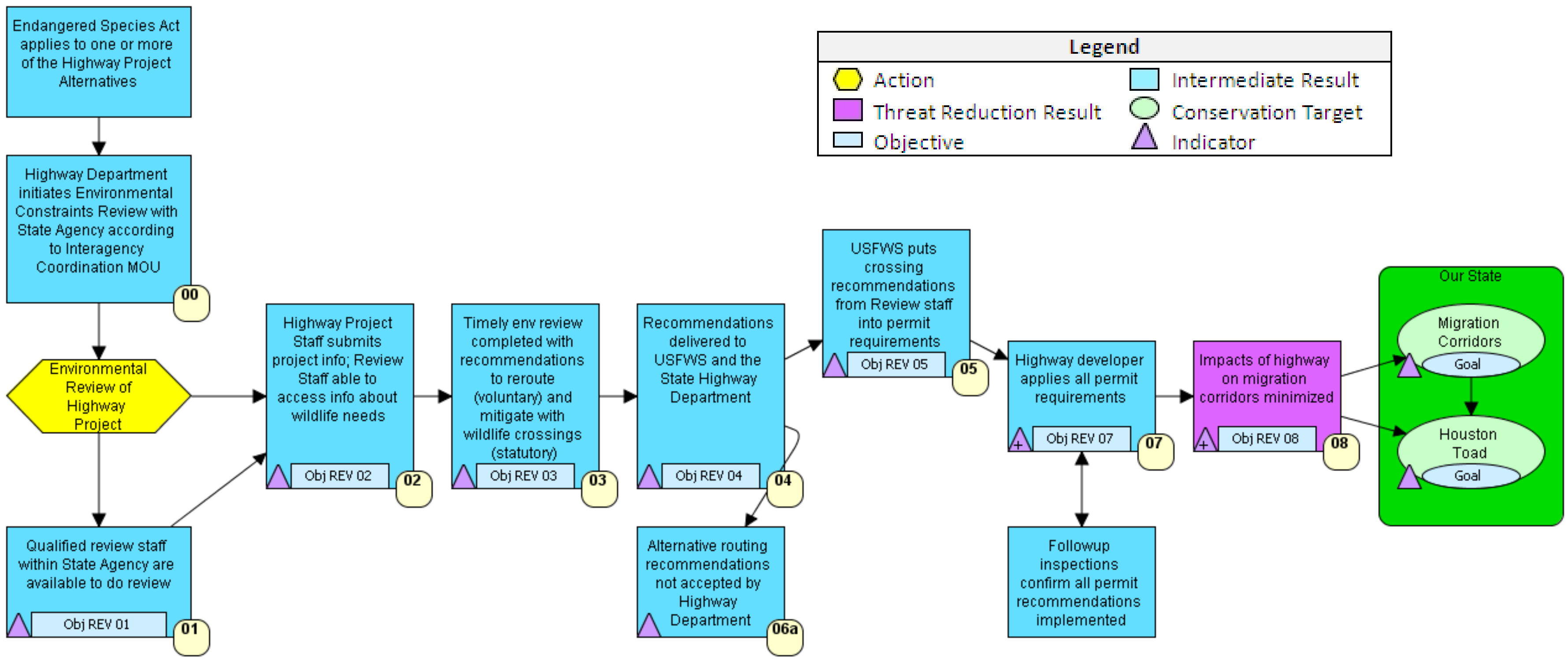


Description: As outlined on the right-hand side of the results chain, Environmental Review is fundamentally about avoiding, minimizing, or mitigating/compensating for threats posed by improperly sited or unsustainable development or policies which may adversely affect SGCN and their habitats. An environmental review strategy assumes that each state which conducts these reviews has regulations and a process for triggering reviews of development efforts or key policies proposed by government agencies or private entities (00). Important elements in this chain include the availability of sufficient staff expertise (01) and information (02) needed to conduct the review (03). Once the review has been completed and the recommendations delivered (04), the chain diverges in the cases of *statutory* guidance in which the regulatory authority has the power to impose recommendations (05) versus *voluntary* guidance in which case no regulations or formal relationships require the implementer to "comply" with the reviewers' suggestions (06).

If review recommendations are not accepted by either partner agencies (statutory guidance) and/or the implementer (voluntary guidance), then the agency needs to examine review practices, timelines, communication, collaboration, and messaging. Finally, the implementers need to apply the recommendations and modify their development plans or policies as appropriate (07). In some cases, verification or enforcement may be needed.

D. Example Results Chain for Environmental Review:

This fictitious example is based on a case of review of a highway project that potentially affects both key wildlife migration corridors that require wildlife crossings to mitigate their effects (accepted by the USFWS and made a mandatory condition of permits) and a toad species that requires rerouting of key sections of the highway (voluntary and in this case, not accepted by the State Highway Department).



E. Cross-walk of Generic and Real-world Example Results, Objectives and Measures for Environmental Review:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
ENV REV 01	**Generic:** "Sufficient" staff / capacity exists	Following initiation of Environmental Review, reviewers ensure "sufficient staff" or capacity exists in terms of number of staff and the specific skills they possess	Available staff / capacity	None	App 1. What types of projects /policies may be/were covered in your Environmental Review(s)? App 2a. Are/were there sufficient qualified staff or contractors available to conduct the review? App 2b. If not, how will/did you address the deficiency? *Note: these are suggested questions for the SWG proposal and the performance report.*
	Highway Example: *Qualified review staff within State Agency are available to do review*	*Sufficient staff who have experience with highway projects are available within the State Agency to compete the review on a timely basis*	*Availability of staff / contractors with appropriate qualifications*		
ENV REV 02	**Generic: "**Sufficient" information exists, available & is used	Prior to the review, "sufficient" information about affected species and habitats, potential impacts and sites affected, mitigation/compensation options and alternatives are identified and accessible	Availability of information	None	3a. Was sufficient information available for review on: Overall scope and activities of proposed project? Potentially affected species and habitats? Potential impacts and sites affected? Mitigation/compensation options? Alternatives? 3b. If not, how did you address the deficiency?
	Highway Example: *Highway Project Staff submits project info; Review Staff able to access info about wildlife needs*	*Prior to the review, Highway Project Staff submits plans, preliminary constraints, equipment and materials lists; Review Staff has easy access to natural resources occurrences maps, understands wildlife movement and habitat requirements*	*Availability of information on key topics*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
ENV REV 03	**Generic:** Environmental review completed	Review completed within established deadlines that addresses all potential impacts / concerns, and makes recommendations for avoidance, minimization and/or compensation / mitigation as needed	Degree to which review is timely, complete, comprehensive	# of reviews completed, sorted by proposed project type (e.g., wind transmission, roads) and by recommendation type (e.g., avoidance, minimization, compensation / mitigation)	4. Was the review completed on a timely basis within established deadlines? 5. Did the review address all potential impacts and make recommendations for avoidance, minimization and/or compensation/mitigation? 6. If mitigation was recommended (action instead of payment of compensation), did recommendation(s) include specific actions and/or effectiveness measures?
	Highway Example: *Timely env review completed with recommendations to reroute (voluntary) and mitigate with wildlife crossings (statutory)*	*Environmental review completed on time with recommendations to reroute some sections (voluntary) and mitigate with wildlife crossings (statutory)*	*Degree to which review is timely, complete, comprehensive*		
ENV REV 04	**Generic:** Recommendations are delivered / understood	Following review, recommendations are produced and communicated to the implementer in an appropriate fashion	Delivery of recommendations	None	7a. Did you deliver the recommendations from your review to the implementer(s), permitting agency(ies) and/or other departments within your agency and follow up with them to assure delivery, understanding, acceptance? 7b. If not, please explain.
	Highway Example: *Recommendations delivered to USFWS and the State Highway Department*	*Following review, recommendations are produced and communicated to the USFWS and State Highway Department who confirm receipt*	*Degree to which recommendations are delivered in an appropriate fashion*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
ENV REV 05	**Generic:** Statutory authority incorporates recommendations	Following the review, relevant permitting entity(ies) or regulatory agency(ies) accept and incorporate recommendations into their review/permit process and documentation	a. Degree to which recommendations are incorporated into relevant permits and documentation b. If not accepted, reasons for non-implementation	Number/% of instances accepted vs. not accepted	8a. Did permitting agency(ies) add your recommendations to their permit requirements? 8b. If not, explain why to the best of your knowledge.
	Highway Example: *USFWS puts crossing recommendations from Review staff into permit requirements*	*Following the review, the USFWS incorporates crossing recommendations from Review staff into permit regulations*	*Degree to which recommendations are incorporated into relevant permits and documentation*		
ENV REV 06	**Generic:** Voluntary recommendations are accepted	Following review, the project implementers agree to accept all recommendations	a. Degree to which recommendations are accepted by implementer b. If not accepted, reasons for non-implementation	Number/% of instances accepted vs. not accepted	9a. How many reviews conducted provided voluntary recommendations? How many of the projects accepted the voluntary recommendations? 9b. If reviews were not accepted, explain why to the best of your knowledge.
	Highway Example: *Alternative routing recommendations not accepted by Highway Department*		*Reasons for rejection of recommendations*		
ENV REV 07	**Generic:** Implementers apply recommendations	Following review, the project implementers incorporate all recommendations into project plan or policy	a. Degree to which implementers apply statutory recommendations from the permitting agency into project plan or policy b. Degree to which implementers apply voluntary recommendations	Frequency analysis of qualitative categories for recommendation incorporation OR average % recommendations incorporated into project plan or policy, by project type (e.g., wind transmission, roads) and by recommendation type (e.g., avoidance, minimization, mitigation / compensation)	10a. By project type and recommendation type, please provide average percentage for how often an implementer applied recommendations through PERMIT OR REGULATORY COMPLIANCE. 10b. By project type and recommendation type, please provide the frequency for how often an implementer applied VOLUNTARY recommendations. 10c. If your answer to the last two elements in Questions 10a or 10b is “don’t know,” or if only part of your recommendations were incorporated/followed, please explain why and

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
	Highway Example: *Highway developer applies all permit requirements*	*Highway developer applies all permit requirements to mitigate for impacts which cannot be avoided / minimized*	*Degree to which implementers apply statutory recommendations from the permitting agency into project plan or policy*		what might be done in future situations to encourage better reception.
ENV REV 08	**Generic:** Impacts in sensitive places avoided, minimized, or mitigated / compensated	Within X years of the designation of the conservation area, the desired threat reduction is seen	a. Degree to which implemented project avoids impacts in sensitive places b. Degree to which implemented project minimizes impacts in sensitive places c. Degree to which implemented project mitigates / compensates impacts in sensitive places	Qualitative assessments of acceptance by project type (All, Most, Some, None) OR , by project type (wind transmission, roads, O&G), OR Average % of impacts addressed by project type Addressed = avoided, minimized and mitigated / compensated	11. To what degree was each type of recommendation followed?
	Highway Example: *Impacts of highway on migration corridors minimized*	*Within 3 years, there are no impacts from the highway on key wildlife migration corridors*	*Degree to which implemented project avoids, minimizes, or mitigates / compensates impacts in sensitive places*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**Goal:** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Highway Example: *Viability of Houston Toad Population*	***Goal:*** *Within 5 years, viable populations of Houston Toad exist at key sites*	*Population size of Houston Toad at key sites*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	**Goal:** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Highway Example: *Viability of key migration corridors*	***Goal:*** *Suitable corridors for key migrating species exist even after highway is completed*	*Habitat quality index*		

F. Measures Questionnaire for Environmental Review:

SWG PROPOSAL QUESTIONS

App 1. Based on your past activities, what types of projects/policies do you anticipate may be covered in your Environmental Review(s)?

Project/Policy Type	Yes	No
"Green" Power generation, transmission (solar, wind, tidal, other)	○	○
"Traditional" Power generation, transmission (nuclear, coal-fired, hydro, other)	○	○
Road and bridge new construction, expansion of existing, or repair	○	○
Urban development (buildings, parks, subdivisions, commercial centers, etc.)	○	○
Water development (reservoir, groundwater, surface water, etc.) or transmission	○	○
Interagency MOUs, MOAs	○	○
Other	○	○

If you selected "Other", please describe using the IUCN threats categories (add categories in drop down list)

App 2a. Are there sufficient qualified staff or contractors available to conduct the review?

Element	Yes	No
Sufficient, qualified staff available	○	○
Additional training of existing staff needed	○	○
Additional staff (temporary or permanent) needed	○	○
Additional staff from other programs needed	○	○
External contractor required/needed (special expertise, timing, seasonality, …)	○	○

App 2b. If not, how will you address the deficiency?

SWG PERFORMANCE REPORTING QUESTIONS

Environmental Review Types

1. What types of projects and policies were covered in your Environmental Review(s)?

Project/Policy Type	Yes	No	How many?
"Green" Power generation, transmission (solar, wind, tidal, other)	○	○	
"Traditional" Power generation, transmission (nuclear, coal-fired, hydro, other)	○	○	
Road and bridge new construction, expansion of exisiting, or repair	○	○	
Urban development (buildings, parks, subdivisions, commercial centers, etc.)	○	○	
Water development (reservoir, groundwater, surface water, etc.) or transmission	○	○	
Interagency MOUs, MOAs	○	○	
Other	○	○	

If you selected "Other", please describe using the IUCN threats categories (add categories in drop down list)

Staff Capacity to Conduct Review

2a. Were there sufficient qualified staff or contractors available to conduct the review?

Element	Yes	No
Sufficient, qualified staff available	○	○
Additional training of existing staff needed	○	○
Additional staff (temporary or permanent) needed	○	○
Additional staff from other programs needed	○	○
External contractor required/needed (special expertise, timing, seasonality, etc.)	○	○

2b. If not, how did you address the deficiency?

- ☐ Hired outside contractor
- ☐ Hired additional staff (temporary or permanent)
- ☐ Worked within agency to find qualified personnel to assist with review
- ☐ Negotiated time extension or other factor with submitter
- ☐ Refused review
- ☐ Other: describe in box below

Information to Conduct Review

3a. Was sufficient information available for review in the following categories:

Element	Yes	No
Overall scope and activities of proposed project?	○	○
Potentially affected species?	○	○
Potentially affected habitats?	○	○
Potential Impacts from the project or policy?	○	○
All Affected Sites?	○	○
Mitigation/Compensation Options?	○	○
Alternatives?	○	○

3b. If information was not available to complete the environmental review, how did you address the deficiency?

- ☐ Worked with agency or conservation partners to obtain additional EXISTING information
- ☐ Worked with agency or conservation partners to obtain additional NEW information
- ☐ Required submitter to provide additional needed information
- ☐ Negotiated time extension with submitter
- ☐ Refused review
- ☐ Other: describe in box below

Environmental Review Process

4. Was the review completed on a timely basis within established deadlines?

Project/Policy Type	How Many of Each Type		
	On Time, No Extension	On Time, With Extension	Not Within Deadline(s)
"Green" Power generation, transmission (solar, wind, tidal, other)			
"Traditional" Power generation, transmission (nuclear, coal-fired, hydro, other)			
Road and bridge new construction, expansion of exisiting, or repair			
Urban development (buildings, parks, subdivisions, commercial centers, etc.)			
Water development (reservoir, groundwater, surface water, etc.) or transmission			
Interagency MOUs, MOAs			
Other			

5. Did the review address all potential impacts?

Project/Policy Type	**How Many of Each Type**		
	Avoidance	Minimization	Mitigation / Compensation
“Green” Power generation, transmission (solar, wind, tidal, other)			
“Traditional” Power generation, transmission (nuclear, coal-fired, hydro, other)			
Road and bridge new construction, expansion of exisiting, or repair			
Urban development (buildings, parks, subdivisions, commercial centers, etc.)			
Water development (reservoir, groundwater, surface water, etc.) or transmission			
Interagency MOUs, MOAs			
Other			

6.. If mitigation was recommended (action instead of payment or compensation), did recommendation(s) include specific actions and/or effectiveness measures?

Conservation Action	**Effectiveness Measures Included in Recommendations**	**Effectiveness Measures Not Included in Recommendations**
Acquisition/Easement/Lease	○	○
Data Collection or Analysis	○	○
Management Planning	○	○
Direct Management of Natural Resources	○	○
Species Reintroduction/Restoration	○	○
Create New Habitat/Natural Processes	○	○
Training or Technical Assistance	○	○
Outreach or Education	○	○
Land Use Planning	○	○
Data Management or Maintenance	○	○
	○	○

7a. Did you deliver the recommendations from your review to the implementer(s), permitting agency(ies) and/or other departments within your agency and follow up with them to assure delivery, understanding, acceptance?

7b. If not, please explain.

Recommendations to Permitting or Regulatory Agency(ies)/Departments

8a. Did the permitting agency(ies) add your recommendations to their permit requirements? If not, explain why to the best of your knowledge.

Element	How many reviews shared?	Of those, how many incorporated in their permitting or recommendations?
Federal Agency(ies)		
External State Agency(ies)		
Internal [which program(s)?]		

8b. If not, explain why to the best of your knowledge.

Voluntary Recommendations

9a. How many reviews conducted provided voluntary recommendations? How many of the projects accepted the voluntary recommendations? (# or %)

9b. If reviews were not accepted, explain why to the best of your knowledge.

Recommendations Applied to Reduce Threats and Improve Status of SGCN and their Habitats

Monitoring 10a. By project type and recommendation type, please provide average percentage for how often an implementer applied recommendations through PERMIT OR REGULATORY COMPLIANCE.

Project Type	Average Percentage Applied <u># applied during implementation</u> total # of this type of project for which recommendations provided	Don't know *(see Question 7c)*
"Green" Power generation, transmission (solar, wind, tidal, other)		❍
"Traditional" Power generation, transmission (nuclear, coal-fired, hydro, other)		❍
Road and bridge new construction, expansion of existing, or repair		❍
Urban development (buildings, parks, subdivisions, commercial centers, etc.)		❍
Water development (reservoir, groundwater, surface water, etc.) or transmission		❍
Interagency MOUs, MOAs		❍
Other		❍

10b. By project type and recommendation type, please provide the frequency for how often an implementer applied VOLUNTARY recommendations

Project Type	Average Percentage Applied # applied during implementation total # of this type of project for which recommendations provided	Don't know *(see Question 10c)*
"Green" Power generation, transmission (solar, wind, tidal, other)		❍
"Traditional" Power generation, transmission (nuclear, coal-fired, hydro, other)		❍
Road and bridge new construction, expansion of existing, or repair		❍
Urban development (buildings, parks, subdivisions, commercial centers, etc.)		❍
Water development (reservoir, groundwater, surface water, etc.) or transmission		❍
Interagency MOUs, MOAs		❍
Other		❍

Monitoring 10c. If your answer to the last two elements in Questions 10a or 10b is "don't know," or if only part of your recommendations were incorporated/followed, please explain why and what might be done in future situations to encourage better reception (2-3 ¶ sufficient).

11. To what degree was each type of recommendation followed?

Avoidance	All	Most	Some	None
Minimization	All	Most	Some	None
Compensation/Mitigation All	Most	Some	None	

Conservation Targets

Approximately, how many acres of SGCN habitat were protected through avoidance or minimization with all project areas reviewed? ______ acres

Approximately, how many acres of SGCN habitat were compensated/mitigated through recommendations made by these reviews? ______ acres

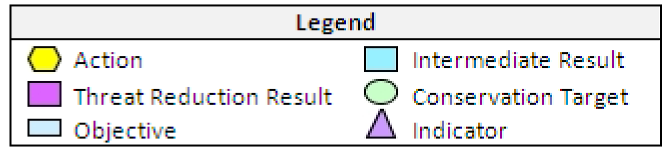
7. Management Planning

A. Definition of Management Planning:

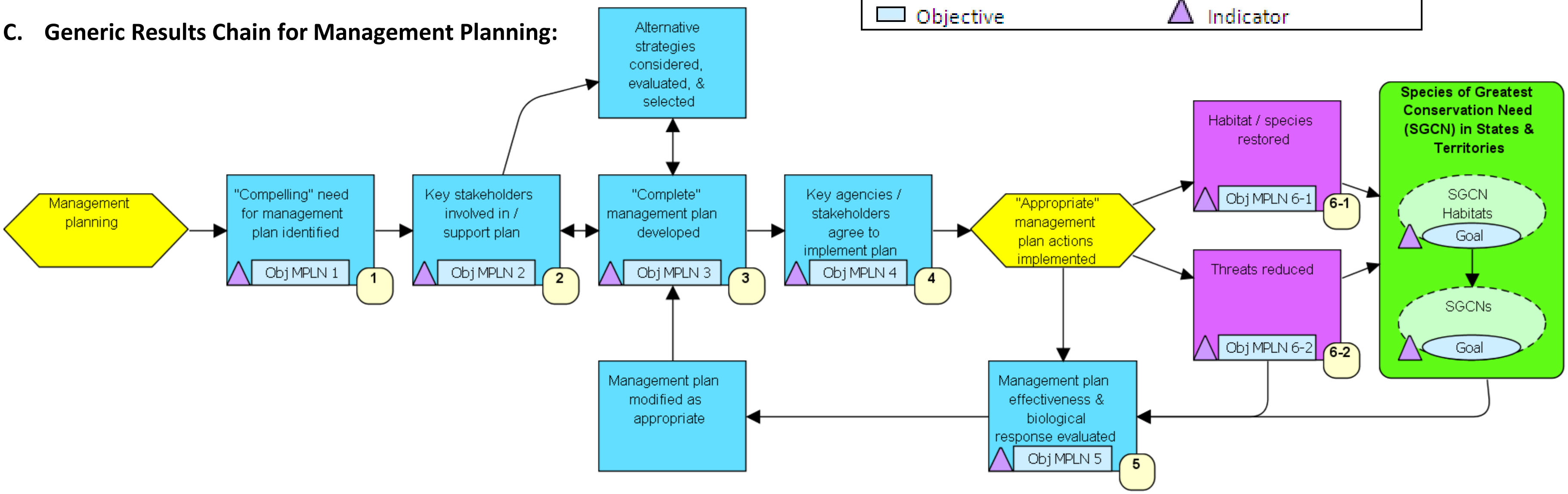
Management Planning is defined as “Development of management plans for species, habitats, and natural processes.”

B. Specific Examples of Management Planning:

1. Develop a management plan for endangered mussels
2. Develop a management plan for Longleaf Pine habitat
3. Develop a management plan for migration corridors



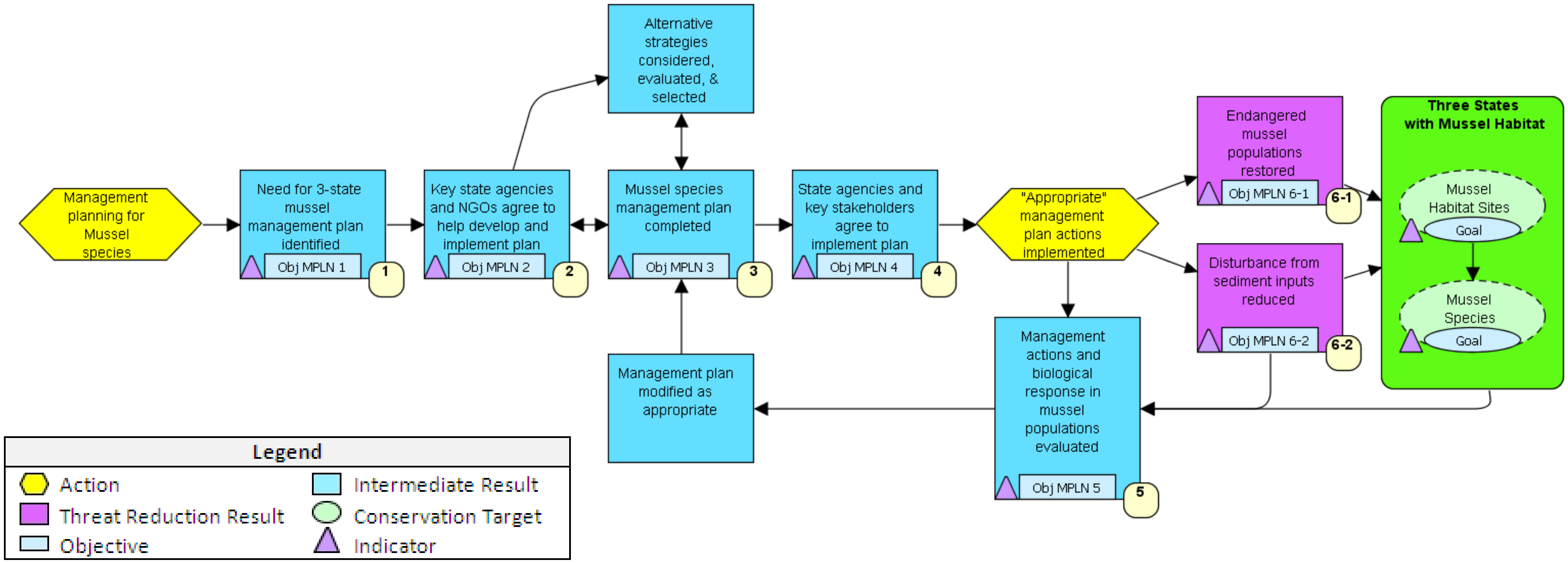
C. Generic Results Chain for Management Planning:



Description: All agencies use some process to develop and describe management actions. The Management Planning Results Chain describes a generic process for developing management plans for species, habitats, and natural processes. The planning process involves first identifying a “compelling” need for management planning (1) and the key stakeholders who will be involved in implementing or otherwise supporting the plan (2). It then involves developing a “complete” management plan that includes viability and threats analyses, an analysis of the factors contributing to the threats and key stakeholders (aka situation analysis), SMART objectives, strategy recommendations, work plan, budget, and a monitoring plan that includes assessing the biological response (3). A good planning process also considers and evaluates alternative strategies. Once the plan is developed, key agencies and stakeholders need to agree to implement the plan (4) which will consist of various management actions designed to restore habitats and species and/or reduce threats (6). It is also important to monitor the effectiveness of implemented actions, the threats, and the status of the conservation targets to adjust and adapt the plan as needed over time (5).

D. Example Results Chain for Management Planning:

This fictitious example is based on a case of developing a management plan for endangered mussel species across three states.



E. Cross-walk of Generic and Example Results, Objectives and Measures for Management Planning:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
MNG PLN 01	**Generic:** Compelling need for management plan identified	Prior to the planning work, an analysis of the situation is completed that outlines a "compelling" need for the management plan to meet specific and measurable threat reduction / restoration goals	"Compelling" argument developed: why plan is needed to meet specific and measurable threat reduction / restoration goals	None	App 1. Describe the threat reduction / restoration problems you are facing and why a management plan is needed to address these issues. App 2. Describe the specific and measurable goals that the plan is seeking to accomplish. *Note: these are suggested questions for the SWG application process.*
	Mussel Example: *Need for 3-state mussel management plan identified*	*Prior to the planning work, a compelling argument is made why mussel planning is required*	*"Compelling" argument developed: why plan is needed to meet restoration goals for the mussels*		
MNG PLN 02	**Generic:** Key stakeholders involved in / support plan	Prior to drafting the plan, key agencies and other stakeholders are involved in drafting plan and/or supportive of the plan (or at least not hostile)	"Key" stakeholders and the roles they play "Key" stakeholder support for the plan	None	App 3. Describe who the key stakeholders are, what their roles are, and their level of support. App 4. Are there stakeholders who will actively work to block the process? How will you engage them? *Note: these are suggested questions for the SWG application process.*
	Mussel Example: *Key state agencies and NGOs agree to help develop and implement plan*	*Prior to drafting the plan, key agencies in the three states as well as key NGOs agree to help draft and implement the plan*	*"Key" stakeholder support for the plan*		
MNG PLN 03	**Generic:** "Complete" management plan developed	"Complete" management plan is developed that includes viability and threats analyses, situation analysis, SMART objectives, strategy recommendations, work plan, budget, and monitoring plan including biological response	Assessment of elements of management plan against standards for "complete" plan	% of planning efforts that result in complete plans	1. Does management plan include suitable: a. Species (system) assessment? b. Viability & threats analyses c. Situation analysis d. SMART objectives e. Strategy recommendations f. Detailed work plan with schedule and personnel g. Budget including funding sources, funding requested, funding in place h. Monitoring plan / biological response 2. Did the plan consider appropriate alternative responses?
	Mussel Example: *Mussel species management plan completed*	*Within 15 months, a complete management plan is developed and reviewed for the mussel species.*	*Assessment of elements of management plan against standards for "complete" plan*		

ASSOCIATION of FISH & WILDLIFE AGENCIES

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
MNG PLN 04	**Generic:** Key agencies / stakeholders agree to implement plan; key agencies / stakeholders actually implement agreed upon actions	Key agencies and other stakeholders receive the plan and agree to implement it in a timely basis	*a. Degree to which responsible agencies incorporate plan elements into their own workplans and resource it appropriately* *b. Degree to which agencies complete agreed upon activities in a timely manner*	% of planning efforts that were accepted by necessary agencies % of planning efforts that are largely "on-track"	3. Did key implementing agencies build agreed upon actions into their own workplans? 4. If not, why? 5. Did the key implementing agencies implement the planned actions on a timely basis? *(If not why)* 6. Since the completion of the management plan, have you seen an increase in the following resources to implement the plan, both within your agency/and or externally? a. Funding b. Human resources c. Programs
	Mussel Example: *State agencies and key stakeholders agree to implement plan and then follow through*	*Within 6 months of the plan's completion, key agencies in the 3 states have plan implementation built into their work schedules and then follow through*	*a. Degree to which responsible agencies incorporate plan elements into their own workplans and resource it appropriately* *b. Degree to which agencies complete agreed upon activities in a timely manner*		
MNG PLN 05	**Generic:** Management plan effectiveness & biological response evaluated	The plan is evaluated and updated on an ongoing basis including assessing biological response of key targets	Evidence of appropriate monitoring of both the effectiveness of actions and the biological response of key targets	% of planning efforts that have appropriate monitoring	7. Is the management plan regularly monitored? a. Effectiveness of actions implemented under the management plan? b. Biological response of key targets? 8. Has the plan been updated based on monitoring results?
	Mussel Example: *Management actions and biological response in mussel populations evaluated*	*The plan is evaluated and updated on a regular basis including assessing biological response of key species*	*Evidence of appropriate monitoring*		
Other Actions	**"Appropriate" Management Plan Actions Implemented**				
MNG PLN 06-1	**Generic:** Habitat / species restored	Within X years of the training, the desired habitat / species restoration occurs	Evidence that conservation area designation is restoring habitats / species	% of initiatives that show viable restoration	9. Is there evidence that the species / habitats have been restored? 10. Additional comments or anecdotes (optional)

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
	Mussel Example: *Endangered mussel populations restored*	*Within 7 years, viable populations of key mussels established at 25 new sites across the 3 states*	*Change in viability of mussel populations in key sites*		
MNG PLN 06-2	**Generic:** Threats reduced	Within X years of completing the management plan, the desired threat reduction is seen	Evidence that management plan is reducing key threats	% of initiatives that show a reduction in key threats being addressed by management plan	11. What threat(s) were you hoping to address through your management plan(s), and do you have evidence that the plan(s) are leading toward reductions in any of these threats? 12. Additional comments or anecdotes (optional) 13. Do you have any suggestions to improve the planning process?
	Mussel Example: *Disturbance from sediment inputs reduced*	*Within 7 years, sediment input into key stream habitats has been reduced to acceptable levels*	*# of sites with acceptable sediment load levels*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**<u>Goal:</u>** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Mussel Example: *Viability of overall mussel populations improves*	***<u>Goal:</u>*** *Within 7 years, there are at least 15 viable populations of mussels across the three states*	*# of viable mussel populations*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	**<u>Goal:</u>** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Mussel Example: *Mussel habitat improves*	***<u>Goal:</u>*** *Within 7 years, habitat for all 15 populations is at suitable levels*	*# of sites with suitable habitat*		

F. Measures Questionnaire for Management Planning:

SWG APPLICATION QUESTIONS

Need for a Management Plan

APP1. Describe the threat reduction / restoration problems you are facing and why a management plan is needed to address these issues.

APP2. Describe the specific and measurable goals that the plan is seeking to accomplish.

Goal	Description
1.	
2.	
3.	
Etc.	

APP3. Describe who the key stakeholders are, what their roles are, and their level of support.

Stakeholder	Role	Level of Support (Strongly For / Moderately For / Neutral / Moderately Against / Strongly Against / NA)

APP4. Are there stakeholders who will actively work to block the process? How will you engage them?

SWG REPORT QUESTIONS

Assessment of Elements of Management Plan

1. Does the management plan include suitable:

Element	Complete	Partial	None
Viability & threats analysis	○	○	○
Situation analysis	○	○	○
SMART objectives	○	○	○
Strategy recommendations	○	○	○
Detailed work plan with schedules	○	○	○
Detailed budget	○	○	○
Monitoring Plan	○	○	○

2. Did the plan consider appropriate alternative responses?

Implementation of Plan

3. Did the key implementing agencies build agreed upon actions into their own workplans?

4. If not, why?

5. Did the key implementing agencies implement the planned actions on a timely basis?

- ○ All or almost all
- ○ Most
- ○ About half
- ○ Some
- ○ Few or none
- ○ Don't know

Please explain:

6. Since the completion of the management plan, have you seen an increase in the following resources to implement the plan, both within your agency/and or externally?

Resource	Yes	No	Don't Know	% increase
Internal agency funding	○	○	○	%
Internal agency human resources	○	○	○	%
Internal agency programs	○	○	○	%
External funding	○	○	○	%
External human resources	○	○	○	%
External agency programs	○	○	○	%

Monitoring

7. Is the management plan regularly monitored? Please describe.

Resource	Yes	No	Don't Know	Comment
a. Effectiveness of actions	○	○	○	
b. Biological response of key targets	○	○	○	

8. Has the plan been updated based on monitoring results? Please describe

Restoration Outcomes

9. Is there evidence that the species / habitats have been restored?

10. Additional comments or anecdotes (optional)

Threat Reduction

11. What threat(s) were you hoping to address through the designation of conservation areas, and do you have evidence that the designation(s) are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org.

Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.

Direct Threat	Check if relevant	Evidence of reduction?	Please explain
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	
7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	

11 Climate Change & Severe Weather	☐	y/n/don't know	

12. Additional comments or anecdotes (optional)

13. Do you have any suggestions to improve the planning process?

8. Land Use Planning

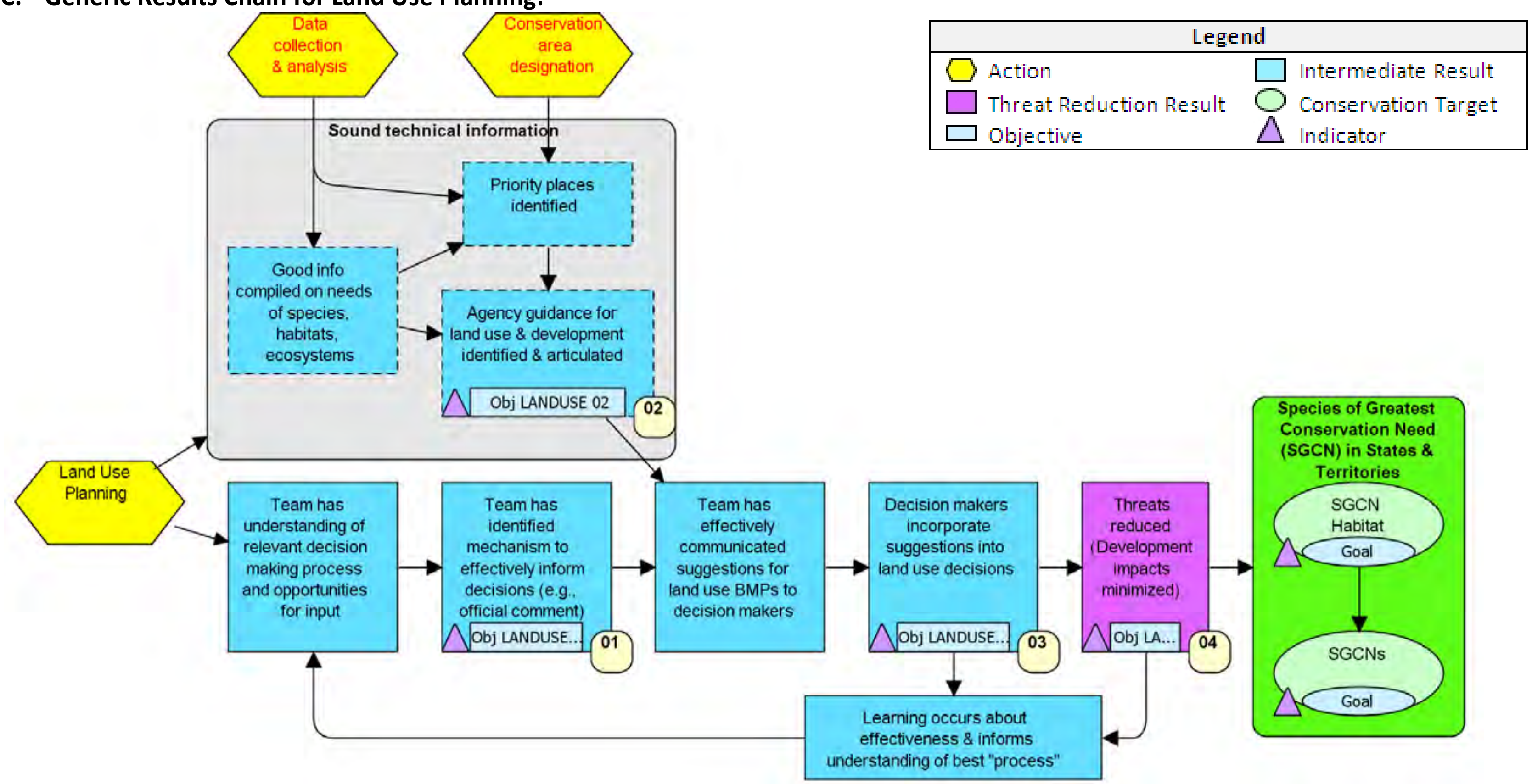
A. Definition of Land Use Planning:

Land Use Planning is defined as "Leading or participating in land use planning for rural, urban, or agricultural lands."

B. Specific Examples of Land Use Planning:

1. Develop county-wide zoning plans.
2. Participate in workgroup regarding low impact development siting.
3. Develop city plan for implementing best management practices for stormwater management.

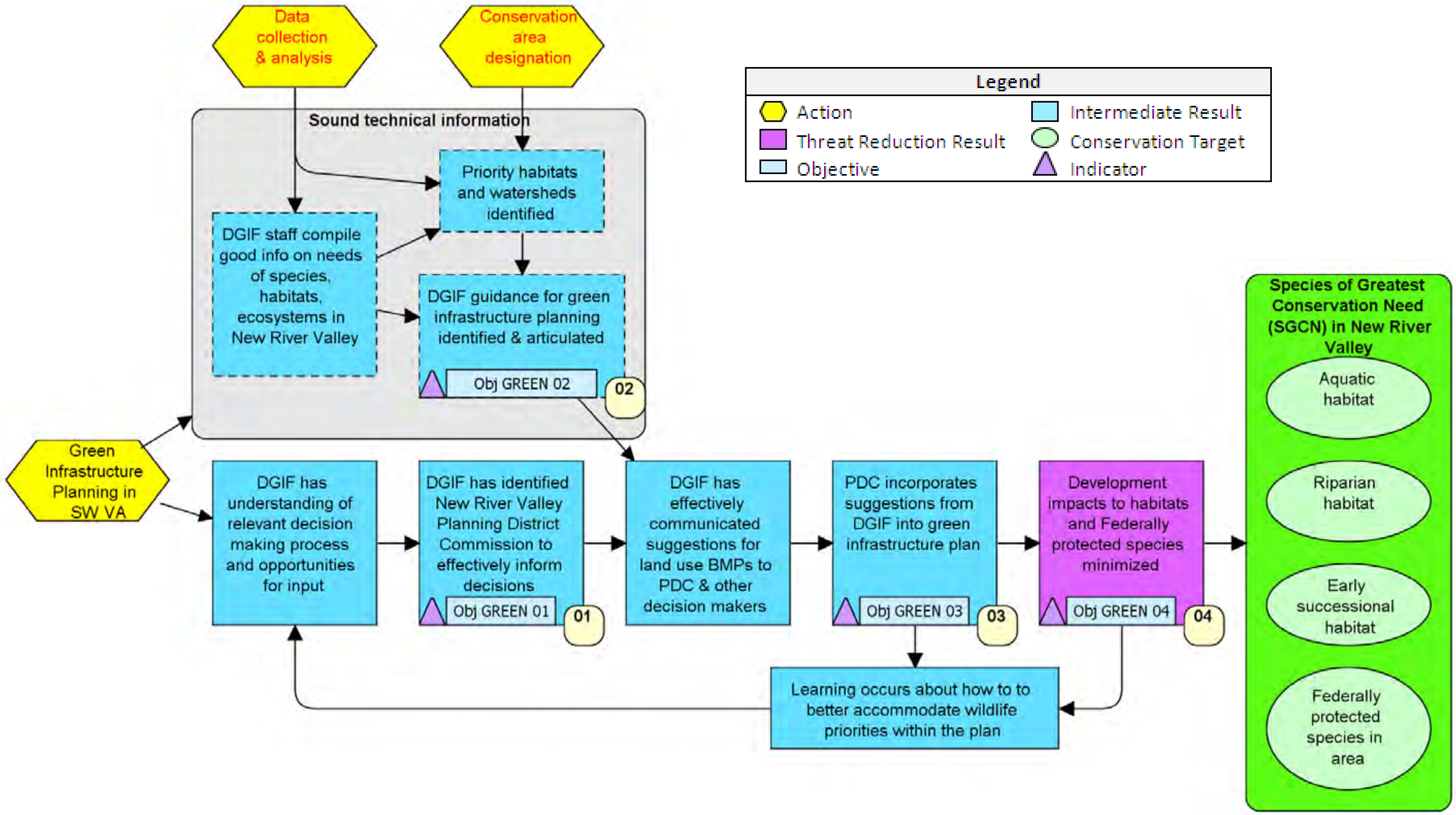
C. Generic Results Chain for Land Use Planning:



Description: All Wildlife Action Plans indicate habitat loss is an important issue impacting the nation's species of greatest conservation need (SGCN). In most states, land use planning decisions are made by municipal or county planners or volunteer land use commissions. The Land Use Planning Results Chain demonstrates how wildlife agency personnel work with local land use decision makers to accommodate wildlife within rural, urban, and agricultural land use plans. This process involves: the wildlife agency personnel using data to identify wildlife needs and habitat priorities within the various political jurisdictions (gray box, including Result 02); understanding the decision making process and identifying a mechanism to inform decisions (01); effectively communicating those needs and priorities to the appropriate decision makers; and helping incorporate wildlife needs and habitat priorities into the final land use plans (03). If this happens as anticipated, it assumed that threats will be reduced and in particular, development-related threats will be minimized (04), leading to benefits for SGCN and their habitat. The chain above also includes a feedback loop resulting from the monitoring of wildlife responses to the changing land uses and the reevaluation the wildlife needs and habitat priorities based upon the new information.

D. Example Results Chain for Land Use Planning:

This results chain draws on and is adapted from a real-world example to initiate a Green Infrastructure planning effort in southwestern Virginia. The VA Department of Game and Inland Fisheries (DGIF) was invited to participate to ensure that local wildlife priorities were adequately considered throughout the process. *Note: Objectives and measures presented in the table for this example are fictional but grounded in this real-world example.*



E. Cross-walk of Generic and Example Results, Objectives and Measures for Land Use Planning:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
LANDUSE 01	**Generic:** Team has identified mechanism to effectively inform decisions	Within X months/years of starting the land use planning initiative, there is a strategy in place for how to most effectively inform key decision makers	Evidence of a strategy in place for how to most effectively inform key decision makers	% of Land Use Planning actions which have evidence of a strategy in place for how to most effectively inform key decision makers	1. Did the agency use a formal plan to communicate information to the planning effort? If yes, which of the following groups were to be contacted? 2. What mechanisms were used to communicate with the target audiences? 3. At approximately which points did your agency provide information to the planning process? 4. How would you characterize your agency's participation in the planning process?
	Green Infrastructure Example: *DGIF has identified New River Valley Planning District Commission to effectively inform decisions*	*Within 6 months of start of the green infrastructure planning initiative, there is a strategy in place for how to most effectively inform green infrastructure planning officials*	*Evidence of a strategy in place for how to most effectively inform green infrastructure planning officials*		
LANDUSE 02	**Generic:** Agency guidance for land use & development identified & articulated	Within X months/years of starting the land use planning initiative, agency land use planning guidance is based on information resources describing the needs of species, habitats, and ecosystems, as well as identified priority places	Evidence that agency guidance is based on information resources describing the needs of species, habitats, and ecosystems, as well as identified priority places	% of land use planning actions which have evidence that agency guidance is based on information resources describing the needs of species, habitats, and ecosystems, as well as identified priority places (% of each category identified)	5. How was the wildlife agency's guidance regarding wildlife and habitat priorities determined? 6. Were conflicting technical, regulatory, or oversight identified during the planning process? If yes, to what degree did this conflict affect the adoption of agency guidance?
	Green Infrastructure Example: *DGIF guidance for green infrastructure planning identified & articulated*	*Within 6 months of joining the Planning District Commission, DGIF staff articulate relevant guidance on preserving /restoring aquatic, riparian, and early successional habitat based on the Wildlife Action Plan, Virginia Fish and Wildlife information system, and expert opinions of those working within the area*	*Evidence that DGIF guidance is based on the Wildlife Action Plan, Virginia Fish and Wildlife information system, and expert opinions of those working within the area*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
LANDUSE 03	**Generic:** Decision makers incorporate suggestions into land use decisions	Within X years of starting the land use planning initiative, key decision makers incorporate Y% of recommendations about priority areas and relevant BMPs into land use planning decisions	% of recommendations about priority areas and relevant BMPs incorporated into land use planning decisions	% of Land Use Planning actions which have met their objectives for incorporating recommendations about priority areas and relevant BMPs into land use planning decisions	7. Was a final land use plan developed from this planning process? 8. Approximately what percentage of the wildlife agency's recommendations was incorporated into the final land use plan? If fewer than half of the wildlife agency's recommendations were incorporated into the final plan, please provide a brief explanation regarding these decisions. 9. During the course of this planning, were other statutory, regulatory, or oversight guidelines identified that superseded the wildlife-related comments? (check all that apply)
	Green Infrastructure Example: *PDC incorporates suggestions from DGIF into green infrastructure plan*	*Within 2 years of DGIF's participation in the PDC, PDC officials incorporate at least 40% of recommendations about priority habitats and relevant BMPs into the green infrastructure plan*	*% of recommendations about priority areas and relevant BMPs incorporated into land use planning decisions*		
LANDUSE 04	**Generic:** Threats reduced (Development impacts minimized)	Within X years of the start of the land use planning action, there is evidence of development impacts being reduced	Evidence that land use planning action is reducing development impacts	% of initiatives that show the expected reduction in key threats (development impacts) being addressed by land use planning actions	10. What threat(s) were you hoping to address through land use planning, and do you have evidence that your land use planning efforts are leading toward reductions in any of these threats? 11. Please provide any narratives, case studies, or additional comments you may have related to your work in land use planning (optional)
	Green Infrastructure Example: *Development impacts to habitats and Federally protected species minimized*	*Within X years of the start of the green infrastructure planning process, there is evidence of development impacts being reduced*	*Evidence that green infrastructure planning is reducing development impacts*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**Goal:** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Green Infrastructure Example: *Forthcoming*				

F. Measures Questionnaire for Land Use Planning:

Mechanism to Inform Decisions Identified

1. Did the agency use a formal plan to communicate information to the planning effort?

   ○ Yes

   ○ No

Programming note: If "no," redirect to Q3)

If yes, which of the following groups were to be contacted? *Check all that apply:*

- ☐ Local elected officials
- ☐ Regional/state elected officials
- ☐ Local planning officials
- ☐ Regional/state/federal planning officials
- ☐ State/federal agency personnel
- ☐ Media
- ☐ Conservation groups
- ☐ Industry groups
- ☐ Businesses
- ☐ Individual landowners
- ☐ General public
- ☐ Other (please specify:__________________)

2. What mechanisms were used to communicate with the target audiences? *Check all that apply:*
   - ☐ In-person meetings
   - ☐ Formal presentations to elected officials and/or planning officials
   - ☐ Presentations at public meetings
   - ☐ Formal written comments
   - ☐ Participation in planning workshops or conferences
   - ☐ Interviews with media
   - ☐ Other (please specify) ________________

3. At approximately which points did your agency provide information to the planning process? (check all that apply)
   - ☐ At the beginning of the planning process (i.e., scoping phase)
   - ☐ Approximately half way thru the planning process (comments to a technical review team, review draft, etc.)
   - ☐ At the end of the planning process (comment on a final draft)

4. How would you characterize your agency's participation in the planning process? (check all that apply)
   - ☐ Commenter (only provided information during public comment periods)
   - ☐ Contributor (provided information when requested by involved parties)
   - ☐ Partner (assigned agency personnel to provide information and actively work with planning officials to incorporate that information into the final plan)
   - ☐ Leader (agency staff coordinate the planning effort and are responsible for drafting the final plan)

Guidance for Land Use & Development Identified & Articulated

5. How were the wildlife agency's wildlife and habitat priorities identified? *Check all that apply:*

- ☐ Existing species mgmt/recovery plans (Please identify _____________________)
- ☐ Wildlife Action Plan
- ☐ Existing habitat mgmt/recovery plans (Please identify ______________________)
- ☐ Other existing natural resource management plan (e.g., climate change adaptation plan, state forest resource assessment, watershed management plan, green infrastructure plan, etc.) (Please identify ___________________)
- ☐ Statute, Regulation or Agency policy
- ☐ Peer-Reviewed Literature
- ☐ Precedent decisions provided in previous guidance
- ☐ Species/habitat info maintained and managed by the agency (GIS data, observation database, etc.)
- ☐ Best professional opinion of agency personnel
- ☐ Other (Please identify: ___________________)

6. Were conflicting technical, regulatory, or oversight guidelines identified during the planning process?

- ○ Yes
- ○ No

If yes, to what degree did this conflict affect the adoption of agency guidance?

- ○ Led to complete rejection of guidance
- ○ Led to partial rejection of guidance
- ○ Had little or no effect on guidance

Additional comments (optional):

Suggestions Incorporated into Land Use Decisions

7. Was a final land use plan developed from this planning process?

- ○ Yes (Please provide the title: ___________________)
  (Which agency/organization is responsible for maintaining this plan? ___________________)
- ○ No

8. Approximately what percentage of the wildlife agency's recommendations was incorporated into the final land use plan?

- ○ 75% to 100%
- ○ 50% to 74%
- ○ 25% to 49% (Please explain below)
- ○ 10% to 24% (Please explain below)
- ○ fewer than 10% (Please explain below)

If fewer than half of the wildlife agency's recommendations were incorporated into the final plan, please provide a brief explanation regarding these decisions.

9. During the course of this planning, were other statutory, regulatory, or oversight guidelines identified that superseded the wildlife-related comments? *(check all that apply)*

☐ Federal: (Briefly identify ____)
☐ State: (Briefly identify ____)
☐ Local: (Briefly identify ____)

Development Impacts Minimized

10. What threat(s) were you hoping to address through land use planning, and do you have evidence that your land use planning efforts are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org. *Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.*

Direct Threat	Check if relevant	Evidence of reduction?	Please explain
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	
7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	
11 Climate Change & Severe Weather	☐	y/n/don't know	

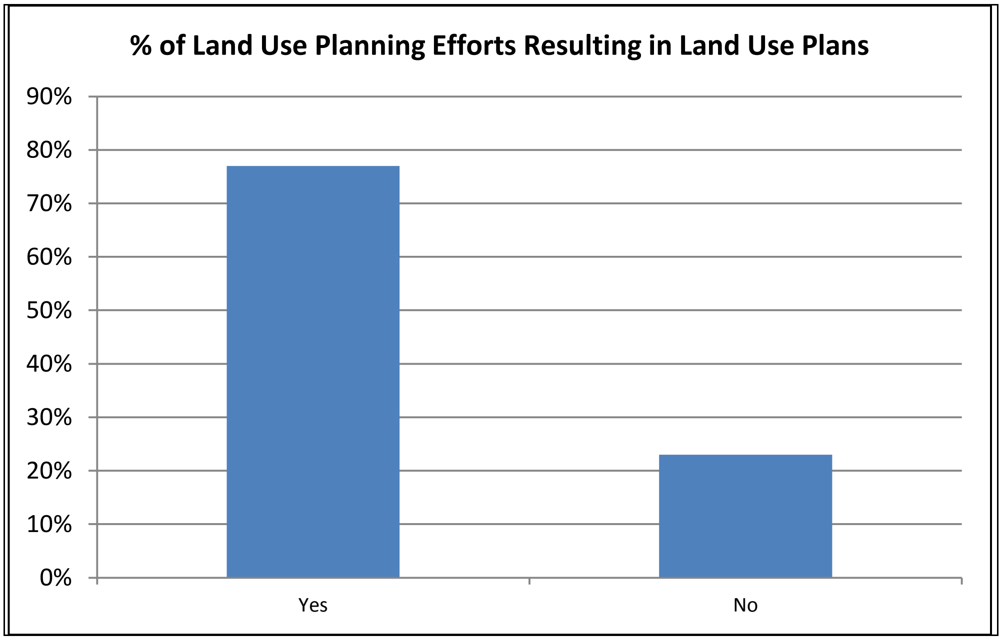
Additional Information

11. Please provide any narratives, case studies, or additional comments you may have related to your work in land use planning (optional).

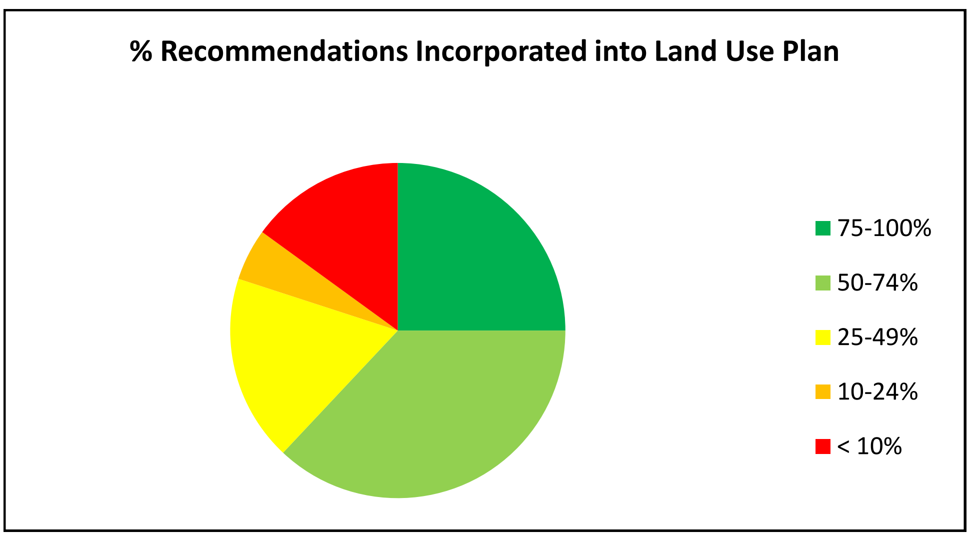
G. Example Graphs and Charts for Reports for Land Use Planning

Potential graphs and charts for a report could include:

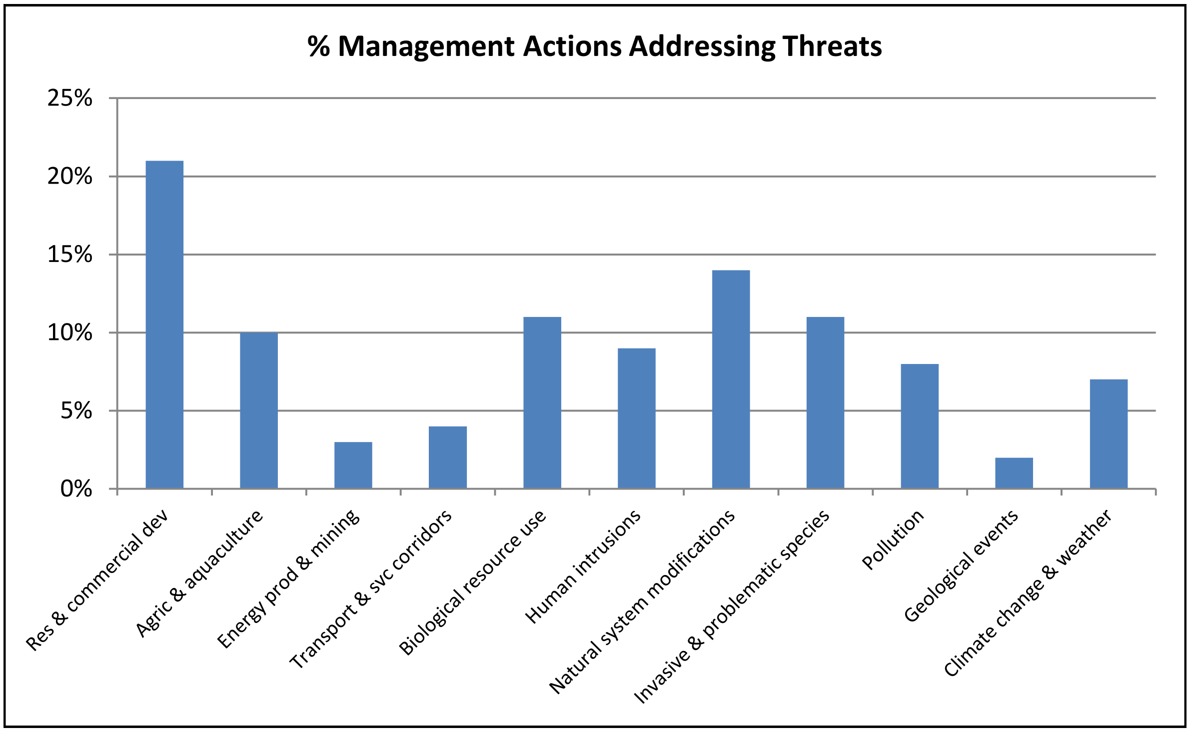
LANDUSE 03 (Decision makers incorporate suggestions into land use decisions): Bar graph or pie chart to show % of projects with land use plans developed



LANDUSE 03 (cont.) Pie chart to show percentage of recommendations incorporated into the final land use plan



LANDUSE 04 (Development impacts minimized): Table or histogram with IUCN-CMP threat categories & # being addressed through land use planning actions, do not report (in graph) on evidence of threat reduction. Note, this figure could also be shown as the total number of initiatives, rather than as percents within that total number.



9. Training & Technical Assistance

A. Definition of Training & Technical Assistance:

Training is defined as "Skills development for professionals, key stakeholders, or others to facilitate needed management activities and techniques." It does not include training that is minor or a routine component of implementing another action. It does include certification, or apprenticeship models. It is not the same as *information delivery* (education or outreach), although training could lead to an education or outreach conservation action for threat reduction.

Technical Assistance (TA) is defined as "Tangible, practical support (skills, knowledge, recommendations) delivered by experts to professionals or key stakeholders for the purpose of helping them implement specific conservation actions."

Both Training and Technical Assistance are precursors to improve the effectiveness of other conservation actions. Although the two are closely related:

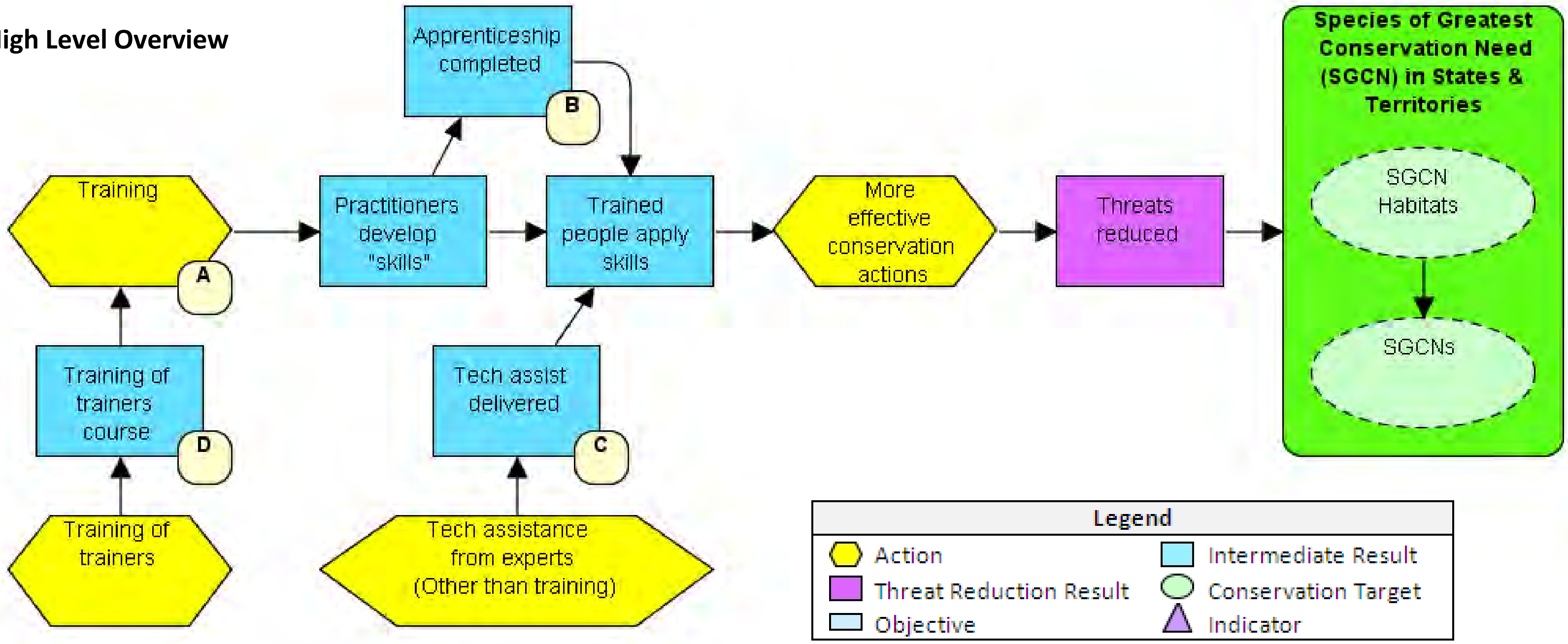
- Training is where you provide skills and hope managers will apply them to their issues – it's primarily about capacity building. Some training might require a formal or informal "apprenticeship" period in which there is more detailed direct training and skills delivery (e.g., step-wise learning process, series of classes leading to practical testing).
- TA is a special case within "training" where the trainer/expert works directly with managers, stakeholders, etc. to solve specific problems, often using skills that might be harder to teach in a group setting (e.g., engineering, prescribed fire, monitoring methods) *or* when delivering advice or recommendations for addressing a specific conservation action.
- The two overlap in that TA can be a way to further improve the skills of the trainee following a training session, and there may be some TA that occurs without a training component upon request from or to a recipient, as part of addressing a specific conservation action.

B. Specific Examples of Training and Technical Assistance:

1. Provide training for agency staff in reptile and amphibian assessment techniques
2. Provide classroom training in elements of prescribed fire qualifications (e.g., planning, tool familiarity, weather) to resource professionals who will eventually take "next steps" to become site-based Fire Operators and Leaders (e.g., Crew Leaders, Burn Bosses)
3. Provide qualified prescribed fire operators with an "apprenticeship" in field skills (e.g., leading crews, ignition, fire management, safety and emergency response) leading toward Fire Leader (Burn Boss) certification or qualification
4. Provide technical assistance in successful techniques to assess (field surveys, boundary document reading, conservation value rapid assessment), write successful terms and conditions, and monitor (timeframes, techniques, etc.) a conservation easement
5. Provide technical assistance in the form of one-on-one engineering consultation for dam removal
6. Provide technical assistance in the form of consulting advice and recommendations for specific Conservation Actions to a private landowner for them to do themselves (or to subcontract)

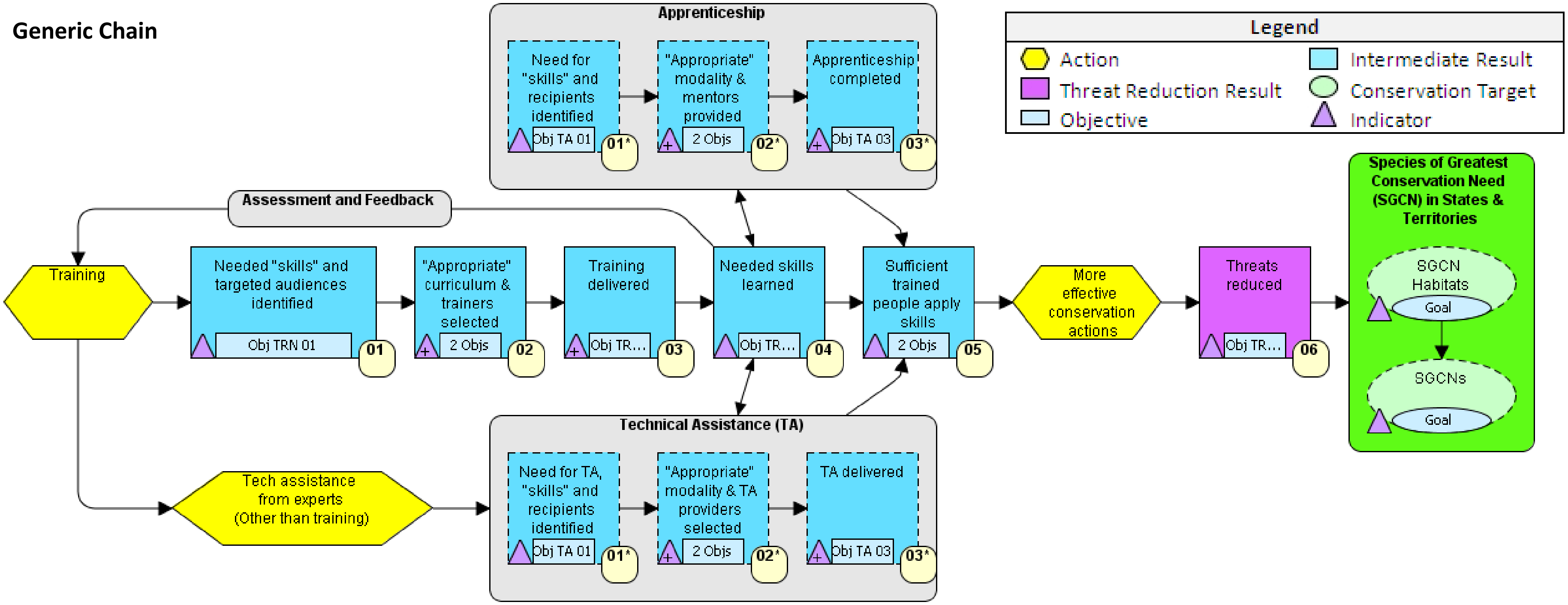
C. Generic Results Chain for Training & Technical Assistance:

High Level Overview



Description: In the High Level Overview Results Chain, training is fundamentally about providing targeted practitioners with the skills needed to more effectively implement other conservation actions to reduce threats or restore wildlife (A). In some cases, training courses also need to be supplemented with a formal or informal "apprenticeship" period in which the trainee gets additional coaching and experience (B). This apprenticeship is conceptually very similar to technical assistance (TA) in which needed skills are shared with key practitioners through direct work together (C). In effect, training is when the focus is on capacity building to solve future problems whereas TA is when the focus is addressing immediate problems. Finally, Training of Trainers is a special case in which the skills being delivered are the ability to train other practitioners (D).

Generic Chain

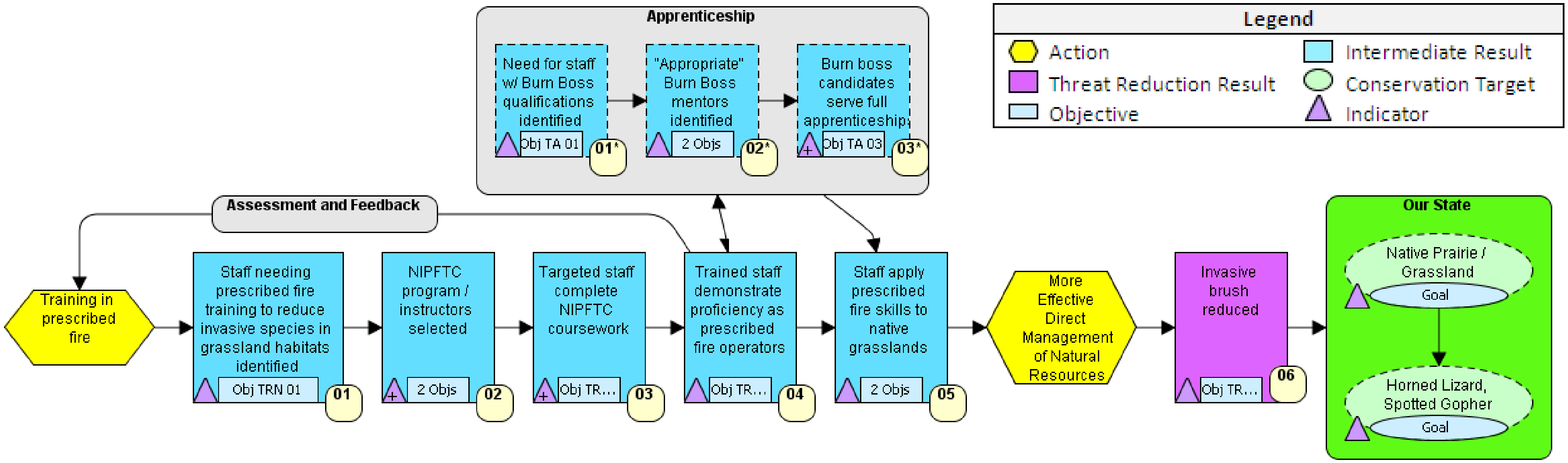


As shown in the Training Results Chain, prior to developing and conducting the training sessions, a justification or compelling argument for training must be created, and specific skills to be delivered and audiences to receive these must be identified (01). Once these are determined the curricula can be selected from existing sources or newly developed, and suitable trainers must be identified (02). Once the training itself takes place (03), trainees must demonstrate learning of the new skills (04) and then ultimately apply these skills to on-the-ground problems (05). In the case where skills are not learned, an assessment or feedback loop requires the training developers to determine whether the skills taught or methods of teaching were appropriate for the audience (and vice-versa), and to modify these accordingly. In some cases, an “apprenticeship” in which the trainee undergoes additional training under the guidance of an experienced mentor is required for certification or professional development. Ultimately, the objective is to have sufficient people with the ability to apply their skills which leads to more effective conservation actions, which in turn will reduce threats and improve SGCN and habitat status (06).

As depicted in the Technical Assistance Results Chain, technical assistance follows a similar pattern to training, but focused more on solving immediate problems and practical skills delivery “on the ground” rather than developing capacity. First, a justification or compelling argument for technical assistance must be created, and specific skills to be delivered and audiences to receive these must be identified (01*). Once these are determined, the modality and providers must be identified (02*) before the TA takes place (03*). Once the TA takes place, trainees must demonstrate learning of the new skills (04) and then ultimately apply these skills to on-the-ground problems (05).

D. Specific Example Results Chain for Training & Technical Assistance:

This fictitious example is based on a case of training and Burn Boss apprenticeship for prescribed fire.



E. Cross-walk of Generic and Real-world Example Results, Objectives and Measures for Training & Technical Assistance:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
TRN 01	**Generic:** Needed "skills" and targeted audiences identified	Before training is initiated, a compelling argument is laid out for specific "skills" needed by specific targeted individuals who will reduce threats / do restoration	"Compelling" argument developed: Appropriate needs / skills to solve a pressing threat reduction or restoration problem; Appropriate individuals are targeted	None	APP 1. Will this proposal include training, technical assistance, or both? APP 2. Describe the threat reduction / restoration problem you are facing. a. What conservation actions are needed to solve this problem? b. What skills are needed/missing in order to apply these actions? APP 3. Who will be trained? a. Who are the targets of these trainings? b. What are the participant prerequisites needed to attend this training? *Note: these are suggested questions for the SWG proposal process.*
	Fire Example: *Staff needing prescribed fire training to reduce invasive species in grassland habitats identified*	*Six months before the training, at least 15 land managers who need prescribed fire training for their jobs have been identified*	*"Compelling" argument developed in terms of skills needed and trainees selected*		
TRN 02-1	**Generic:** "Appropriate" curriculum selected	Before the training is initiated, an "appropriate" curriculum is selected or developed for the audience's learning style including delivery method, location, timing, examples	Qualitative assessment of "appropriate" curriculum development	% types of curricula sorted by actions	APP 4. What curriculum will you use for your training? APP 5. Describe the rationale for selecting this curriculum. *Note: these are suggested questions for the SWG proposal process.*
	Fire Example: *NIPFTC program selected*	*The National Interagency Proscribed Fire Training Center (NIPFTC) offers professional-grade training that meet our needs to partners including our agency; costs are within our budget and the timing meets our needs*	*Qualitative assessment of "appropriate" curriculum development*		
TRN 02-2	**Generic:** "Appropriate" trainers selected	Before the training is initiated, "appropriate" trainers are selected. Appropriate = With relevant skills, teaching competence, etc.	Qualitative assessment of "appropriate" trainers selected	None	APP 6. Describe the knowledge, skills, and teaching ability qualifications of the proposed trainers. *Note: these are suggested questions for the SWG proposal process.*

ASSOCIATION of FISH & WILDLIFE AGENCIES

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
	Fire Example: *NIPFTC trainers available*	*NIPFTC professional trainers, who are nationally recognized as the most capable for prescribed fire instruction to address natural resources threats/restoration, are available for this course*	*Qualitative assessment of "appropriate" trainers selected*		
TRN 03	**Generic:** Sufficient trainees trained	At the end of the training period, xx% of targeted individuals have attended required number of training modules	a. # of trainings b. # of individuals trained c. % of targeted individuals trained	a. Number of trainings conducted sorted by topic/action b. Number of individuals trained sorted by topic/action c. Average % of target audience met across project sorted by topic/action	1. How many training modules were conducted for each action? 2. How many individuals participated in and COMPLETED the training module/sessions for each action? 3. What % of your targeted audience completed all trainings proposed as part of this project?
	Fire Example: *Targeted staff complete NIPFTC coursework*	*By the end of the training period, at least 13 of the 15 targeted individuals have attended the 3 NIPFTC training courses*	a. # of NIPFTC trainings attended b. # of individuals completing all 3 NIPFTC courses c. % of 15 targeted individuals trained		
TRN 04	**Generic:** Needed skills learned	At the end of the training, at least xx% of trainees demonstrate minimum proficiency in the needed skills	% of trainees demonstrating proficiencies	Average % of targeted trainees that demonstrate minimum threshold proficiencies	4. What % of trainees demonstrated minimum threshold proficiencies at the end of the training? 5. How did you make this assessment? 6. What were the barriers keeping trainees from passing?
	Fire Example: *Trained staff demonstrate proficiency as proscribed fire operators*	*At the end of the training, at least 13 targeted staff members have proficiency in basic proscribed fire skills*	*% and total # of trainees who demonstrate proficiency in basic proscribed fire skills*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
TRN 05	**Generic:** Sufficient trained people apply skills	Within X months of the training, xx% of trainees successfully apply their new skills at least once to appropriate problems Within X months of the end of the training, there are sufficient numbers of trained individuals to meet the threat reduction / system restoration needs who are actively applying their skills	# / % of trained individuals applying skills % increase in capacity of people with skills	Average % of targeted trainees that have applied skills	7. What % of trainees who completed the training have applied their skills at least once? 8. How did you determine whether trainees have applied skills? 9. What is the % increase in capacity (people sufficiently trained) who have the skills to undertake needed conservation actions? *Note: these are suggested questions for the SWG proposal process.*
	***Fire Example:** Staff apply prescribed fire skills to native grasslands*	*Within 6 months of the training, at least 12 of the trainees successfully apply their new skills at least once to manage a controlled burn on land that they manage; Within 6 months of the end of the training, there are sufficient numbers of trained fire operators and crew leaders to use prescribed fire to remove invasive brush from key sites in our state*	*# / % of trained individuals applying skills* *% increase in capacity of people with applied fire skills*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
TA 01*	**Generic:** Need for TA, "skills" and recipients identified	Before TA is initiated, a compelling argument is laid out for specific "skills" (skills, knowledge, advice) needed by specific targeted individuals that are needed to reduce threats / do restoration	"Compelling" argument developed: Appropriate needs / skills to solve a pressing threat reduction or restoration problem; Appropriate individuals are targeted	None	APP 2.* Describe the threat reduction / restoration problem you are facing. a. What conservation actions are needed to solve this problem? b. What skills are needed/missing in order to apply these actions? APP 3.* Who will receive technical assistance? a. Who are the targets of this technical assistance? b. What are the participant prerequisites needed to receive technical assistance? *Note: these are suggested questions for the SWG proposal process.*
	Fire Example: *Need for staff with Burn Boss qualifications identified*	*After the initial training, at least 3 staff who could serve as Burn Bosses are identified*	*"Compelling" argument developed*		
TA 02-1*	**Generic:** "Appropriate" modality selected	Before the TA is initiated, an "appropriate" modality is selected	Qualitative assessment of "appropriate" modality selection	None	APP 4.* What modality will/did you use for your assistance? APP5.* Describe the rationale for selecting this modality. *Note: these are suggested questions for the SWG proposal process.*
	Fire Example: *"Appropriate" modality selected*	*Before the apprenticeship is initiated, an appropriate mentorship model is selected*	*Qualitative assessment of "appropriate" modality selection*		
TA 02-2*	**Generic:** "Appropriate" TA providers selected	Before the TA is initiated, "appropriate" provider(s) are selected	Qualitative assessment of "appropriate" trainers selected	None	APP 6.* Describe the knowledge, skills, and teaching ability qualifications of the proposed technical assistance providers. *Note: these are suggested questions for the SWG proposal process.*
	Fire Example: *"Appropriate" Burn Boss mentors identified*	*Before the apprenticeship is initiated, at least two qualified burn boss mentors are identified*	*Prescribed burn mentors identified*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
TA 03*	**Generic:** Sufficient recipients receive TA	At the end of the TA period, xxx individuals have received needed TA	a. # of individuals receiving TA b. % of targeted individuals receiving TA	a. Number of individuals receiving TA sorted by topic/action b. Average % of target audience met across project sorted by topic/action	1.* What was the total number of individuals receiving TA? 3.* What % of your target audience received necessary TA proposed as part of this project?
	Fire Example: *Burn Boss candidates serve full apprenticeships*	*For the six months following the training sessions, the three Burn Boss candidates apprentice on at least 5 burns each*	*a. # of individuals completing apprenticeship* *b. % of targeted individuals completing apprenticeship*		
TRN 06	**Generic:** Threats reduced	Within X years of the training, the desired threat reduction is seen	Evidence that training is reducing threats	% of initiatives that show a reduction in key threats being addressed	10. Do you have evidence of this training action leading towards reductions in any of these threats? Please describe.
	Fire Example: *Invasive brush reduced*	Within 2 years of the training, invasive brush in grassland systems in 5 key sites is reduced	Presence of invasive brush		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**<u>Goal:</u>** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Fire Example: *Viability of grassland SGCN (Horned Lizard, Spotted Gopher) improved*	***<u>Goal:</u>*** *Within 5 years, viable populations of Horned Lizard, and Spotted Gopher exist in at least 5 sites within the State*	*Population size of Horned Lizard and Spotted Gopher at key sites*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	**<u>Goal:</u>** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Fire Example: *Viability of grassland habitat*	***<u>Goal:</u>*** *Within 3 years, grassland habitat quality improves to at least "fair"*	*Habitat quality index*		

F. Measures Questionnaire for Training and Technical Assistance:

SWG APPLICATION

Compelling Argument

APP 1. Will this proposal include:

- ❍ Training
- ❍ Technical Assistance

a. Both

b. Neither

APP 2. Describe the threat reduction or restoration problem you are facing.

APP 2a. What Conservation Actions will be applied to the threat or restoration problem following the Training or during/following the Technical Assistance – see [AFWA Effectiveness Measures Report Appendix I]() ?

(Check all that apply and provide the number of trainings you will complete per action)

- ❍ Conservation Area Designation
- ❍ Acquisition/Easement/Lease
- ❍ Data Collection/Analysis
- ❍ Management Planning
- ❍ Direct Management of Natural Resources
- ❍ Species Reintroduction
- ❍ Creating New Habitat/Natural Processes
- ❍ Outreach/Education
- ❍ Land Use Planning
- ❍ Environmental Review
- ❍ Partner Engagement
- ❍ Data Management and Maintenance

APP 2b. What skills are needed/missing in order to apply these actions?

APP3. Who will be trained?

a. Who are the targets of these trainings?

b. What are the prerequisites for this training?

APP 4. What curriculum will you use for your training and why (e.g., available, cost-effective, in-house trainer available, etc.)?

- ❍ Established curriculum – citation/source (author, date):

- ❍ New curriculum – contact information (name, affiliation, email):

APP 5. Describe the rationale for selecting this curriculum.

APP 6. Describe the knowledge, skills, and teaching abilities/qualifications of the proposed trainers.

SWG REPORTING

Note – May need to restate application questions in past tense for report.

Training or Technical Assistance Implemented

1. How many training modules/sessions were conducted in the reporting period for each action?
2. How many individuals participated in and COMPLETED the training module/sessions for each action?
3. What % of your target audience completed all trainings proposed as part of this project?

Type of Management Action Requiring Training	1. # of Training Modules Conducted	2. # of Individuals Completing Modules	3. % of Target Audience	4. % of Trainees Demonstrating Proficiency

Proficiency Demonstrated

4. What % of trainees demonstrated minimum threshold proficiencies at the end of the training?
5. How did you make this assessment?

6. What may have been barriers to trainee completion and/or passing minimum proficiencies?

Training Applied: Meeting the Objective

7. What % of trainees who completed the training has applied their skills at least once?
8. How did you determine whether trainees have applied skills?
9. What is the % increase in capacity (people sufficiently trained) who have the skills to undertake needed conservation actions?

Type of Management Action Requiring Training	7. % of Trainees Who Have Applied Skills	8. How Did You Determine Whether Skills are Applied?	9. % of Increase in Capacity of Trained People

Threat Reduction

10. What threat(s) were you hoping to address through the management action(s), and do you have evidence that the trainings / management actions are leading toward reductions in any of these threats? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org.

Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example). Only show "evidence of reduction" and "please explain" options if they check that the threat is relevant.

Direct Threat	**Check if relevant**	**Evidence of reduction?**	**Please explain**
1 Residential & Commercial Development	☐	Drop down: y/n/don't know	
2 Agriculture & Aquaculture	☐	y/n/don't know	
3 Energy Production & Mining	☐	y/n/don't know	
4 Transportation & Service Corridors	☐	y/n/don't know	
5 Biological Resource Use	☐	y/n/don't know	
6 Human Intrusions & Disturbance	☐	y/n/don't know	
7 Natural System Modifications	☐	y/n/don't know	
8 Invasive & Other Problematic Species & Genes	☐	y/n/don't know	
9 Pollution	☐	y/n/don't know	
10 Geological Events	☐	y/n/don't know	
11 Climate Change & Severe Weather	☐	y/n/don't know	

11. Additional comments or anecdotes (optional)

Evidence of Expected Response

9. Did you achieve your objectives regarding **target SGCNs** response to the trainings and ultimate direct management actions?

- ○ Most or all SGCN responded to the desired level (comments, optional)
- ○ Most or all SGCN responded but not to the level desired (comments, optional)
- ○ Some SGCN responded fully or partially but not all responded (comments, optional)
- ○ SGCN did not respond as expected (please explain ____________________)
- ○ Don't know (please explain____________________)
- ○ Not applicable (main focus of action was on habitats/processes)

Programming notes: Depending upon response, bring up an additional field for comments (optional) or please explain, as indicated above. For roll-up, SGCNs that at least partially benefit should fall into one of the first 3 categories.

10. Did you achieve your objectives regarding **target habitats/processes** responses to the trainings and ultimate direct management actions?

 - ○ Most or all habitats/processes responded to the desired level (comments, optional)
 - ○ Most or all habitats/processes responded but not to the level desired (comments, optional)
 - ○ Some habitats/processes responded fully or partially but not all responded (comments, optional)
 - ○ Habitats/processes did not respond as expected (please explain ___________________)
 - ○ Don't know (please explain___________________)
 - ○ Not applicable (main focus of action was on SGCNs, not their habitats or processes)

Programming notes: Depending upon response, bring up an additional field for comments (optional) or please explain, as indicated above. For roll-up, habitats/processes that at least partially benefit should fall into one of the first 3 categories.

11. Additional comments or anecdotes (optional)

10. Data Collection and Analysis

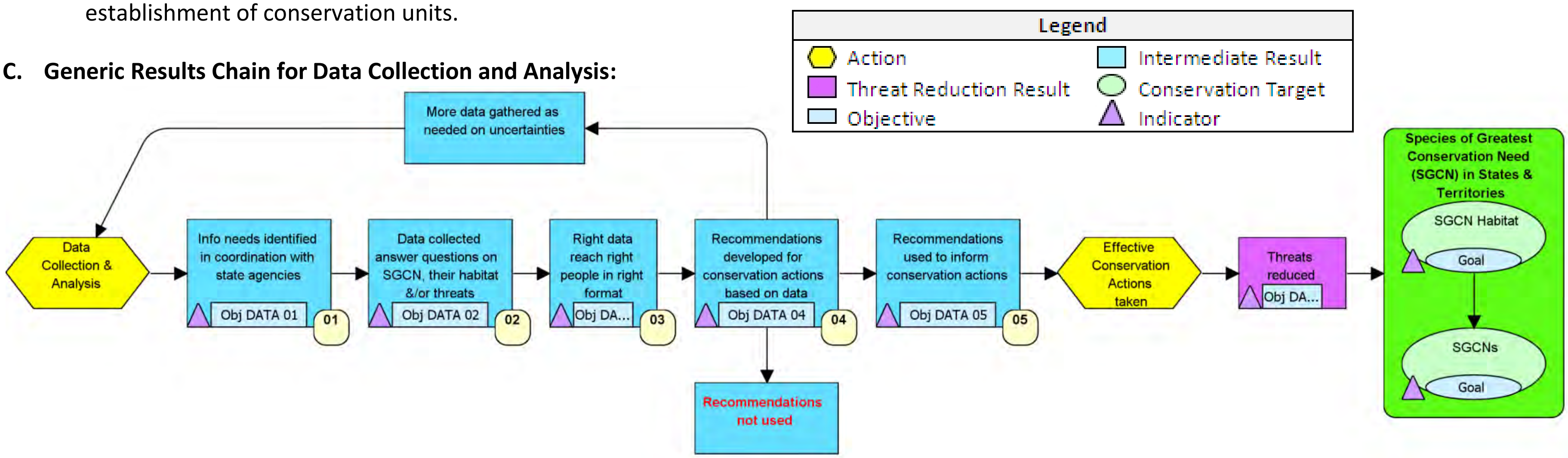
A. Definition of Data Collection and Analysis:

Data Collection and Analysis is defined as "Collecting data about species and habitats and the threats to them to fill information needs; includes compilation, management, synthesis, analysis, and reporting of spatial and nonspatial data."

B. Specific Examples of Data Collection and Analysis:

1. Gather data on the Shenandoah Salamander to define current distribution and survey methodologies, and understand habitat use and threats.
2. Conduct surveys and genetic assessments of three North American minnow SGCNs to determine baseline population data to assist in the establishment of conservation units.

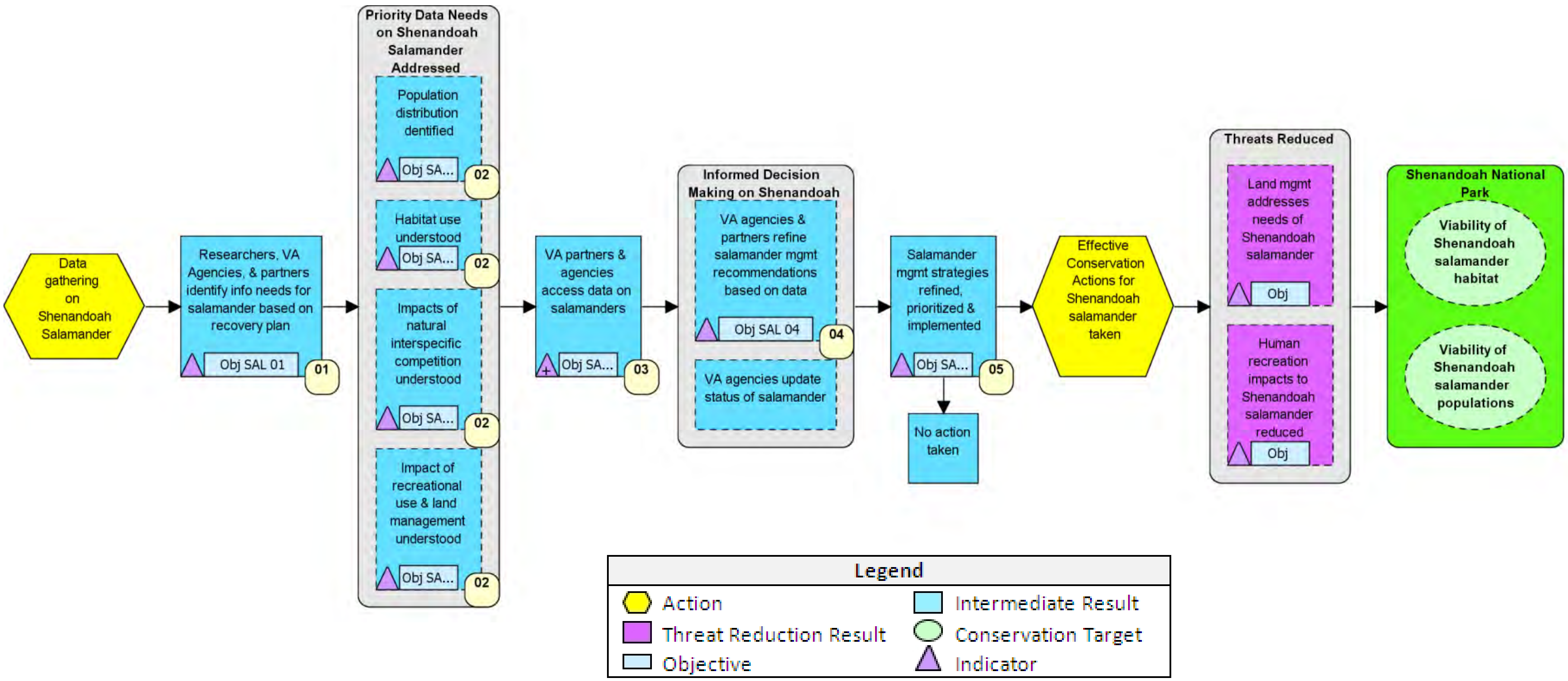
C. Generic Results Chain for Data Collection and Analysis:



Description: The development and implementation of effective conservation actions requires that state natural resource managers and their partners have data available to them that answer specific resource management questions related to species and habitats, and the threats to them. The critical first step in any data collection initiative is clearly defining the management needs and the questions the data collection and analysis will answer (01). For this to happen, relevant data users should be involved upfront in the development of the data collection proposal. (01). Having addressed the foundation for a successful data collection effort, the result chain focuses on how the data was collected. Did the researchers address the relevant questions and how well did the data answer those questions (02)? The final section of the result chain brings home the importance of data being used by people to implement and improve the effectiveness of conservation actions. For this critical final RESULT to be realized, the right data needs to reach the right people in the right format (03), who then apply it through recommending (04) and implementing (05) a course of action based on the data. There is, of course, the possibility that recommendations were not developed or used and capturing the reasons for this can provide important learning for improving future data collection initiatives. Applying these practices to a data collection initiative should result in effective conservation actions that reduce threats and positively impact SGCN and their habitats.

D. Example Results Chain for Data Collection and Analysis:

This fictitious example is based on a case of collecting data on the Shenandoah Salamander in Shenandoah National Park.



E. Cross-walk of Generic and Example Results, Objectives and Measures for Data Collection and Analysis:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
DATA 01	**Generic:** Info needs identified in coordination with state agencies	The grant application includes clear management needs and outcomes that have been identified with input from relevant data users	Evidence that clear management needs and outcomes have been identified with input from relevant data users	N/A – this is a question for grant application process	APP1. What relevant question or information need is this Conservation Action addressing?
	Salamander Example: *Researchers, Virginia agencies, & partners identify information needs for salamander based on recovery plan*	*Within 3 months of the start of the salamander data collection effort, clear research needs and desired outcomes have been identified with input from the VA Dept of Game & Inland Fisheries, USFWS, and NPS*	*Evidence that the salamander data collection effort has clear research needs and desired outcomes identified with input from VA Dept of Game & Inland Fisheries, USFWS, and NPS*		
DATA 02	**Generic:** Data collected answers relevant questions on SGCN*, their habitat and threats	By the end of the project/grant funding cycle the researcher clearly provides answers to relevant questions on needs identified	Evidence that the researcher clearly provides answers to relevant questions.	% of Information and Data Collection Actions in which researcher provided relevant answers to questions.	1. Did the Data Collection & Analysis appropriately answer the relevant research question?
	Salamander Example: Population distribution identified	Within 6 months of the start of the data collection, researchers clearly provide data on the current distribution of Shenandoah Salamander populations	Evidence that researcher provided data on the current distribution of Shenandoah salamander populations		
	Salamander Example: *Habitat use understood*	*Within 6 months of the start of the data collection, researchers clearly provide data on habitats used by Shenandoah Salamander populations*	*Evidence that researcher provided data on habitats used by Shenandoah salamander populations*		
	Salamander Example: *Impacts of natural interspecific competition understood*	*Within 2 years of the start of the data collection, researchers provide data on impacts of natural interspecific competition on*	*Evidence that researcher provided data on impacts of natural interspecific competition on Shenandoah Salamander populations*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
		Shenandoah Salamander populations			
	Salamander Example: *Impact of recreational use & land management understood*	*Within 2 years of the start of the data collection, researchers provide data on impacts of recreational use & land management on Shenandoah Salamander populations*	*Evidence that researcher provided data on impacts of recreational use & land management on Shenandoah Salamander populations*		
DATA 03	**Generic:** Right data reach right people in right format	Within X months/years of start of research, appropriate audiences are accessing data	Evidence that data are reaching relevant audiences (by audience)	% of data collection efforts in which data are reaching relevant audiences (by audience)	2. Who is the intended end user of the data? 3. Which end users have access to the data? 4. Comments/anecdotes
	Salamander Example: *VA partners & agencies access data on salamanders*	*Within 2.5 years of the start of the Shenandoah Salamander data collection, a reporting framework for synthesizing and sharing data is in place, and appropriate audiences are accessing that data*	a. *Evidence that data are reaching VA Dept of Game & Inland Fisheries, USFWS, and NPS* b. *Existence of a reporting framework for synthesizing and sharing data on Shenandoah Salamander populations*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
DATA 04	Generic: Recommendations are developed for Conservation Actions based on data	Within X months/years of the start of the data collection effort, (delete unless we can define good quality) recommendations for conservation action have been developed	Evidence that data collection effort resulted in conservation action recommendations Utility of recommendations	% of Information and Data Collection Actions that resulted in recommendations	5. Have recommendations for Conservation Actions (other than additional research) been developed based upon the data provided by this Data Collection & Analysis effort? If no, specify why.
	Salamander Example: *VA agencies & partners refine salamander management recommendations based on data*	*Within 3 years of the start of the data collection effort, VA agencies & partners develop &/or refine Shenandoah Salamander management recommendations based on data collected*	*Evidence of management recommendations for Shenandoah Salamander based on data collection*		
DATA 05	**Generic:** Recommendations used to inform conservation actions	Within X months of the end of the data collection project, recommendations to revise or maintain conservation actions have been developed	Evidence data are being used to inform conservation actions	% of data collection projects in which data have been used to inform conservation actions	6. Have *end users* used the data to inform *conservation actions*? If no, why. If yes, tell us how.
	Salamander Example: *Salamander mgmt strategies refined, prioritized, & implemented*	*At least 60% of management recommendations developed for the Shenandoah Salamander as a result of the data collection are being implemented*	*% of management recommendations developed for the Shenandoah Salamander as a result of the data collection that are being implemented*		

F. Measures Questionnaire for Data Collection and Analysis:

Research Need

APP1. What relevant question or information need is this Data Collection & Analysis effort addressing? Check all *uses of information that apply: (Programming note: This is an application question)*

- ☐ Inform habitat acquisition
- ☐ Inform habitat management
- ☐ Inform status of habitat quality
- ☐ Track habitat status
- ☐ Inform species and habitat interactions
- ☐ Track species population status or distribution
- ☐ Inform species management
- ☐ Inform species vulnerability assessment
- ☐ Inform species relocation
- ☐ Inform efforts to mitigate a threat and/or stressor
- ☐ Adding new SGCN species
- ☐ Removing SGCN species
- ☐ Support environmental review
- ☐ Inform new state or federal legislation or policy
- ☐ Inform species or habitat recovery plan
- ☐ Assess effectiveness of previously applied conservation actions
- ☐ Other (please describe:____________________)

Describe the specific research question or information need (max 1000 characters):

1. Did the data collected appropriately answer the relevant research question(s)?

- ○ Fully answered all research questions
- ○ Mostly to Somewhat answered all research questions
- ○ Provided partial answers to research questions
- ○ Did not appropriately answer the research questions

2. Who is the intended **end user(s)** of the data? *Check all intended users that apply:*

- ☐ Agency Administrators (Director, Deputies, Chiefs, etc)
- ☐ Agency Program Managers
- ☐ Agency Regional Supervisors
- ☐ Agency Field Biologists/Land Managers
- ☐ Agency Environmental Review staff
- ☐ Private Landowners
- ☐ Local, State or Federal Elected Officials
- ☐ State or Federal Regulators
- ☐ Municipality/County Land Use Planners
- ☐ Federal Partners
- ☐ Federal Funders
- ☐ NGO Partners (Private Sector)
- ☐ NGO Funders (Private Sector)
- ☐ Law Enforcement Personnel
- ☐ Colleges/Universities
- ☐ Environmental Regulators
- ☐ Other (please describe:__________________)

3. Which **end user(s)** have access to the data? *Check all intended users that apply:*

- ☐ Agency Administrators (Director, Deputies, Chiefs, etc)
- ☐ Agency Program Managers
- ☐ Agency Regional Supervisors
- ☐ Agency Field Biologists/Land Managers
- ☐ Agency Environmental Review staff
- ☐ Private Landowners
- ☐ Local, State or Federal Elected Officials
- ☐ State or Federal Regulators
- ☐ Municipality/County Land Use Planners
- ☐ Federal Partners
- ☐ Federal Funders
- ☐ NGO Partners (Private Sector)
- ☐ NGO Funders (Private Sector)
- ☐ Law Enforcement Personnel
- ☐ Colleges/Universities
- ☐ Environmental Regulators
- ☐ Other (please describe:__________________)

4. Additional comments or anecdotes (optional)

Management Recommendations

5. Have recommendations for *Conservation Actions* (other than additional research) been developed based upon the data provided by this Information Collection and Analysis effort? (*Programming note: flag this question for follow-up inquiries by the Service. Were recommendations made at the end of the project? Within three years of the project's end? Within five years of the project's end?)*

○ Yes, recommendations made

○ No, because: *(programming note: if "no" selected, auto drive back to project description w/ prompt – "you're being taken back to justify why recommendations were not made. If Reasoning and justification has already been made, click here↑ ")*

- ☐ Too early in the process to make recommendations
- ☐ Inadequate funding to complete data collection or analysis
- ☐ Logistical obstacles prevented sufficient completion of the data collection or analysis
- ☐ Data collected did not meet management objectives
- ☐ Data collected insufficient for management decision
- ☐ Other (please describe:________________________________)

6. Have *end users* used the data to inform *conservation actions*? (*Programmers note: flag this question for follow-up inquiries by the Service. Were recommendations made at the end of the project? Within three years of the project's end? Within five years of the project's end?)*

- ○ Yes, *end users* have used the data
- ○ No, because: *(programming note: if "no" selected, auto drive back to project description w/ prompt – "you're being taken back to justify why recommendations were not made. If Reasoning and justification has already been made, click here↑ ")*
  - ☐ Spatial scale of data collected was not adequate to inform agency actions
  - ☐ Agency or *end user* priorities no longer required the data provided
  - ☐ Recommendations for data use were not in line with Agency or *end user* priorities
  - ☐ Agency had insufficient personnel to help end users incorporate the data into their conservation priorities
  - ☐ End users did not have the ability/capacity to incorporate the data into their conservation priorities
  - ☐ Other (please describe:_____________________________)
- ○ Unknown

If "Yes," Tell us how! (*1000 character limit)*

Additional Information

7. Please provide any narratives, case studies, or additional comments you may have related to your work in direct management of natural resources (optional)

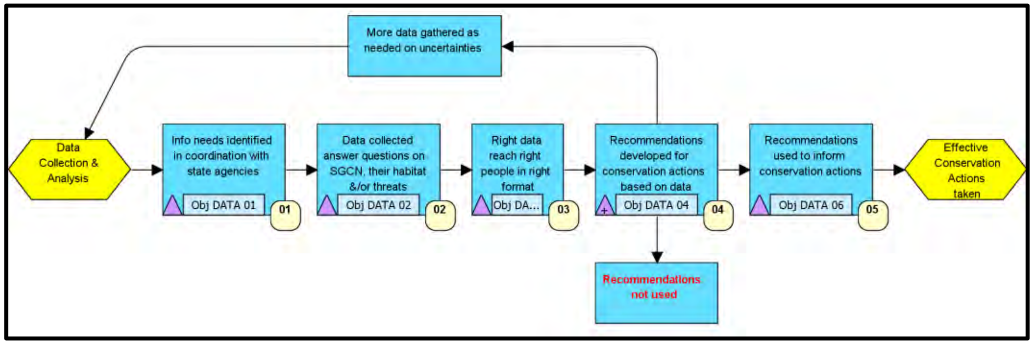
G. Example Graphs and Charts for Reports for Data Collection and Analysis:

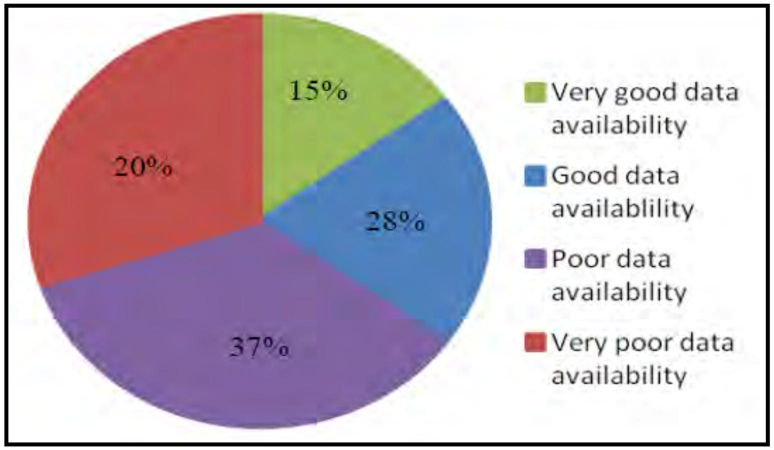
Effectiveness of Data Collection & Analysis

What Does This Include?

Efforts to fill information needs about SGCN and their habitats through the collection of data about species, habitats, and threats, including the compilation, management, synthesis, analysis, and reporting of spatial and nonspatial data. Examples include:

- Data gathered on the Shenandoah Salamander to define current distribution, survey methodologies, and understand habitat use and threats.
- Survey and genetic assessments of three North American minnow species of greatest conservation need to determine baseline populations for the purpose of establishing conservation units.





Progress to Date: Results Chain for Data Collection & Analysis

215 data collection and analysis grants to 40 states were made from 2008-2010. The majority of those led to data providing appropriate or useful recommendations to inform conservation actions.

Effectiveness of funded data collection efforts

1. 93% of the efforts provided appropriate answers to the relevant research question
2. In 89% of the efforts, the data reached the relevant audience
3. 68% of the efforts provided recommendations for conservation actions based on the data acquired
4. 85% of recommendations were useful or appropriate for the conservation action

Where do we go from here?

State Wildlife Action Plans, completed in 2005, identified more than 12,000 Species of Greatest Conservation Need (SGCN). These are species for which populations are declining, or face serious threats. SGCN designation and conservation strategies for these species were based on information available when the plans were developed. For many of these species, data collection and analysis is essential to improve manager's knowledge of SGCN population status and reproduction, habitat requirements, and response to threats in order to develop and implement effective conservation actions and measure their effectiveness.

11. Outreach to key Resource Users

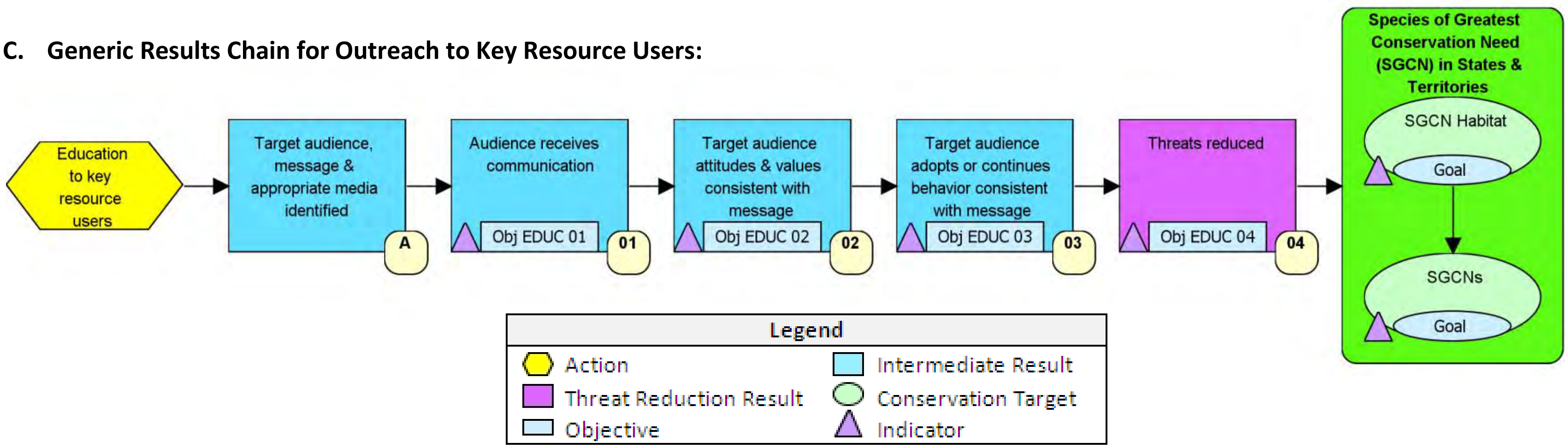
A. Definition of Outreach to Key Resource Users:

Education is defined as "Actions or efforts to increase knowledge or understanding and encourage practices in support of SGCN conservation through instruction or distribution of materials or to provide general information in response to inquiries from the public or partners about SGCN conservation programs, actions, or activities." *Includes both formal (classroom) and non-formal education efforts.*

B. Specific Examples of Outreach to Key Resource Users:

1. Implement a Timber Rattlesnake educational program that includes developing educational materials, conducting workshops on conservation efforts, and conducting habitat management demonstration tours to NGOs interested in implementing Timber Rattlesnake conservation projects.
2. Conduct outreach to landowners to implement land management practices to benefit species.
3. Provide decision makers with data about pollution impacts on at-risk aquatic species to help them set water quality standards for key water bodies.

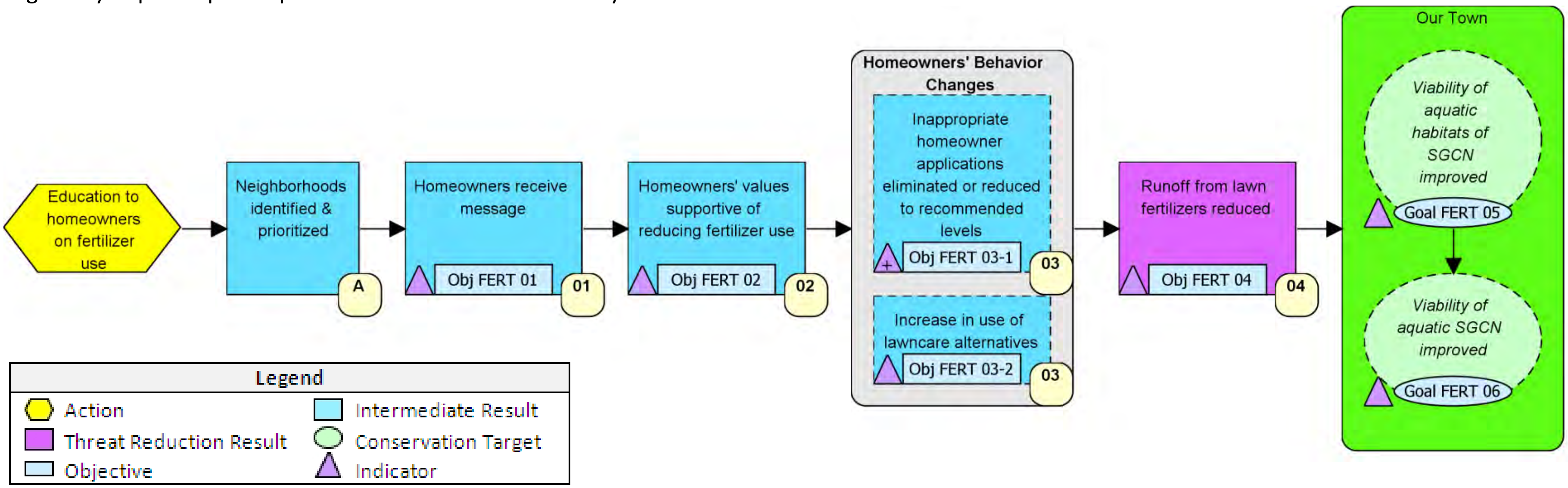
C. Generic Results Chain for Outreach to Key Resource Users:



Description: This action involves providing information and materials to key resource users, with the hope that they will use that information and material to adopt or reinforce behaviors supportive of SGCNs and their habitats. The start of any outreach initiative involves being clear about who the target audience is, what message they need to hear, and what the most appropriate method of reaching them is (A). Though this is shown as the first result of implementing this action, a project team should have already completed this result prior to applying for funding, and any application review should ensure that this is the case. The remainder of the chain follows a typical "knowledge-attitudes-practices" model for behavior change or reinforcement. If the audience receives the message (01), then the first expectation is that they will have the desired knowledge, attitudes, and values (02). This will, in turn, lead them to adopt or continue a practice that is consistent with the message (03). The practice should lead to a reduction in threats (04), which would have positive impacts on SGCN habitats and/or SGCNs.

D. Example Results Chain for Outreach to Key Resource Users:

This fictitious example is based on a case of reaching out to homeowners to help them understand how lawn fertilizer practices contribute to runoff and negatively impact aquatic species and habitat and what they can do to reduce fertilizer runoff.



E. Cross-walk of Generic and Example Results, Objectives and Measures for Outreach to Key Resource Users:

<table>
<tr><th>Label</th><th>Result</th><th>Objective</th><th>Specific Measure (Indicator)</th><th>Rolled Up Measure</th><th>Monitoring Questions</th></tr>
<tr><td>A</td><td>Generic: Target audience, message, & appropriate media identified</td><td>N/A – should be part of application and review process</td><td>N/A</td><td>N/A</td><td>App1. Identify your target audiences for this outreach effort (incl. how many you intend to reach)
App2. Identify what message you intend to share and the expected change
App3. Identify how you will share that message
App4. Identify how many individuals’ <u>attitudes and values</u> you expect to influence
App5. Identify how many individuals’ <u>behaviors</u> you expect to influence
Note: these are suggested questions for the SWG application process. If the application process changes to incorporate these, duplicate questions below for the reporting process should be removed</td></tr>
<tr><td rowspan="2">EDUC 01</td><td>Generic: Target audience receives message</td><td>Within X months/years of campaign, at least X% of target audience receives the message</td><td>% of target audience that receives message</td><td>% of outreach actions where target audience "reach" objectives were met</td><td rowspan="2">1. Identify your target audiences for this outreach effort
2. For each target audience, identify the primary methods used to reach the audience
3. For each target audience, identify approximately how many individuals or entities you:
a. <u>Wanted</u> to reach with this effort
b. <u>Were able</u> to reach
(% objective met autocalculated and categorized)
4. If Somewhat or Did not meet:
a. Indicate why your outreach effort did not reach as many individuals or entities as hoped.
b. Describe what you learned and whether you would (or did) do anything differently based on what you learned.
5. Additional comments or anecdotes (optional)</td></tr>
<tr><td>Fertilizer Example: Homeowners receive message</td><td>Within 4 months of the start of the fertilizer campaign, at least 90% of homeowners receive message about fertilizer impacts and alternatives</td><td>% of homeowners that receive message about fertilizer impacts and alternatives</td><td></td></tr>
</table>

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
EDUC 02	**Generic:** Target audience attitudes & values consistent with message	Within X months/years of campaign, there is an increase from X% to Y% in target audience desired attitudes & values	% of target audience that has desired attitudes & values	% of outreach actions where target audience attitude/value objectives were met	6. For each target audience, identify approximately how many individuals with the desired **attitudes and values**: a. You had <u>before</u> your campaign b. You *wanted* to have after the campaign c. You *actually* had <u>after</u> your campaign. 7. What is the perception of **attitudes and values** based upon? 8. If *Somewhat* or *Did not meet*: a. Indicate why your outreach effort did not lead to the changes in **attitudes and values** you had hoped. b. Describe what you learned and whether you would (or did) do anything differently based on what you learned. 9. Additional comments or anecdotes
	Fertilizer Example: *Homeowners' values supportive of reducing fertilizer use*	*Within 6 months of fertilizer campaign, at least 70% of homeowners surveyed has attitudes & values supportive of limiting conventional fertilizer use and/or using alternatives*	*% of homeowners surveyed that has attitudes & values supportive of limiting conventional fertilizer use and/or using alternatives*		
EDUC 03	**Generic:** Target audience adopts or continues behavior consistent with message	Within X months/years of start of campaign, there is an increase from X% to Y% in the amount of target audience that has adopted or continued the desired behavior	% of target audience that has adopted or continued desired behavior	% of outreach actions where target audience behavior objectives were met	10. For each target audience, identify approximately how many individuals with the desired **behaviors**: a. You had <u>before</u> your campaign b. You *wanted* to have after the campaign c. You *actually* had <u>after</u> your campaign. 11. What is the perception of **behaviors** based upon? 12. If *Somewhat* or *Did not meet*: a. Indicate why your outreach effort did not lead to the changes in **behaviors** you had hoped. 13. Describe what you learned and whether you would (or did) do anything differently based on what you learned.
	Fertilizer Example: *Inappropriate homeowner applications eliminated or reduced to recommended levels*	*Within 1 year of fertilizer campaign, at least 50% of homeowners state they no longer use or have reduced their use of conventional fertilizers*	a. *% of homeowners who state they no longer use conventional fertilizers* b. *% of homeowners who state they have reduced their use of conventional fertilizers*		
	Fertilizer Example: *Increase in use of lawn care alternatives*	*Within 1 year of fertilizer campaign, at least 25% of homeowners indicate they are using lawn care alternatives instead of conventional fertilizers*	*% of homeowners who indicate they are using lawn care alternatives instead of conventional fertilizers*		

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
EDUC 04	**Generic:** Threats reduced	Within X years of the start of the action, the desired threat reduction is seen	Threat reduction measures	% of initiatives that show a reduction in key threats being addressed by outreach efforts	14. Do you have evidence of this outreach action leading towards reductions in any of these threats? Y/N; Please describe
	Fertilizer Example: *Runoff from lawn fertilizers reduced*	*Within 18 months of start of fertilizer campaign, concentration of fertilizers in runoff from target neighborhoods has decreased by 25% at discharge point*	*Concentration of fertilizers in runoff from target neighborhoods at designated discharge point*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN improved	**<u>Goal:</u>** Within X years of the start of the action, the species of interest have improved viability	Species measures (e.g., population size, reproductive success)	Status measure – will not be rolled up	N/A
	Fertilizer Example: *Viability of aquatic SGCN improved*	***<u>Goal:</u>*** *Within 3 years of the start of the fertilizer campaign, toxic tolerance levels for benthic macro-invertebrates (as measured by the Hilsenhoff Biotic Index) are no higher than "moderately impaired" (4-6 range)*	*Toxic tolerance levels for benthic macro-invertebrates (as measured by the Hilsenhoff Biotic Index)*		
N/A - Conser-vation targets	**Generic:** Viability of SGCN habitats improved	**<u>Goal:</u>** Within X years of the start of the action, the desired habitat improvement is seen	Habitat measures (e.g., size, condition)	Status measure – will not be rolled up	N/A
	Fertilizer Example: *Viability of aquatic habitats of SGCN improved*	***<u>Goal:</u>*** *Within 2 years of the start of the fertilizer campaign, the stream condition index in designated water bodies consistently (at least 85% of measurements per year) falls in the "good" to "very good" range*	*Stream condition index*		

F. Measures Questionnaire for Outreach to Key Resource Users:

Target Audience Reach

1. Identify your target audiences for this outreach effort

   Audience 1: ______

   ☐ Add another audience

   Programming note: Allow them to identify as many audiences as they wish. Then, ask the following questions for each audience. Ideally, the audiences would be identified in the grant application process and could be auto-filled here.

2. For each target audience, identify approximately how many individuals or entities you wanted to reach with this effort and how many you were able to reach.

Audience	Target # individuals to reach	Actual # reached	% Objective Met
Audience 1 *(programming note: autopopulate from response above)*	☐ Individuals/ entities	☐ Individuals/ entities	Autofilled with % and category (see programming note)
Audience 2 *(programming note: autopopulate from response above)*	☐ Individuals/ entities	☐ Individuals/ entities	Autofilled with % and category (see programming note)
Etc.			

Programming note: Divide actual # reached/ target number to get % objective met and classify as follows:
Completely met: 100% or more of target individuals reached
Mostly met: 75-99% of target individuals reached
Somewhat met: 30-74% of target individuals reached
Did not meet: 29% or fewer of target individuals reached

3. Please indicate why your outreach effort did not reach as many individuals or entities as expected. Check all that apply.
   Programming note: Show this question if one or more audience reach objectives (col. 4 in table above) are below 75% met.

   ☐ Too early in the process to expect to meet our objective
   ☐ Audience was more difficult to reach than expected
   ☐ Wrong audience was defined
   ☐ Insufficient funding to reach as many individuals/entities as hoped
   ☐ Logistical problems in reaching the audience
   ☐ Internal agency or project management issues
   ☐ Other (Please specify __________________)

4. If applicable, please describe what you learned and whether you did (or would do in the future) anything differently based on what you learned. *Programming note: Show this question if one or more audience reach objectives (col. 4 in table above) are below 75% met*

5. Additional comments or anecdotes (optional)

Target Audience Attitudes and Values

6. For each target audience, please identify approximately how many individuals had the desired **attitudes and values** before and after your outreach effort.

Audience	**# individuals with desired attitudes before outreach**	**Target # individuals for desired attitudes**	**Actual # individuals with desired attitudes after outreach**	**% Objective Met**
Audience 1 *(programming note: autopopulate from response above)*	Individuals/ entities	Individuals/ entities	Individuals/ entities	*Autofilled with % and category (see programming note)*
Audience 2 *(programming note: autopopulate from response above)*	Individuals/ entities	Individuals/ entities	Individuals/ entities	*Autofilled with % and category (see programming note)*

Programming note: Divide actual # reached/ target number to get % objective met and classify as follows:
Completely met: 100% or more of target individuals reached
Mostly met: 75-99% of target individuals reached
Somewhat met: 30-74% of target individuals reached
Did not meet: 29% or fewer of target individuals reached

7. Upon what is the perception of **attitudes and values** based?

- ○ Rough guess
- ○ Attitude survey or similar data collection effort
- ○ Other (please specify ____________________)

8. Please indicate why your outreach effort did not lead to the changes in **attitudes and values** you had expected. Check all reasons that apply. *Programming note: Show this question if one or more attitude/values objectives are below 75% met (col. 5 above).*

   - ☐ Too early in the process to expect to meet our objective
   - ☐ Change in context affected attitudes and values
   - ☐ Target audience was more resistant to adopting values and attitudes than expected
   - ☐ Internal agency or project management issues
   - ☐ Not as successful in reaching target audience as expected
   - ☐ Other (Please specify _________________)

9. If applicable, please describe what you learned and whether you did (or would do in the future) anything differently based on what you learned. *Programming note: Show this question if one or more attitude/values objectives are below 75% met (col. 5 above).*

10. Additional comments or anecdotes (optional)

Target Audience Behaviors

11. For each target audience, please identify approximately how many individuals had the desired **behaviors** before and after your outreach effort.

Audience	**# individuals with desired behaviors before outreach**	**Target # individuals for desired behaviors**	**Actual # individuals with desired behaviors after outreach**	**% Objective Met**
Audience 1 *(programming note: autopopulate from response above)*	Individuals/ entities	Individuals/ entities	Individuals/ entities	*Autofilled with % and category (see programming note)*
Audience 2 *(programming note: autopopulate from response above)*	Individuals/ entities	Individuals/ entities	Individuals/ entities	*Autofilled with % and category (see programming note)*
Etc.				

Programming note: Divide actual # reached/ target number to get % objective met and classify as follows:
Completely met: 100% or more of target individuals reached
Mostly met: 75-99% of target individuals reached
Somewhat met: 30-74% of target individuals reached
Did not meet: 29% or fewer of target individuals reached

12. Upon what is the perception of **behaviors** based?

   - ○ Rough guess
   - ○ Attitude survey or similar data collection effort
   - ○ Other (please specify ___________________)

13. Please indicate why your outreach effort did not lead to the changes in **behaviors** you had expected. Check all reasons that apply.
   Programming note: Show this question for those efforts that fall into the somewhat met or did not meet categories.

   - ☐ Too early in the process to expect to meet our objective
   - ☐ Change in context affected behaviors
   - ☐ Target audience was more resistant to adopting behaviors than expected
   - ☐ Obstacles to behavior adoption were too great
   - ☐ Internal agency or project management issues
   - ☐ Not as successful in reaching target audience as expected
   - ☐ Not as successful in changing attitudes or values as expected
   - ☐ Other (Please specify _________________)

14. If applicable, please describe what you learned and whether you did (or would do in the future) anything differently based on what you learned.
   Programming note: Show this question for those efforts that fall into the somewhat met or did not meet categories.

15. Additional comments or anecdotes (optional)

Threat Reduction

16. What threat(s) were you hoping to address through the direct management of natural resources? For a more detailed description of the threat categories provided, see the Conservation Measures Partnership's website: www.conservationmeasures.org.
Programming note – provide check box of IUCN CMP Taxonomy of threats (level 1 or level 2 – level 1 shown in this example).

Direct Threat	Check if relevant
1 Residential & Commercial Development	☐
2 Agriculture & Aquaculture	☐
3 Energy Production & Mining	☐
4 Transportation & Service Corridors	☐
5 Biological Resource Use	☐
6 Human Intrusions & Disturbance	☐
7 Natural System Modifications	☐
8 Invasive & Other Problematic Species & Genes	☐
9 Pollution	☐
10 Geological Events	☐
11 Climate Change & Severe Weather	☐

17. Do you have evidence of this outreach action leading towards reductions in any of these threats?
☐ Yes ☐ No

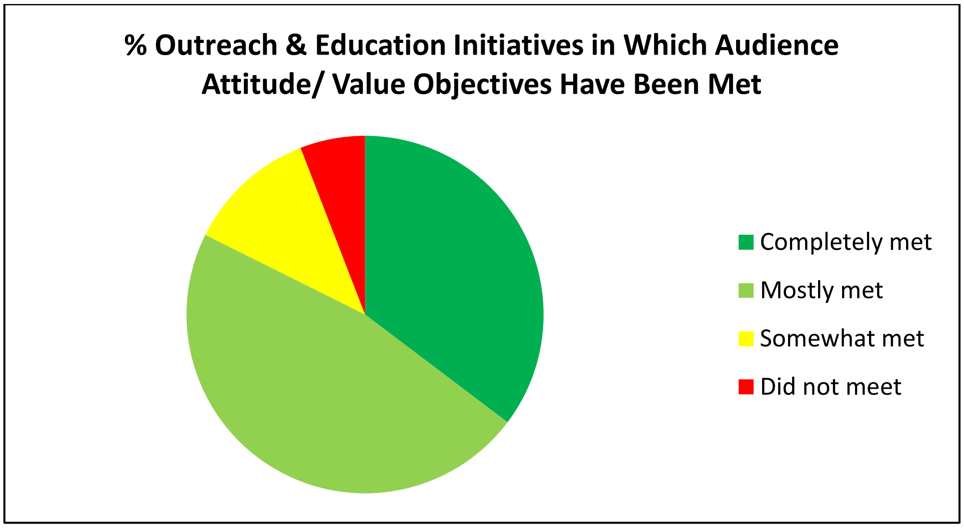
If yes, please describe:
Programming note: Only show this question if they checked "yes" above

Additional Information

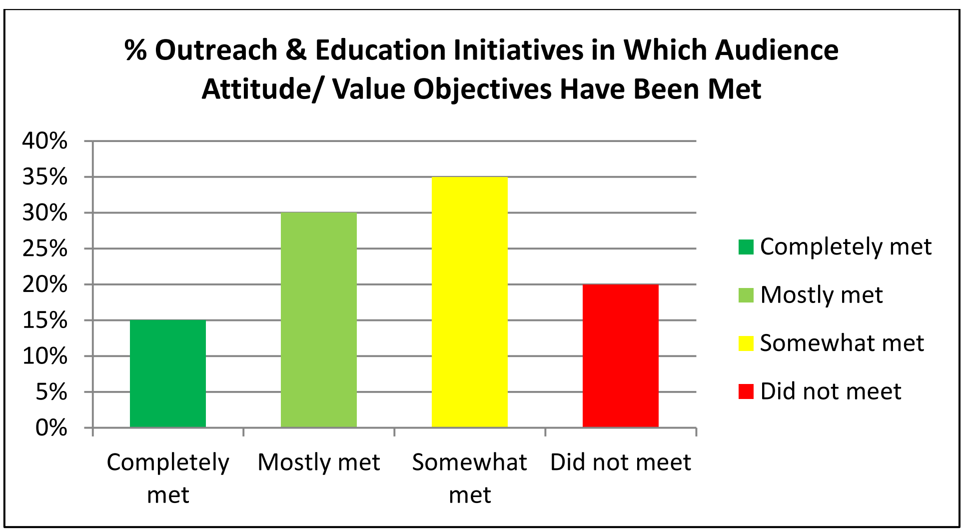
18. Please provide any narratives, case studies, or additional comments you may have related to this outreach effort (optional)

G. Example Graphs and Charts for Reports for Outreach to Key Resource Users:
Potential graphs and charts for a report could include:

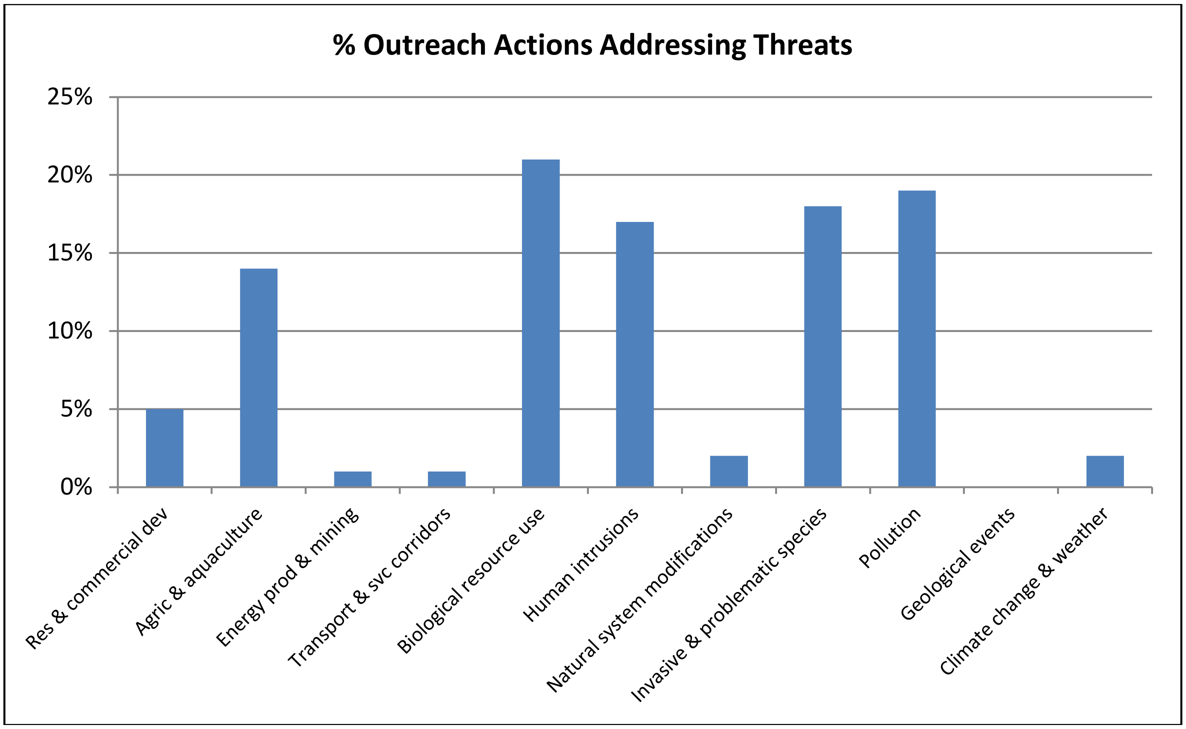
EDUC 02 (Target audience attitudes & values consistent with message): Pie chart (preferred) or bar graph showing % objective met - colors indicative of % of objective met (green = v. good; red = v. poor)



EDUC 03 (Target audience adopts or continues behavior consistent with message): Pie chart (preferred) or bar graph showing % objective met - colors indicative of % of objective met (green = v. good; red = v. poor) – bar graph shown here to vary from previous figure.



EDUC 04 (Threats reduced): Table or histogram with IUCN-CMP threat categories & # being addressed through education, do not report on evidence of threat reduction (except anecdotally). Note, this figure could also be shown as the total number of initiatives, rather than as percents within that total number.



A. INCENTIVES (partial chain to be inserted into others)

A. Definition of Incentives:

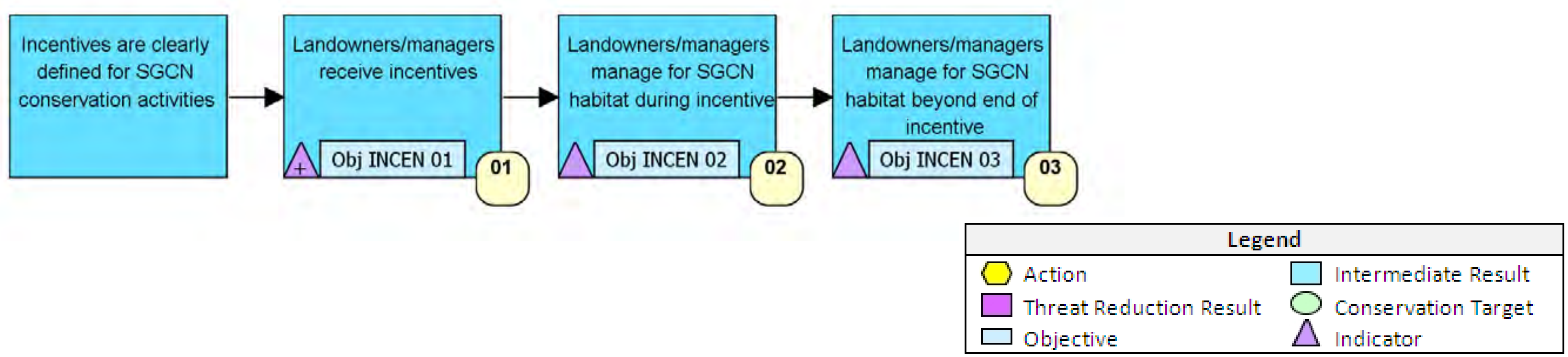
Incentives are defined as "Development and delivery of incentives to private landowners to influence responsible stewardship of land/water and specific species."

B. Specific Examples of Incentives:

1. Tax breaks
2. Stewardship payments to landowners (doing the right thing, continue to do the right thing)
3. Management infrastructure & practices incentives ($ to build a fence, infrastructure, delay hayfield)
4. Restoration incentives ($ to restore wetland)
5. Regulatory streamlining
6. Technical assistance

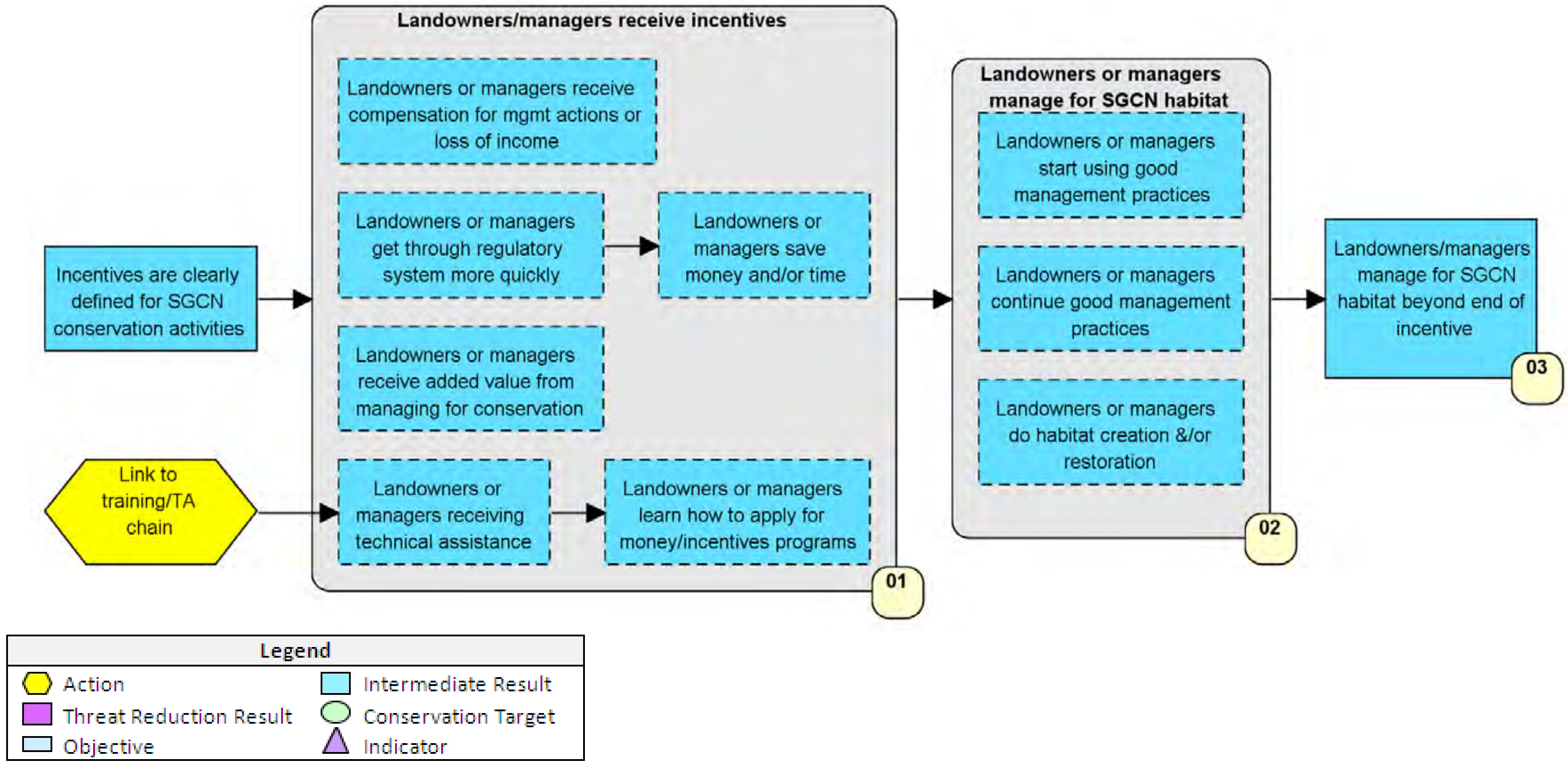
C. Generic Results for Incentives:

Note: This is not presented as a full chain, but rather as a series of boxes that could be used in various chains where incentives might be part of a broader strategy (e.g., direct management of natural resources; creation of new habitat; acquisition/ easement/ lease)



Description: Regardless of what broader action is being implemented, it is possible to think of incentive-oriented components of those broader actions in a series of four generic results. First, it is assumed that a project team would clearly define appropriate incentives for conservation actions designed to influence species of greatest conservation need. If those are defined, then the next assumption holds that landowners or land managers receive those incentives (01). As shown in the more detailed figure in Section D, those incentives can come in a variety of forms, including: compensation for management actions or loss of income; assistance in getting through the regulatory system more efficiently, which allows them to save money and/or time; added value from managing for conservation (e.g., ability to get certified, attract hunters, attract ecotourists); and technical assistance, which could also help them to apply for money or other incentives programs. Assuming the landowners or land managers receive the incentives, then it is expected that they would manage for SGCN habitat during the timeframe in which they are receiving the incentive (02). Again, referring to the more detailed figure in Section D, management might include starting to use good management practices, continuing to use good management practices, and/or doing habitat creation and/or restoration. An important assumption in this chain is that the landowners or managers will continue to manage for SGCN habitat beyond the end of the incentive (03). Thus, it is hoped that the incentive provides the impetus to start or continue good management, but that landowners or managers would see benefits in continuing those practices over the longer term.

D. Generic Results (More detail) for Incentives:



E. Generic Results, Objectives and Measures for Incentives:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
INCEN 01	Landowners/managers receive incentives	Within X timeframe, sufficient incentives are available to get enough landowners to participate	a. # of landowners/managers receiving direct compensation b. # acres of SGCN habitat covered by direct compensation c. Amount of money spent on direct compensation d. Amount of additional money needed for direct compensation	a. # of landowners/managers receiving direct compensation b. # acres of SGCN habitat covered by direct compensation c. Amount of money spent on direct compensation d. Amount of additional money needed for direct compensation	1. Considering where the on-the-ground action covered by the incentives took place: a. How many landowners/managers are receiving direct compensation? b. How many acres of SGCN habitat are covered by direct compensation? c. How much money was spent on direct compensation? d. Was there more demand than you were able to provide via direct compensation? If yes, approximately how much more money was needed?
INCEN 02	Landowners/managers manage for SGCN habitat during incentive	Within X timeframe of receiving the incentive, at least 90% of landowners/managers are complying with their incentive agreement	% of landowners/managers who are complying with their incentive agreement	% of initiatives in which at least 90% of landowners/ managers are complying with their incentive agreement	How many landowners/managers receive an incentive? (see earlier question – 1a) 2. How many landowners/managers are complying with their incentive/agreement?
INCEN 03	Landowners/managers manage for SGCN habitat beyond end of incentive	After the end of the incentive, it is at least somewhat likely that the landowner/manager will continue mgmt of SGCN habitat without incentive	Likelihood that landowner/manager continues mgmt of SGCN habitat without incentive *Note: Ideally, you should measure this landowner by landowner (not across a group of landowners)*	% of initiatives in which landowner/manager is at least somewhat likely to continue mgmt of SGCN habitat without incentive	3. Given current trends, to what degree do you think the landowner or manger will continue to manage for SGCN habitat beyond the end of the incentive? 4. What is the basis for your response?

F. Measures Questionnaire for Incentives:

Incentives Received

1. Considering where the on-the-ground action covered by the incentives took place, please answer the following questions:
   a. How many landowners/managers are receiving direct compensation? _______
   b. How many acres of SGCN habitat are covered by direct compensation? _______
   c. How much money was spent on direct compensation? _______
   d. Was there more demand than you were able to provide via direct compensation?

      ○ Yes. If yes, approximately how much more money was needed? _______

      ○ No

Managing for SGCN Habitat (during incentive)

2. How many landowners/managers are complying with their incentive/agreement? _______

Managing for SGCN Habitat (beyond incentive)

3. Given current trends, to what degree do you think the landowner or manger will continue to manage for SGCN habitat beyond the end of the incentive?

   ○ Very likely

   ○ Somewhat likely

   ○ Somewhat unlikely

   ○ Not likely

   ○ Don't know

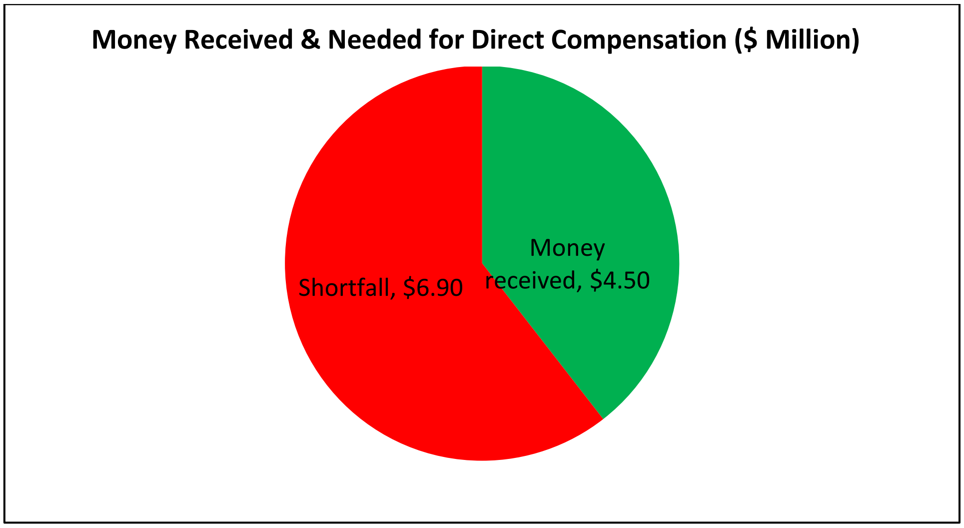
4. What is the basis for your response?
   ☐ Poll with landowners
   ☐ Personal opinion
   ☐ Other (specify) _____________

G. Example Graphs and Charts for Reports for Incentives

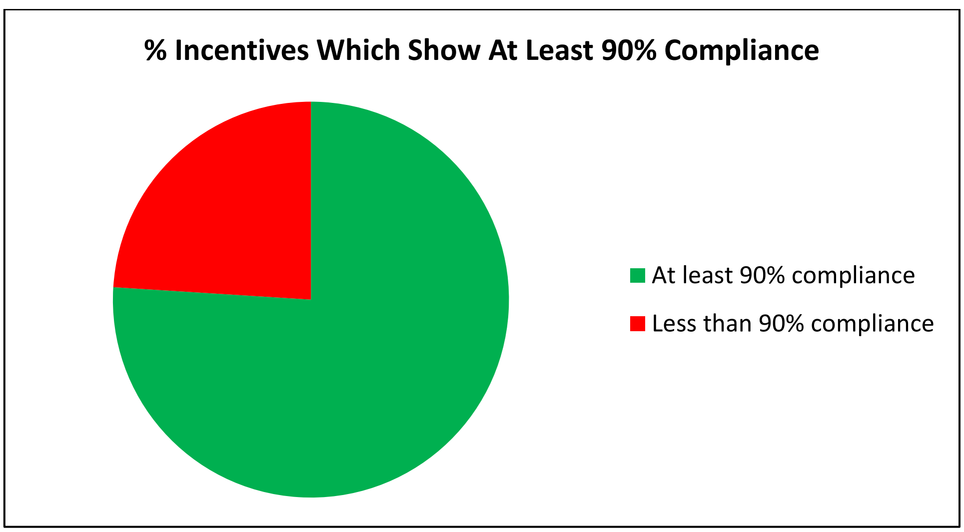
INCEN 01 (Landowners/managers receive incentives.) Table to show summary figures

# Landowners or managers receiving direct compensation	563
# Acres of SGCN habitat covered by direct compensation	3.2 million hectares
Money spent on direct compensation	$4.5 million

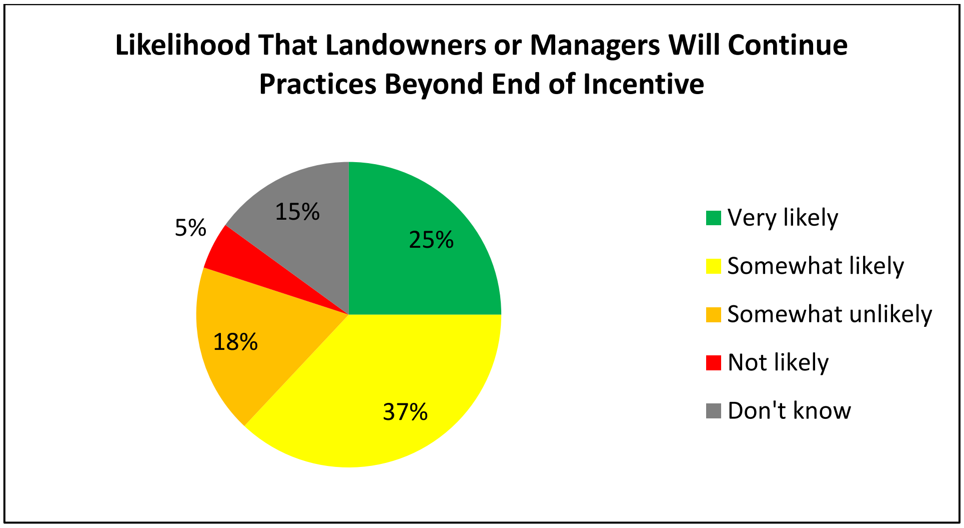
Pie chart to show money received for direct compensation and shortfall



INCEN 02 (Landowners/managers manage for SGCN habitat during incentive) Pie chart (or bar graph) to show % of initiatives in which at least 90% of landowners or land managers are complying with their incentive agreement



INCEN 03 (Landowners/managers manage for SGCN habitat beyond end of incentive) Pie chart to show % of initiatives in which landowner/manager is at least somewhat likely to continue mgmt of SGCN habitat without incentive. *Note: this pie chart shows full distribution, not just the "at least somewhat likely" category.*



B. Stakeholder Involvement (partial chain to be inserted into others)

A. Definition of Stakeholder Involvement:

<u>Stakeholder involvement</u> is defined as “Engaging state and federal agencies, tribal entities, the NGO community, and other partners to achieve shared objectives and broader coordination across overlapping areas.”

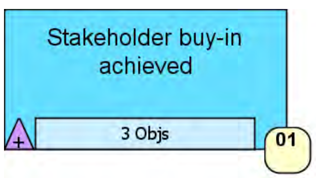
Note: This was listed as a separate action (partner engagement) in the Phase 1 report, but the workgroup concluded that partners were most often engaged through active participation in the other Conservation Actions. Many of the conservation actions include “stakeholder buy-in or involvement” as a component of their results chain. The work group concluded that, at least from the standpoint of SWG/SWAP, there was not sufficient distinction between partner engagement and stakeholder involvement to warrant Partner Engagement as a separate conservation action.

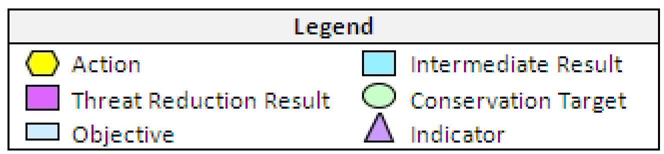
B. Specific Examples of Stakeholder Involvement:

1. Establish decision making processes with state agencies
2. Outreach with tribal governments
3. Convene an advisory committee to assist with implementation of a State Wildlife Action Plan

C. Generic Result for Stakeholder Involvement:

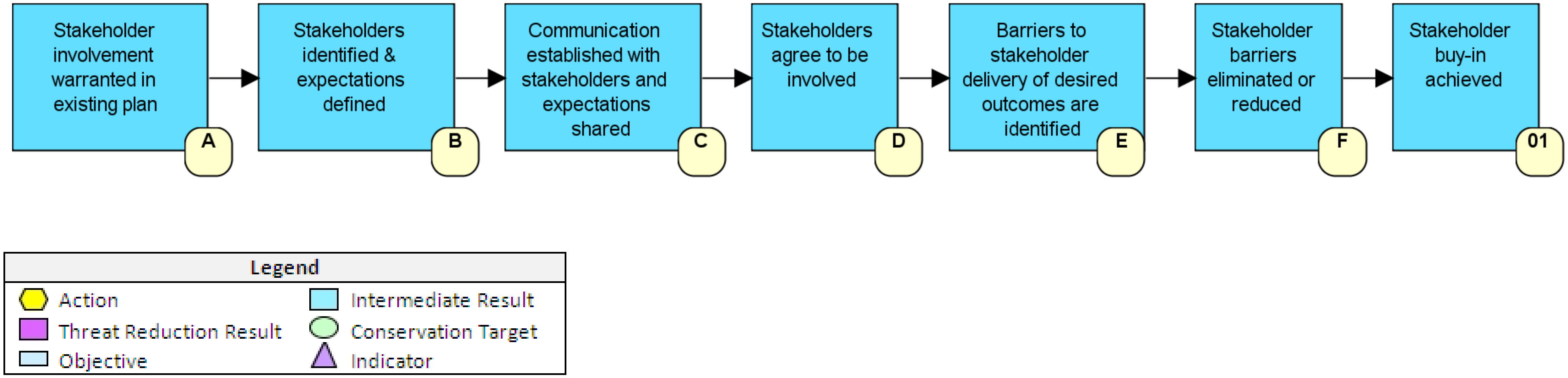
Note: This is not presented as a full chain, but rather a box that could be used in various chains where stakeholder involvement might be part of a broader strategy (e.g., land use planning, direct management of natural resources,)





Description: Many conservation actions require the involvement of various stakeholders and achieving their buy-in. Using this generic result in all conservation actions that include stakeholder involvement assures consistency across result chains for objectives, measures, rolled-up measures, and survey questions. The most important result to include is that stakeholder buy-in has been achieved (01). Still, there are a series of steps and results that lead up to stakeholder buy-in. These are presented in a more detailed chain in Section D. This chain was developed to encourage the use of best practices when engaging stakeholders in conservation actions. The chain shows the importance of determining if stakeholder involvement is warranted (A) and if so, identifying stakeholders and defining their expectations (B). Once this happens, it is then assumed that a project team would effectively communicate with stakeholders and share expectations with them (C), which would lead to their agreement to be involved in the effort (D). If stakeholders are involved in the conservation action, then this would facilitate the identification of barriers (E) and their elimination (F). The final and key result is that all of these steps and results would lead to the achievement of stakeholder buy-in (01). For more information on stakeholder involvement, IAP2.org is a good resource http://www.iap2.org/. See IAP2 public participation spectrum at http://www.iap2.org/associations/4748/files/IAP2%20Spectrum_vertical.pdf.

D. Generic Results (More detail) for Stakeholder Involvement:



E. Generic Results, Objectives and Measures for Stakeholder Involvement:

Label	Result	Objective	Specific Measure (Indicator)	Rolled Up Measure	Monitoring Questions
STAKE 01-1	Stakeholder buy-in achieved	By {target date}, expectations for X% of identified stakeholders have been established and communicated.	a. # stakeholders/ stakeholder groups identified b. % stakeholders with whom communication has been achieved and expectations shared	% projects which meet their objectives for contacting stakeholders and sharing expectations	1. This project identified stakeholders by: (drop-down) 2. How many stakeholders did you identify for this project? 3. Of the stakeholders you identified, how many were you able to communicate with?
STAKE 01-2	Stakeholder buy-in achieved	By {target date}, of those who have received communications, at least X% have agreed to participate	% of contacted stakeholders who agree to participate	% projects which meet their objective for stakeholder agreement	4. Of the number you communicated with, how many stakeholders agreed to participate in your action?
STKAKE 01-3	Stakeholder buy-in achieved	By {target date}, of participating stakeholders, at least X% have fulfilled their commitments to the project	% of participating stakeholders who fulfill commitments	% projects which meet their stakeholder commitment objective	5. For participating stakeholders, how many fulfilled their commitments to your project? 6. Were participating stakeholders recognized for their involvement? If yes, please share!

F. Measures Questionnaire for Stakeholder Involvement:

Stakeholder Buy-In Achieved

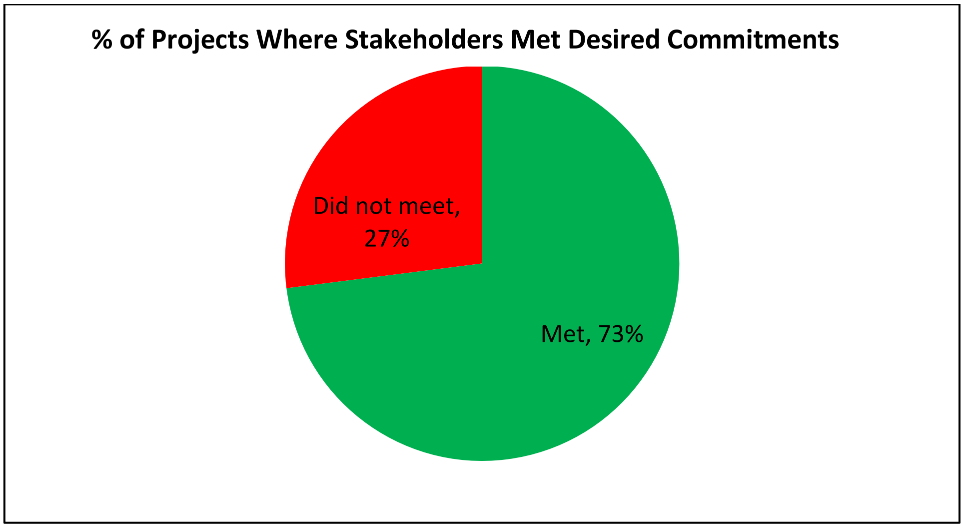
1. This project identified the following stakeholders :
   - Internal/Agency Partners
   - Community members at large
   - Financial contributor/ capital commitment holder
   - Special interest group
   - Other ____________________
2. How many stakeholders were identified for this project?
3. Of the X#* stakeholders identified, how many were you able to communicate with?
   **Programming note: Auto populate X# with number from Question 2*
4. Of the X#* stakeholders you communicated with, how many agreed to participate in your action?
   **Programming note: Auto populate X# with number from Question 3*
5. For the X#* participating stakeholders, how many fulfilled their commitments to your project?
   **Programming note: Auto populate X# with number from Question 4*
6. Were participating stakeholders recognized for their involvement?
   - Yes
   - No

   If "Yes," please describe:

G. Example Graphs and Charts for Reports Stakeholder Involvement:

STAKE 01-3(Stakeholder buy-in achieved) Pie chart to show % projects which meet their stakeholder commitment objective

Note: Could do something similar for other objectives/measures, but this seems to be the most important one.



APPENDIX III. EXAMPLE OF EFFECTIVENESS MEASURES REPORT

The following diagram shows a mockup of a potential roll-up report for species restoration.

Mock-up Example of 2-Page Layout for Reporting on Conservation Actions

Effectiveness of Species Restoration Efforts

What Does This Include?

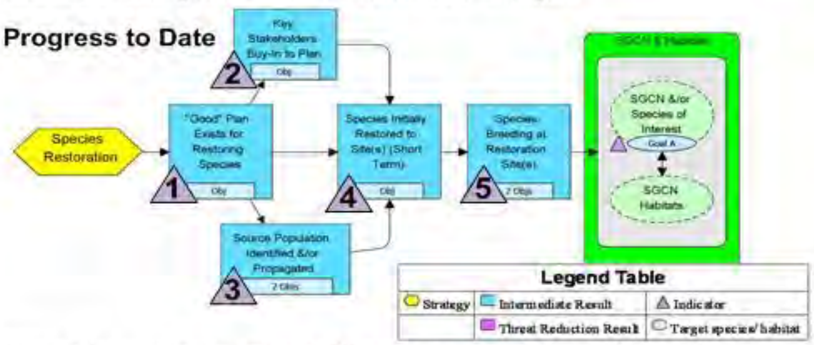
Efforts to reintroduce, relocate, or stock native animals or plants or translocate animals to an area where they are not currently found. Some examples include:

- Translocating/breeding in captivity black-footed ferrets to establish new populations in suitable habitat.
- Restoring mussel assemblages to historically occupied stream stretches

How Do We Measure Effectiveness?

Establishing good effectiveness measures for conservation actions requires being clear about the linkages among conservation actions, changes in threats those actions are designed to address, and the status of the relevant species and habitats. Laying out this "theory of change" isolates and limits the key factors that need to be monitored in order to assess whether our conservation actions are leading to the intended outcomes or changes.

Progress to Date



115 species restoration grants to 28 states were made from 2008-2010. The majority of those led to species breeding at restoration sites.

Effectiveness of Funded Species Restoration Efforts

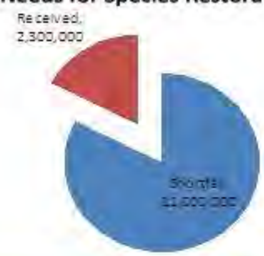
1. 90% of efforts have "good" plans that meet key criteria
2. 70% have stakeholder support to move the efforts forward
3. 81% have identified or propagated sufficient species to meet restoration needs
4. 65% have released sufficient species for initial restoration
5. 47% show restored species are breeding successfully

For more info: www.swgdb.org/species-restoration/

Where Do We Go From Here?

While much has been accomplished with funding for species restoration, the support is currently not adequate to meet conservation goals established by states to protect Species of Greatest Conservation Need and their habitats. Consequently, species restoration efforts are falling short. Specifically, it is estimated that states require an additional $11 million dollars to meet their goals for species restoration activities.

Funding Needs for Species Restoration



Stories from the Field

Washington Department of Fish and Wildlife and partners, with SWG support, are helping conserve and restore western pond turtle populations - a state endangered species that has been impacted by habitat loss and non-native predators like large-mouth bass and bullfrogs which eat young turtles.

As part of their recovery strategy, managers implemented a "head start" program for captive bred and wild hatchlings. The young turtles are raised in captivity until they are too large to be eaten by bass and bullfrogs – at which point, the turtles are released into suitable habitats to augment existing or create new populations.

In 2007, Washington achieved goals for restoring at least four self-sustaining populations in the Columbia Gorge. Although efforts to restore this species to Puget Sound recovery areas continue, meeting the Columbia Gorge recovery goals means it is unlikely this species will be extirpated or require protection under the Federal Endangered Species Act

Photos by Kate and Frank Slavens

Questions to Explore

- How can states better engage stakeholders and explain practical benefits of species restoration to improve support?
- Under what conditions does it make sense to do species restoration versus other less labor and cost intensive, like outreach or economic incentives?

APPENDIX IV. CRITERIA FOR EVALUATING DATABASES

This Appendix contains a brief summary of the characteristics and criteria we developed for evaluating databases. State IT developers and their partners in federal and private organizations should design systems based on the following best practices:

- **Wherever possible, integrate use of information systems into existing business processes.** One challenge will be to fit data needs into a broader system that are beyond the control of individual agencies (e.g., integrating basic information about a grant application collected at grants.gov with more specific information needed for state wildlife agency purposes).
- **Focus on collecting data with known uses.** Instead of trying to collect all possible data, design systems to collect data that will be used by key audiences. It is often helpful to design the final reports that the system will produce before building the system.
- **Avoid double entry of data.** Whenever possible, it is better to link to existing data sets than to have users enter the data manually. For example, rather than try to collect new information about the distribution of key species, link to the existing NatureServe databases and Natural Heritage Program databases that already contain this information.
- **Develop systems looking forward, not backward.** It is often more effective to design systems to collect future data, without worrying about the backlog of existing information.
- **Ensure long-term access to both data and information systems.** Data from projects and actions funded with public dollars need to be placed in data systems that guarantee appropriate access, with safeguards for legitimately sensitive information.

As an aid to states in using common data structures and terms, the Working Group identified the following characteristics and criteria to guide the selection of tools best suited for measuring effectiveness.

CHARAC-TERISTIC	DEFINITION	CRITERIA			
		Poor	Fair	Good	Ideal
KEY DATA FIELDS					
Units of Analysis	Basic units for records within the database, e.g., actions, projects, sites or targets				
Systems Supported	Types of planning systems supported by the database, e.g. Open Standards, Logic Models				
What is the model of the unit of analysis	Description for each system				
Basic Information	Basic project summary info and meta data	None	Some fields	All fields	Many more
Context Information	Targets, viability, threats, contributing factors	None	Some fields	All fields	Many more
Action Information	Description of actions being taken with target, threats, and actions	None	Some fields	All fields	Many more
Workplan Tools	Levels of effort going into the action; ability to assign tasks to different people; ability to assess work load	None	Some fields	All fields	Many more

CHARAC-TERISTIC	DEFINITION	CRITERIA			
		Poor	**Fair**	**Good**	**Ideal**
Budgeting Tools	Ability to track funds needed	None	Some fields	All fields	Many more
Actual Financials	Actual funds spent	None	Some fields	All fields	Many more
Action/Project Status	Fields for tracking the current status of the action or project	None	Some fields	All fields	Many more
SPATIAL DATA					
Spatial Data	Degree to which the system allows spatial data analyses	None or basic project coordinates	Allows map-based search for projects	Allows import/export and basic GIS capabilities (e.g., points and polygons on a base map)	Full GIS capabilities
Base Maps	Types of spatial base maps that the system supports, e.g., ESRI, Google	None	Only custom	One standard	All standard
Graphical Diagrams	Support for results chains and similar graphical data, e.g., Miradi, Visio	None	Static images (JPG, PNG, etc.)	Full Files	Editable in place
Reports	Support for standard and custom reports	None	Limited standard reports from templates	Full standard reports and limited custom	Full suite of standard -AND- Custom
Customizability	Ability to add custom fields and terms	None	Custom programming work	User experts	All users
DATA MNGMT					
Ease of Use	Degree to which system is easy to use	Extensive training required	Some training required	Easy for most users	Easy for all users
Granularity of Data Privacy Flags	Level at which data can be tagged as private	None	Entire record	Certain types of fields within a record	All fields
Levels of Privacy	Different settings for data privacy	No control	Little control	Some control	Full control
Public Input of Data	Degree to which public can add data	None	Selected public can apply to enter data	Most can enter data	Anyone can enter data
Project Data QA/QC	Degree of editorial control over data	None – project team enters data	Some – Data entered through external site	Basic – Editor gives review (flagging)	Editor gives full review plus peer reviewed
Data Importing	Capacity to import data in a variety of formats, e.g., sql, mpz, xls, shp	No formats	Some formats	Most formats	All formats
Data Export	Capacity to export data in various formats, e.g., sql, mpz, shp	No formats	Some formats	Most formats	All formats
BUSINESS MODEL					
License Type	License type and requirement, e.g., none, commercial, open source				
Hosting Model	Hosted, on individual server				
License Cost	Cost per user or organization over time (all in)	Very expensive	Expensive	Moderate	Free
Funding source	Sources of funding for the database, e.g., user fees	None	Limited	Short-term secure	Long-term secure
Current status	Current status of the system development	Planned	Pilot	Deployed 1-3 years	Deployed > 3 years
Number of users	How many organizations, or projects are using the database	None	Some	Few	Many

Database Systems that Use Projects as the Main Unit of Analysis
(Tools are listed in alphabetical order)

- **ConPro** (conpro.tnc.org) – ConPro is an online database originally developed by the Nature Conservancy (TNC) to track its conservation projects. The basic unit of analysis is the project. Project records are based on TNC's Conservation Action Planning (CAP) methodology, which is closely related to the Open Standards for the Practice of Conservation. Project records contain summary information about the project, as well as specific details about facets of the project including scope, targets, target viability, threats, contributing factors, goals and objectives, strategies, monitoring plan, work plan and budget, and progress reports. Users can attach maps, results chain diagrams, and other information to project records. ConPro has a powerful search tool that enables users to find projects based on any combination of the above facets. Projects are also geo-referenced and can be found using a map interface. Users can seamlessly upload and download data between ConPro and Miradi Software. ConPro is now working with the Conservation Measures Partnership and Miradi to open up the system to non-TNC users under a business model currently in development. This will include the ability to create custom portals for organizations as well as the ability to set granular data access controls. There are currently over 1000 projects in ConPro from around the world, several hundred of which are currently available to the public.

- **Conservation Registry** (www.conservationregistry.org) – The Registry is an online application designed to promote sharing of information and knowledge about conservation actions. As such, the Registry aims for broad access and ease of use. There are no limitations on who can use the Registry. The tool uses Google Maps to map the locations of projects. The mapped projects are accompanied by text that describes each project, the actions associated with the project, and the status of the actions (e.g., "in progress"). Project descriptions can be supplemented with hot links and reference materials. All projects must have at least one conservation target using common ecological classifications at both national and state scales. Species targets are supported, but not required. Threat/stressor data are not yet included, but this is a desired future component. Organizations can use the standard portal, or set up a customized portal that contains the basic Registry data fields but is otherwise designed to meet their specific needs. Custom portals also enable users to set access restrictions on the data. The tool can import/export spatial data in ESRI formats as well as KML. The system is maintained by Defenders of Wildlife (www.defenders.org) with funds from a variety of sources, including Oregon Department of Fish and Wildlife SWG funds and NFWF. Although the tool is free now, the business plan calls for a yearly maintenance fee to ensure long-term viability. The Registry was developed using all open source technology, written in Ruby. The back-end database is postgre SQL/postgis, with Rex Space cloud hosting.

- **HabITS** – HabITS is a centrally-hosted, geo-spatial database for the USFWS Partners for Fish and Wildlife and Coastal Programs to track agreements, projects and sites. Actions, conservation targets, and monitoring design are defined, prioritized and tracked spatially within the system. Base maps include ESRI files and Bing. The conservation targets are all USFWS trust species that are expected to benefit from the actions, which are defined as habitat treatments in the field. HabITS also includes work plan and budgeting tools that track staff days and financial contributions (both USFWS funds and partner match). Reporting is highly flexible, including standard and user-defined formats, as well as charts (pie, bar, etc.). At this time, access to the system is limited to the Partners for Fish and Wildlife Program with a high level of privacy protection, but some level of public access is being considered for the future. HabITS is easy to use. There are approximately 700 users within the USFWS, all of whom received training aimed mostly at quality control. The business model is based on organizational support from USFWS, leveraged across ECOS programs.

- **Miradi** (www.miradi.org) – Miradi is a project management, desktop software application designed to help program managers organize and track project activity based on the Conservation Measures Partnership's Open Standards for the Practice of Conservation. It is not a database in the strict sense, but rather is a data aggregation tool that can then feed into other databases. It includes several views of a project including summary information, diagrams (conceptual models and results chains), and planning/work plan tools (for example, all of the results chains diagrams in this report were produced using Miradi). Users typically develop strategies for conservation, specific actions within the strategies and indicators of project effectiveness. Strategies are explicitly structured to lead toward improvement in the viability of conservation targets, and the system can track supplementary information about the targets and their viability status. Threats/stressors are classified and prioritized using open standards. Among all the software evaluated, Miradi has the most highly developed set of tools for developing and tracking indicators of project performance. It does not include spatial GIS data, but that is a planned enhancement for the future. Nor does it include any data security tools/restrictions, beyond the fact that it resides on a desktop. Built-in wizards help guide users through the software's planning and reporting modules. Miradi produces XML output that can be imported into other databases. For example, Miradi currently produces an XML output that can be directly imported into TNC's ConPro system. Miradi is a non-profit joint venture between the Conservation Measures Partnership (conservationmeasures.org) and Benetech (www.benetech.org). Miradi runs on Windows, Mac, and Linux Operating Systems. Miradi is released under an Open Source License. Although the source code is freely available, Miradi's business model involves having user fees support the ongoing development and improvement of the software. Compiled versions of the software are available for a small annual fee. Organizational licenses that allow unlimited ability to use the software and custom data fields and training are also available.

- **Wildlife TRACS** (Tracking and Reporting Actions for Conservation of Species) (www.fws.ekosystem.us) – Wildlife TRACS is a new, online database under development by the USFWS and being piloted by Washington Department of Fish and Wildlife. A prototype is planned for release at the 2010 AFWA Annual Meeting. Completion of a version deployable to the states is expected in 2011. Wildlife TRACS is the only data management tool that is explicitly being designed to facilitate WSFR/FWS tracking and reporting on federal assistance grants, including SWG, with the ultimate purpose of strategically directing SWG funds to meet SWAP priorities. The design team includes representatives from state fish and wildlife agencies, AFWA, and many of the organizations that maintain the other data management tools listed here (Conservation Registry, HabITS, Miradi, Biotics) to create a forum for planning future interoperability among these systems. Because the design of Wildlife TRACS is occurring in concert with the AFWA Effectiveness Measures Working Group, it will incorporate most or all of the key recommendations of this report over time, including capability to manage data about projects, actions, conservation targets (in the context of projects), threats/stressors, monitoring design, and project context. The tool will have both a public access interface, as well as a more controlled, security enabled interface for the States and WSFR. Only the States and WSFR will be able to enter or edit data. States and WSFR will have control over the types of data displayed on the public website. The business model is based on organizational support by the USFWS, including implementation assistance to the states. The USFWS will hold all rights to the software in perpetuity.

Other Important Systems

- **Biotics 4** (www.natureserve.org/prodServices/biotics.jsp) – Biotics 4 is a desktop application designed to integrate into the workflow of state natural resource agencies for tracking the location and status of species and ecosystems. The fundamental data unit is the conservation target, which can be either a species or ecological element. The targets are mapped in GIS following published standards for Element Occurrences (www.natureserve.org/prodServices/eodata.jsp) and are accompanied by extensive text information in an Oracle database. Users can add their own, custom data tables to the standard core without restriction. Data security tools are highly refined to support the variety of state-specific data privacy rules, and most states restrict access to the primary data set. To provide data access, NatureServe and the states publish Biotics data through websites such as NatureServe Explorer (www.natureserve.org/explorer) or the Montana Online Field Guide (fieldguide.mt.gov). Biotics 4 incorporates open standards for a variety of data types, including species taxonomy, ecological classification, threats/stressors, conservation status, population viability and ecological integrity, spatial data formats, and metadata. Data about actions are captured in unstructured text fields. Project descriptions, budget and work plan details are not part of the data model. System enhancements under development include improved handling of field observation data, as well as a significant redesign to a hosted web application with a streamlined user experience. Biotics's contribution to measuring SWG/SWAP effectiveness is its ability to track changes in the status of a conservation target over time based on scientifically sound, nationally consistent, peer reviewed methods that allow status and trends to be compared among places and among conservation targets, and support rollup for multi-state reporting and analysis. Biotics 4 installations are licensed from NatureServe (www.natureserve.org) for an annual maintenance fee. The system is currently deployed in 46 US states and Puerto Rico, six Canadian provinces, three countries in Latin America, and a handful of other institutions (e.g., Navajo Nation and

Parks Canada). The remaining states all use fully compatible and interoperable systems. Biotics 4 is relatively complex, and requires user training that emphasizes data QA/QC. Most states employ a full-time or part time Biotics data manager. Licensed users receive full support services including online help, regularly-scheduled webinar training, customer service/phone support during business hours, system maintenance upgrades, and have the opportunity to participate in system design teams.

- **DataBasin** (http://databasin.org) – This is an online tool for sharing and visualizing spatial data, currently in beta version. DataBasin's larger objective is to create a vibrant, online community of conservation practitioners who self-organize into interest groups that share and improve spatial data, thereby reducing the time and effort it takes to find and access relevant data sets. The general public can browse the available datasets and preview maps, but users must register (for free) to access interactive maps, upload or download spatial data. Attributes of the data sets are not standardized, so DataBasin requires users to provide metadata with uploaded data sets to ensure proper use. The current version of the tool was built by the Conservation Biology Institute in partnership with ESRI, and is powered by ArcServer and ArcGIS Online. Thus registering with DataBasin also registers users with an ESRI global account, which includes 2 GB of free, personal data storage space for uploaded data. Although DataBasin is not currently set up to deliver data via web services, it should be a valuable source of quality spatial data that states can integrate into their SWAP analyses.
- **NatureServe Explorer Web Service** (http://services.natureserve.org/index.jsp) – This tool provides free and open access to virtually all of the data maintained in the Biotics 4 data system, except for sensitive spatial data. This web service provides direct access to data on the status, distribution, range, taxonomy (including synonyms), habitat preferences, threats and management needs of over 53,000 species of the United States in easy to manipulate XML format for incorporation into state-based data systems or other tools such as Wildlife TRACS. This information and the full national vegetation classification are also freely searchable by the public on the NatureServe Explorer website (www.natureserve.org/explorer) with search results downloadable in PDF or XML formats.

APPENDIX V. WORKING GROUP CHARTER

Purpose
The Working Group will develop, test, and roll-out a performance reporting framework for assessing the effectiveness of State Wildlife Grants and the broader Wildlife Action Plans.

Working Group Members
AFWA Staff: Mark Humpert, Terra Rentz
Contractor-Foundations of Success: Nick Salafsky, Caroline Stem
Working Group Members:

Faith Balch, *Minnesota Department of Natural Resources*
Dana Baxley, *Kentucky Dept. of Fish & Wildlife Resources*
Tara Bergeson, *Wisconsin Dept of Natural Resources*
Chris Burkett, *Virginia Dept of Game & Inland Fisheries*
Wendy Connally, *Texas Parks and Wildlife Dept*
Jenny Dickson, *Connecticut Dept. of Environmental Protection*
Mike Harris, *Georgia DNR, Wildlife Division*
Eric Rickerson, *Oregon Dept of Fish & Wildlife*
Tracey Tomajer, *New York Dept of Environmental Conservation*
Ron Essig, *US Fish & Wildlife Service*
Karl Hess, *US Fish & Wildlife Service*
Connie Young-Dubovsky, *US Fish & Wildlife Service*
Matthew Birnbaum, *National Fish & Wildlife Foundation*
Amielle DeWan, *Defenders of Wildlife*
Shelley Green, *The Nature Conservancy*
Mary Klein, *NatureServe*
Tess Present, *National Audubon Society*
Priya Nanjappa, *Association of Fish & Wildlife Agencies*

Working Group Advisors:

Jon Kart, Vermont
Jon Ambrose, Georgia
Dee Blanton, USFWS
Cindi Jacobson/Mary Rabe, Alaska
Dennis Figg, Missouri
Mike Hickey, OMB**
Kelly Rezac, Florida
Jeff Lerner, Doris Duke Charitable Foundation**
** ex officio

Working Group/Advisor Roles

Working Group members will collaboratively develop effectiveness measures and an implementation plan for roll out of an effectiveness measures framework. Working Group members will attend monthly conference calls, attend 2-3 multiday working group meetings, assist with work products and contribute knowledge and expertise. Advisors will serve as first-line reviewers, contribute their knowledge and expertise, and potentially serve on subcommittees. Advisors may be invited, but not required, to attend conference calls or a workshop.

Relationship of Working Group to AFWA
The Effectiveness Measures Working Group under the Teaming With Wildlife Committee (approval by Directors)

Background
State Wildlife Action Plans were completed by all states and territories in 2005. In the plans, states were required by Congress to include a proposed monitoring plan for at-risk species and their habitats and for monitoring the effectiveness of proposed conservation actions and for adapting these conservation actions to respond appropriately to new information or changing conditions (Required Element 5). Arguably, implementation of the monitoring plan has been one of the greatest challenges that states have faced. In addition, reporting of performance measures for federal programs has taken on greater significance during the last four years. There is a need to demonstrate that federal investments in Wildlife Action Plans through the State and Tribal Wildlife Grants are having a measureable impact. This project will build on and use the processes developed in the northeast as part of the Regional Monitoring and Performance Reporting Framework project. The ultimate goal of the project is to develop an agreed upon effectiveness measures framework that is national in scope and can be used to report progress and successes of Wildlife Action Plans and the State and Tribal Wildlife Grants Program.

Workgroup Charges

1. Develop an initial iteration of a monitoring framework that strategically prioritizes audiences, information needs, methods and potential indicators to measure the effectiveness of conservation interventions.
    a. Identify who the audiences are
    b. Clearly define what each audience needs to know and how each audience will use the information they get and how detailed an answer they will need
    c. Review current monitoring efforts and identify additional monitoring needs to feed the framework
2. Test this monitoring framework with a mixture of different kinds of projects
3. Agree on process and next steps for implementing this framework across all states
4. Identify pilot program states to initiate rollout of monitoring framework

Who Will Be Served

Member states of the Association of Fish and Wildlife Agencies, US Fish and Wildlife Service, Office of Management & Budget, Congress, Partners

Measures of Success

To be determined by Working Group

Products/Deliverables

Final Report & Implementation Plan

Duration

The Working Group was established at AFWA's Annual Meeting in Austin, TX in September 2009. It will remain active until AFWA's 2010 Annual Meeting unless extended by the establishing committee. An interim report will be presented at the 2010 North American Wildlife and Natural Resources Conference in Milwaukee, WI.

Anticipated Timeline

Timeframe	Task	Location	Milestone
September 2009	AFWA & FOS staff meet	DC	Initial Scoping – develop plan; identify working group needs; review background information
September 2009	TWW committee approval	Texas	Working group established by the Teaming With Wildlife Committee
Mid-October '09	Meet with FOS to complete charter/determine working group members	DC	First draft of Charter is completed; working group members identified and confirmed
November 19, '09	Conference call with working group members	N/A	Review/revise draft charter; draft agenda for first in-person meeting; reading assignments
December 8-10, 2009	First working group meeting	DC	Introductions, ID audiences, examine past work on indicators, begin developing indicators
Mid-Jan, Feb & Mar '10	Web/conference call	N/A	Report on work assignments
March	North American NRE Conference	Wisconsin	Interim progress report at TWW Committee mtg.
Mid-April '10	Web/conference call	N/A	Report on work assignments
Mid-May '10	Second working group meeting	N/A	Pilot measures developed
Mid-June '10	Web/conference call	N/A	Report on work assignments
Mid-July '10	Third Working group meeting	TBA	Measures and framework refined
Mid-August '10	Web/conference call	N/A	Develop final report; identify next steps
Mid-Sept '10	Presentation/Approval at AFWA Annual Meeting	Michigan	Present final product at AFWA Annual meeting
Oct-December '10	TBD		Implement rollout plan

Objectives from Policy Grant from Doris Duke Charitable Foundation.
Issue 4-Develop Indicators of Success. Development of State Wildlife Action Plans in each state and territory was a major milestone. However the success of this planning effort is dependent upon showing results to policy makers, partners, and the public. To date there are no national effectiveness indicators that can be used to show progress. The development of measures would enable AFWA, the states, and their partners to assess performance and communicate successes.

Background: Increasingly, federal and state governments are using performance and effectiveness measures to assess how well programs are working. The use of performance measures gained attention in the Clinton Administration which used balanced measures as part of its National Partnership for Reinventing Government. The Bush Administration has been using the Program and Reporting Tool (PART) for its performance-based budgeting process. President-elect Obama has stated his intent to make government more accountable and efficient so it's likely that the use of performance measures to assess government programs will continue. The Northeast Association of Fish and Wildlife Agencies contracted with Foundations for Success to develop performance measures for State Wildlife Grants, the only regional association to do so. We propose to work with Foundations of Success to develop national effectiveness measures for State Wildlife Action Plan implementation using a similar process that was used in the northeast.

Goal: Develop key national effectiveness measures to help assess and communicate the performance of State Wildlife Action Plans.

Proposed Action: Assemble a national workgroup to develop measures and communicate State Wildlife Action Plan effectiveness.

Strategy 1. Hire a contractor (i.e., Foundations of Success) to assemble a workgroup and facilitate a process to develop and test national effectiveness measures for State Wildlife Action Plans.

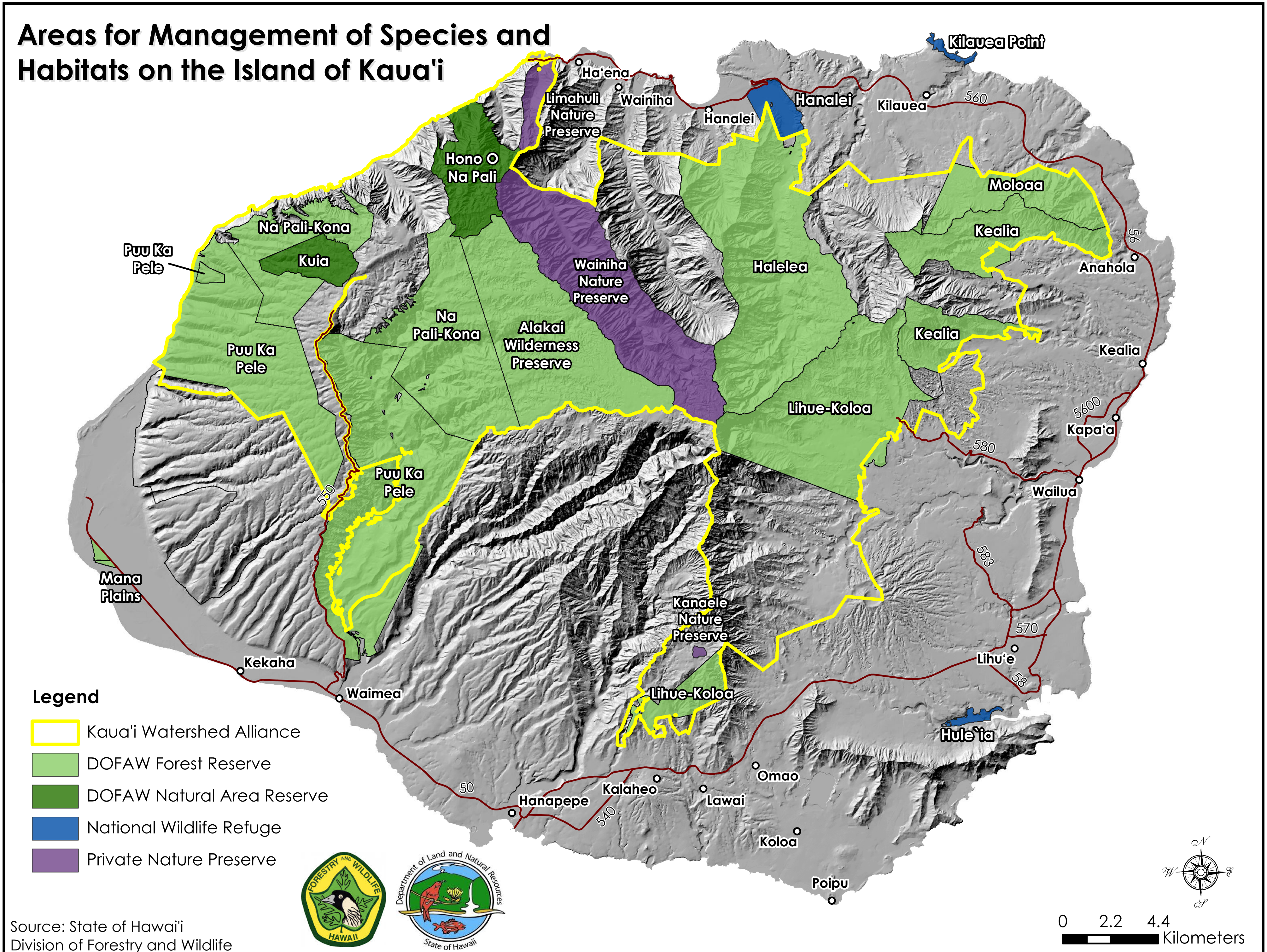
Strategy 2. Develop and implement a communication strategy for implementing national effectiveness measures.

Strategy 3. Provide training to interested states on how to use and report State Wildlife Action Plan performance.

Strategy 4. Begin rollout and implementation of effectiveness measures in interested states.

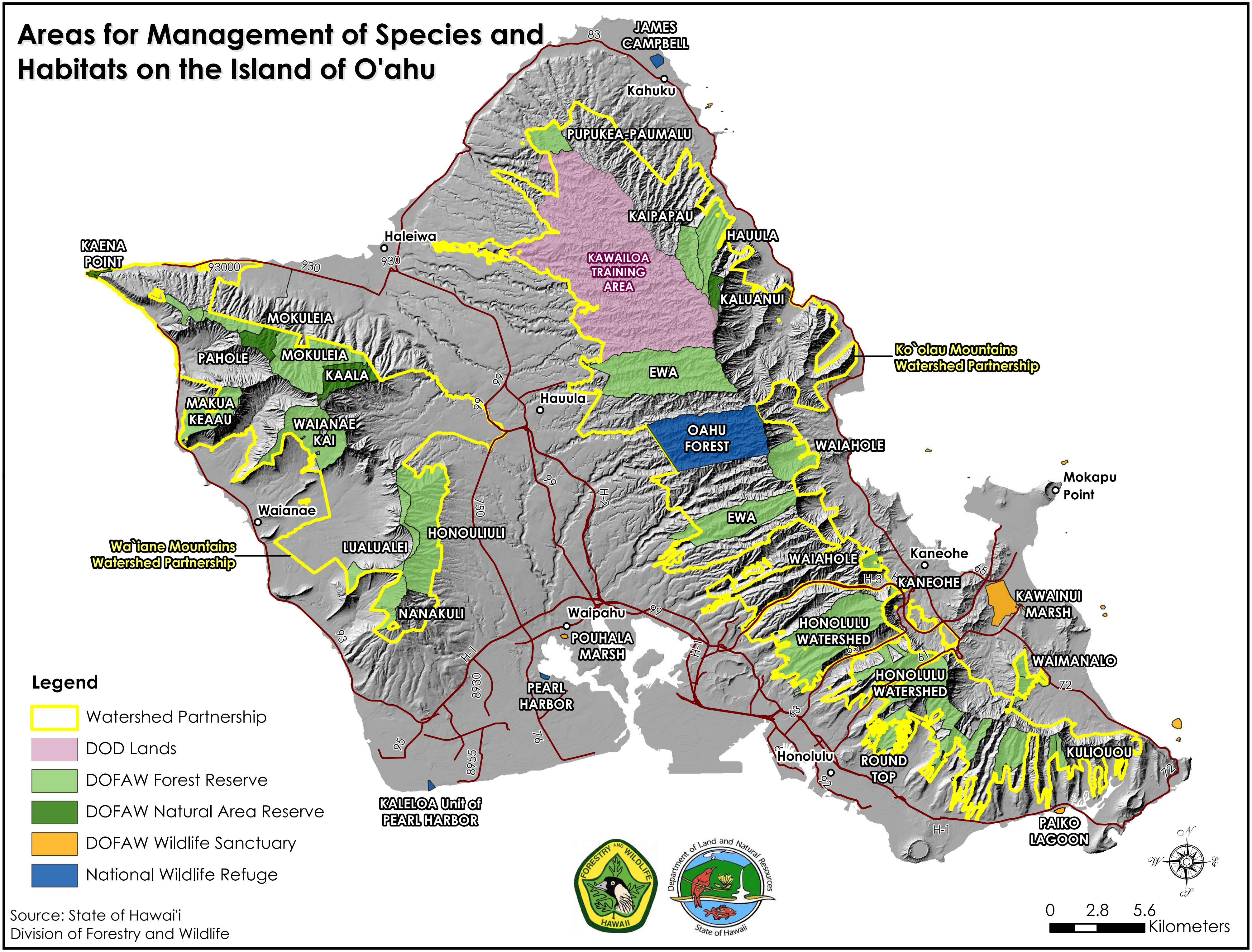
Association of Fish & Wildlife Agencies
444 North Capitol Street, NW
Suite 725
Washington, DC 20001
202/ 624-7890
www.fishwildlife.org / www.teaming.com

Areas for Management of Species and Habitats on the Island of Kaua'i



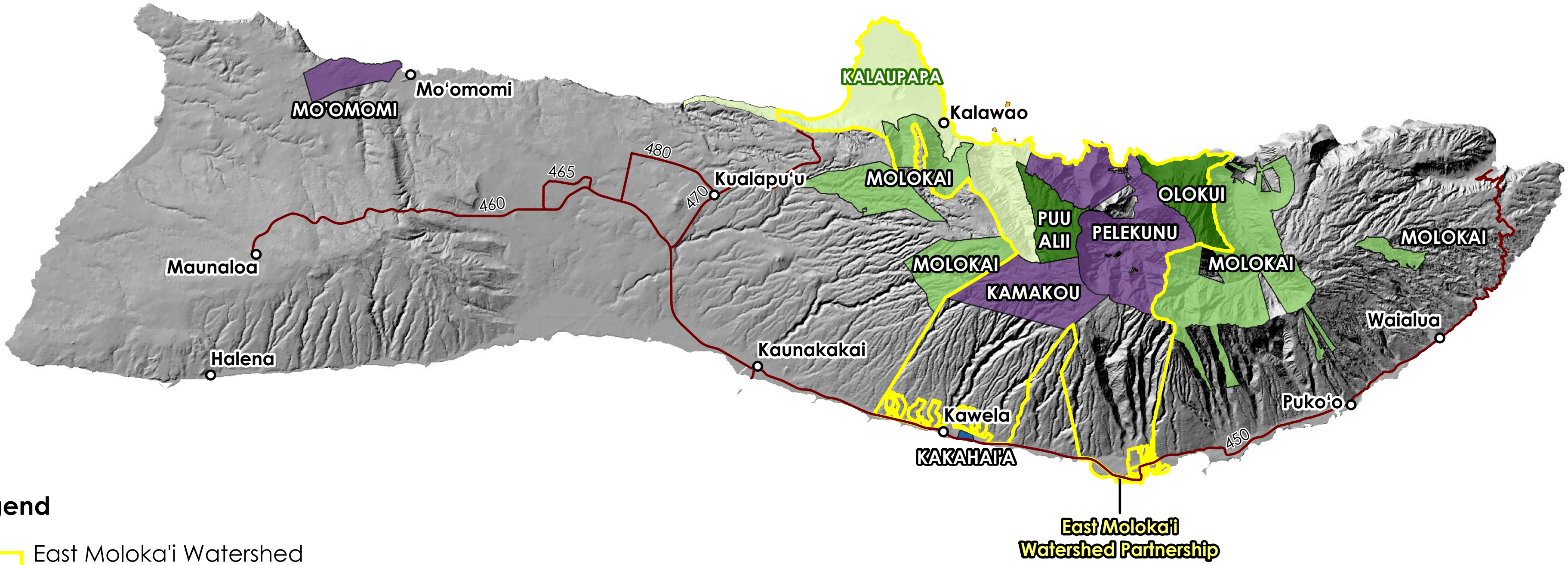
Source: State of Hawai'i
Division of Forestry and Wildlife

Areas for Management of Species and Habitats on the Island of O'ahu



Source: State of Hawai'i
Division of Forestry and Wildlife

Areas for Management of Species and Habitats on the Island of Moloka'i

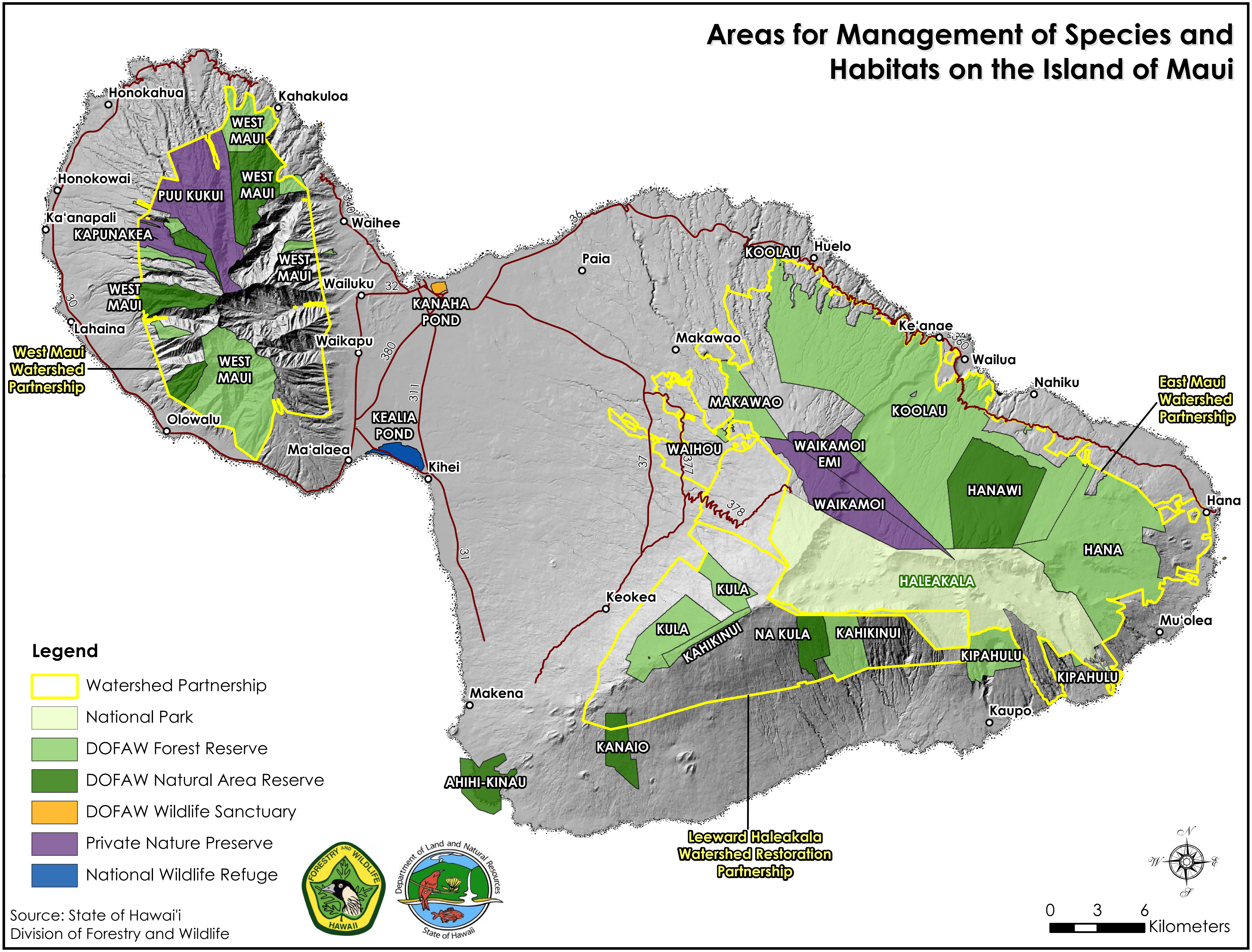


Legend

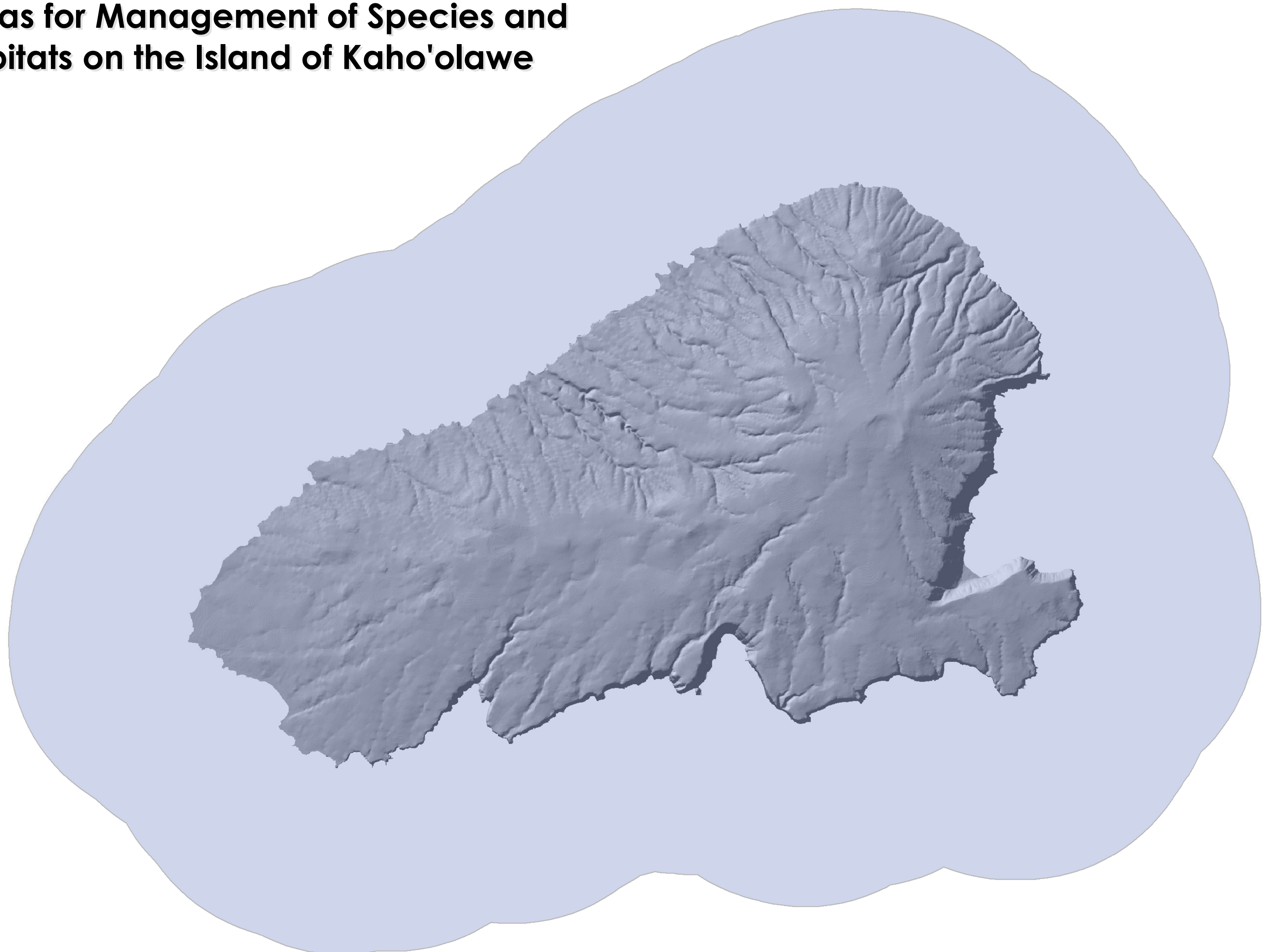
- East Moloka'i Watershed Partnership
- National Park
- DOFAW Forest Reserve
- DOFAW Natural Area Reserve
- DOFAW Wildlife Sanctuary
- Private Nature Preserve
- National Wildlife Refuge

Source: State of Hawai'i
Division of Forestry and Wildlife

0 2.6 5.2 Kilometers


Areas for Management of Species and Habitats on the Island of Maui
Honokahua
Kahakuloa
WEST MAUI
WEST MAUI
PUU KUKUI
Honokowai
Ka'anapali
KAPUNAKEA
Waihee
WEST MAUI
WEST MAUI
Wailuku
Lahaina
West Maui Watershed Partnership
WEST MAUI
Waikapu
KANAHA POND
Olowalu
Ma'alaea
KEALIA POND
Kihei
Paia
KOOLAU
Huelo
Makawao
MAKAWAO
Ke'anae
Wailua
Nahiku
KOOLAU
East Maui Watershed Partnership
WAIHOU
WAIKAMOI EMI
WAIKAMOI
HANAWI
Hana
HANA
HALEAKALA
KULA
Keokea
KULA
KAHIKINUI
NA KULA
KAHIKINUI
KIPAHULU
KIPAHULU
Mu'olea
Kaupo
Makena
KANAIO
AHIHI-KINAU
Leeward Haleakala Watershed Restoration Partnership
30
32
36
37
31
311
340
360
377
378
380
Legend
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
FORESTRY AND WILDLIFE
HAWAII
Department of Land and Natural Resources
State of Hawaii
0 3 6
Kilometers
N
E
S
W

Areas for Management of Species and Habitats on the Island of Kaho'olawe



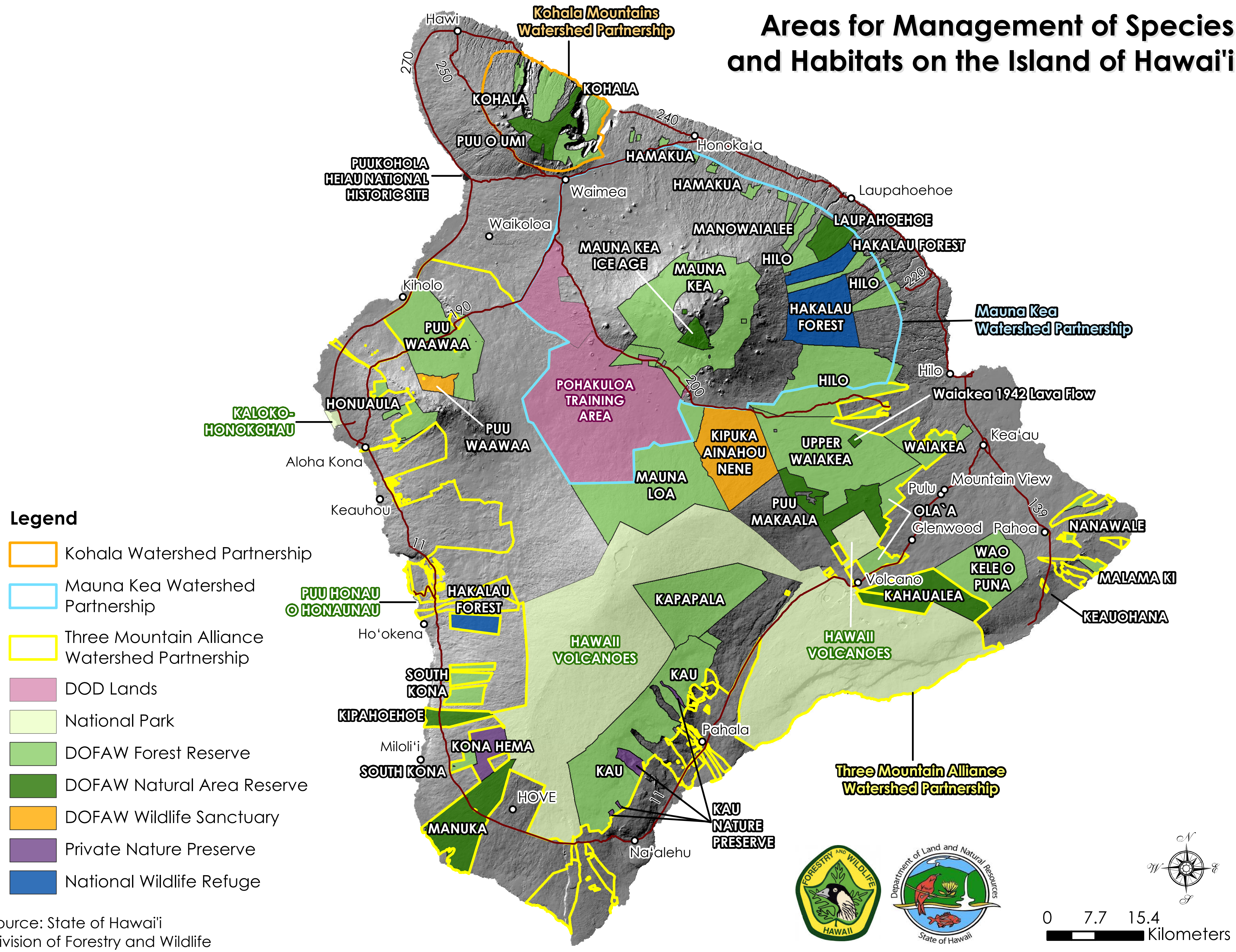
Legend

Kaho`olawe Island Reserve

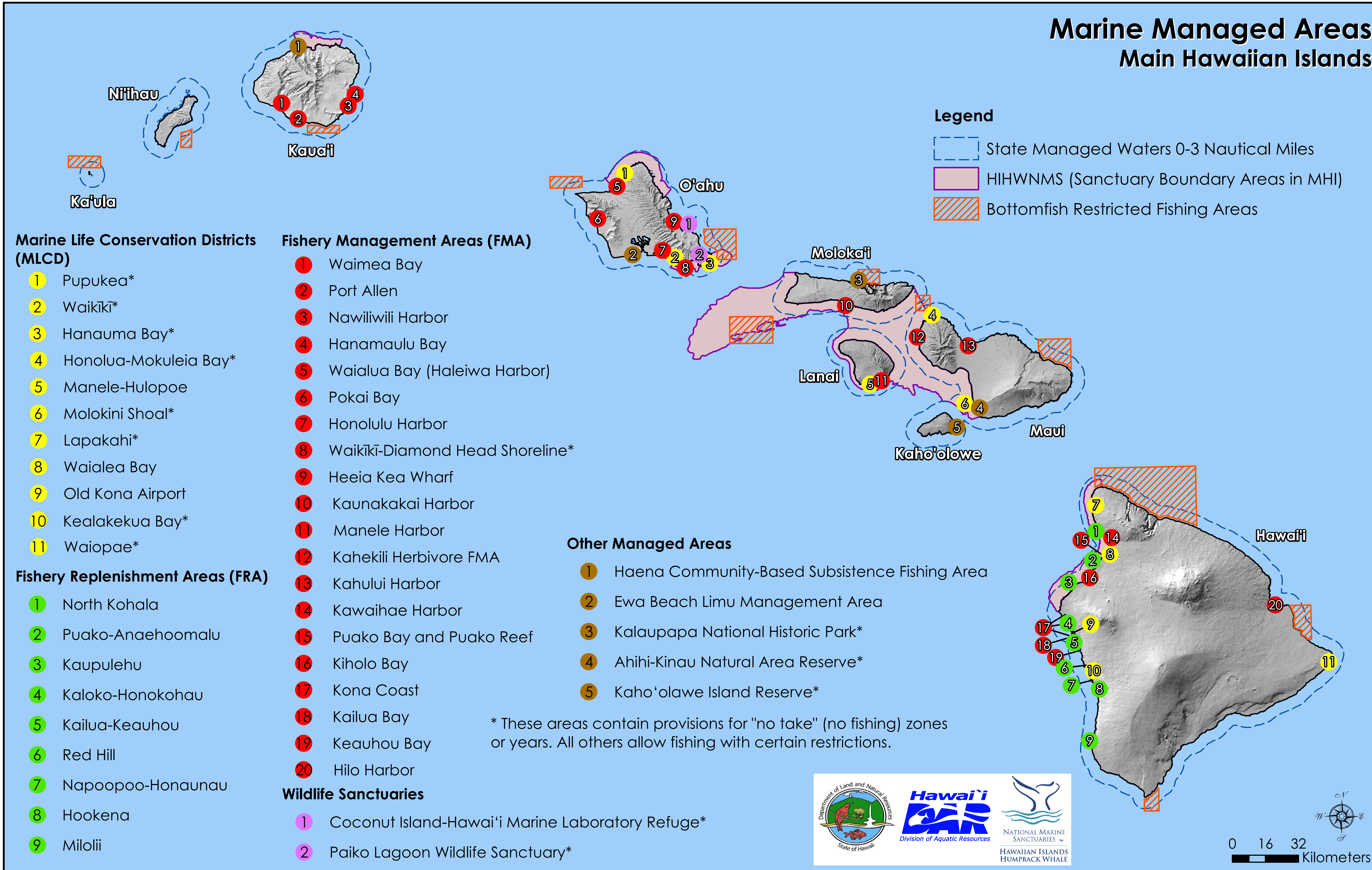
Source: State of Hawai'i
Division of Forestry and Wildlife

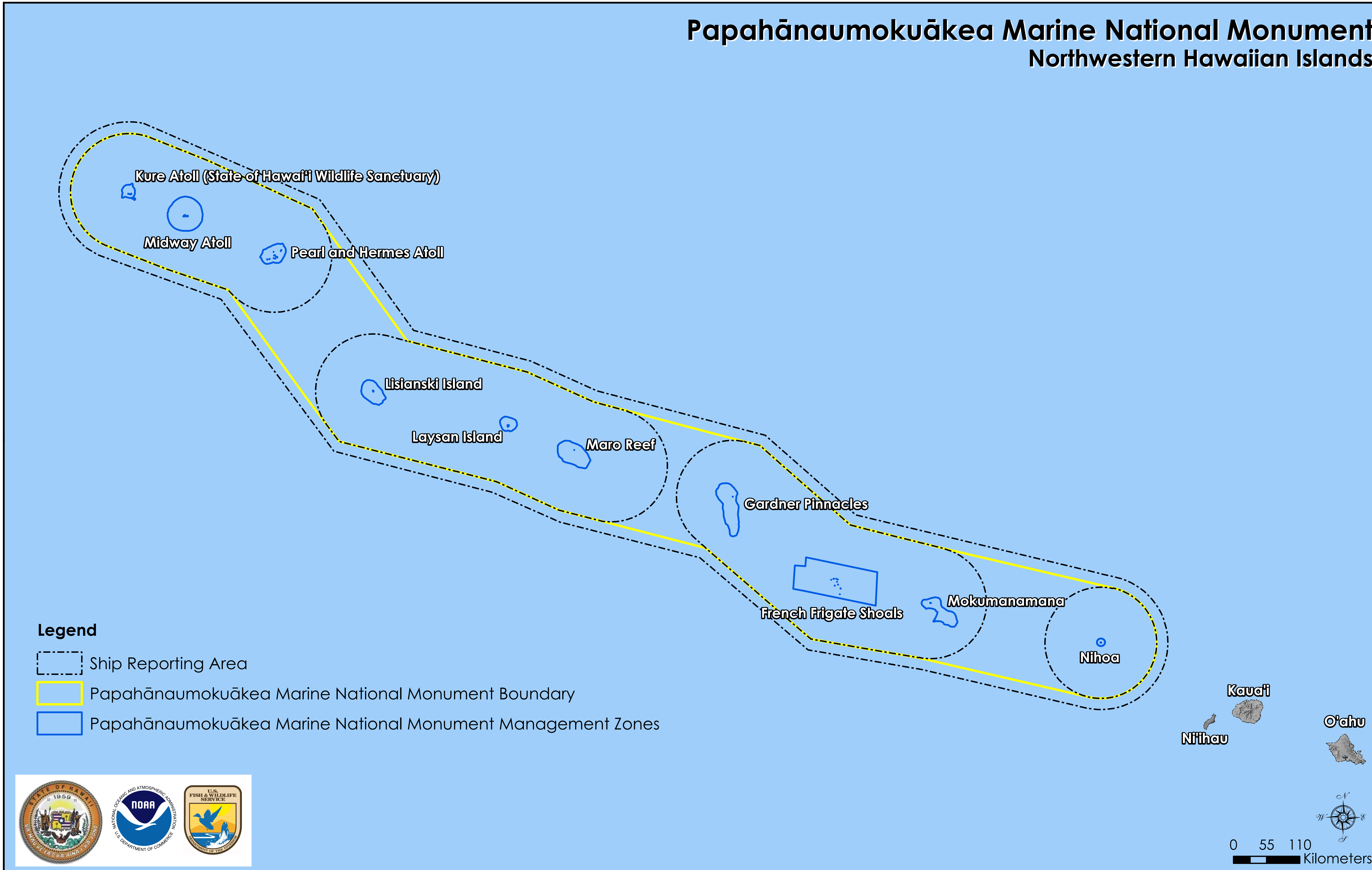
0 1.1 2.2 Kilometers

Areas for Management of Species and Habitats on the Island of Hawai'i



Source: State of Hawai'i
Division of Forestry and Wildlife


Marine Managed Areas
Main Hawaiian Islands
Legend
State Managed Waters 0-3 Nautical Miles
HIHWNMS (Sanctuary Boundary Areas in MHI)
Bottomfish Restricted Fishing Areas
Ni'ihau
Kaua'i
Ka'ula
O'ahu
Moloka'i
Lanai
Maui
Kaho'olawe
Hawai'i
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
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