CHAPTER 3: STATE OF HAWAIʻI OVERVIEW

Due to its extreme isolation and climactic conditions, Hawaiʻi is characterized by high levels of endemism in both its native animals and plants, with over 10,000 species found nowhere else on earth. Unique and varied habitats are also found across the islands. As a result, Hawaiʻi presents both an opportunity and challenge for conservation. While the threats to Hawaii's native species persist, recent years have seen greater awareness of the need to take action to conserve biodiversity, more assertive political will to take steps to address the problems, and wider community involvement in projects. These changes have resulted in positive steps towards the recovery for Hawaii's endangered species and towards the protection for those species that remain common so that they do not become endangered. Success stories include bringing the nēnē (*Branta sandvicensis* [Hawaiian goose]) from the edge of extinction, increasing populations of honu (*Chelonia mydas agassizi* [green sea turtle]), protection of important habitats such as that of Hanawī on Maui, and community-led restoration efforts of Waimānalo streams encouraging the return of the endangered aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]). However, despite these success stories, Hawaiʻi continues to face major conservation challenges in protecting its over 10,000 native wildlife species. Chapter 3 provides both a social and biological overview, assessing the current status of natural resources in the State. This chapter, in combination with Chapter 4, addresses elements 1-4 at the statewide level.

SOCIAL OVERVIEW

HUMAN LANDSCAPE

The population of the State of Hawaiʻi was estimated at 1,262,840 people in 2004, with the majority (70%) found on Oʻahu, in the City and County of Honolulu (899,593). The nearly seven million visitors in 2004 contributed an additional average of 170,000 people per day, mostly on Oʻahu and Maui.

Hawaiʻi has four local governments: the City and County of Honolulu (island of Oʻahu and the Northwestern Hawaiian Islands), the County of Kauaʻi (islands of Kauaʻi and Niʻihau), the County of Maui (islands of Maui, Molokaʻi, Lānaʻi and Kahoʻolawe), and the County of Hawaiʻi (island of Hawaiʻi). Hawaiʻi also has a fifth county, Kalawao County, which does not have a separate government unit. Kalawao County covers the former Hansen's disease settlement at Kalaupapa (Molokaʻi) and is managed by the National Park Service (NPS) under a cooperative agreement with the State Department of Health.

Tourism is the primary economic activity in the State, with more than 6.9 million visitors and $10.3 billion in expenditures in 2004 alone. Agriculture, primarily pineapple cultivation and diversified agriculture, and military expenditures are important secondary economic drivers.

LAND AND WATER USE

Nearly half of Hawaii's 1.66 million hectares (4.1 million acres) are managed by the State or Federal government. The largest landowner, the State of Hawaiʻi, manages over 467,000 hectares (1,155,900 acres) for watershed protection, preservation of natural resources, agricultural use, recreation, transportation, and public safety. The State Department of Hawaiian Home Lands manages an additional 82,000 hectares (202,658 acres) in trust for the present and

future use by Native Hawaiians. The Federal government (NPS, U.S. Fish and Wildlife Service (USFWS), and Department of Defense) owns or manages, through leases or cooperative agreements, more than 270,000 hectares (671,579 acres) for a variety of purposes, including conservation of natural and cultural features, protection of wildlife habitat, military support and training, and public safety. There are no lands managed by the U.S. Forest Service or the Bureau of Land Management in Hawai‘i.

The remaining land is in private ownership. Much of this land is controlled by a few owners; seven private landowners own approximately 20 percent of the land in the State (Kamehameha Schools, Parker Ranch, Castle & Cooke, Inc., Alexander and Baldwin, Inc., James Campbell Estate, C. Brewer and Company, Ltd., and Dole Food Company, Inc.). Some of these lands are managed in cooperation with adjacent landowners for conservation purposes as part of a watershed partnership. Modeled after the first watershed partnership that began in East Maui in 1991, there are now nine watershed partnerships on six islands, involving more than 50 public and private partners and covering over 344,000 hectares (850,000 acres) of forested watershed. These voluntary partnerships are the primary vehicle for conservation on private lands in Hawai‘i (as opposed to conservation easements, acquisition, or other methods).

Over the last decade, major land use trends include the transition from agriculture (e.g., sugar cane, pineapple cultivation) to resort-residential development and large-lot residential subdivisions on agricultural lots. Example areas include Mānele Bay (Lāna‘i), west Maui, central O‘ahu, and the Hāmākua Coast (island of Hawai‘i). The dissolutions of the Campbell Estate and the Damon Estate private trusts are expected to result in additional land use changes. Increased military activity associated with the location of a U.S. Army Stryker Brigade and the possible stationing of an aircraft carrier group is anticipated to result in additional land use changes in the Urban District for housing and infrastructure and in the Conservation District for construction related to training.

Unlike many other states, Hawai‘i has statewide land use classifications, with all land being zoned in one of four categories: Conservation, Agricultural, Urban, and Rural. About 48 percent of the State (798,702 hectares or 1,973,636 acres) is in the State Conservation District, a designation where development and commercial activity is generally limited with varying levels of restrictions based on the applicable subzone. While the State Department of Land Natural Resources (DLNR) manages land in the Conservation District, the counties have primary responsibility for land in the other three districts. Those Districts are subject to county land-use and development controls, including county community plans, zoning, and building code regulations which affect farm, residential, commercial, and industrial development and use. In addition, in Special Management Areas located along the shoreline, each county has an additional layer of regulation that provides special control of development, even for land already subject to Conservation District restrictions.

Hawai‘i withdraws about two billion gallons per day of water, with just over 500 million gallons coming from groundwater sources, and the rest from surface water diversions and withdrawals. Water consumption is about 550 million gallons per day (mgd).

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

A significant portion of the State (31%) has been designated for long-term resource protection and receives varying degrees of management: 260,267 hectares (643,134 acres) are in State Forest Reserves (DLNR), 147,710 hectares (365,000 acres) are within National Parks (NPS), 44,177 hectares (109,164 acres) are in State Natural Area Reserves (DLNR), 38,400 hectares (94,900 acres) are in State Wildlife Sanctuaries (DLNR), and 265,897 hectares (657,048 acres) of emergent and submerged land are in National Wildlife Refuges (USFWS). The Hawaiian Islands Humpback Whale National Marine Sanctuary (NOAA and DLNR) protects an additional 364,200 hectares (900,000 acres) of marine waters, while the Northwestern Hawaiian Islands (NWHI) Coral Reef Ecosystem Reserve protects submerged lands and waters in the NWHI.

CULTURAL SIGNIFICANCE OF NATIVE WILDLIFE

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

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

Native wildlife also play an important role in Native Hawaiian culture as many species such as the pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), ʻio (*Buteo solitarius* [Hawaiian hawk]), ʻelepaio (*Chasiempis sandwichensis*), ʻalalā (*Corvus hawaiiensis* [Hawaiian crow]), sea turtles, and sharks are believed to be ʻ*aumakua* (ancestors or guardians) of certain Hawaiian families. Hawaiian names have been given to many of the native wildlife and they have been incorporated into *oli* (chants) and *moʻolelo* (legends). Today, Native Hawaiian teachings play an increasing role in natural resource management, especially in areas of cultural significance like Kahoʻolawe or Wao Kele o Puna (island of Hawaiʻi). The CWCS recognizes that the State and its agencies are obligated to protect the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible, in accordance with *Public Access Shoreline Hawaii versus Hawaii County Planning Commission* and subsequent case law.

PUBLIC SUPPORT FOR CONSERVATION

Public Perspectives on Wildlife

Based on a 2004 "Wildlife Values in the West" survey, 71 percent of Hawaii's residents strongly agree that it is important to prevent the extinction of endangered species, 79 percent agree that in order to do this it is acceptable to eliminate introduced game animals from some areas, and 94 percent find it acceptable to close some areas to human use to protect wildlife (Teel & Dyer, 2005). In 2001, an estimated 20 percent of the population participated in some type of wildlife-associated recreation (e.g., fishing, hunting, wildlife watching), with expenditures for terrestrial wildlife watching activities in Hawaiʻi estimated at $132 million dollars. However, this is only a fraction of expenditures related to ocean wildlife viewing. A large proportion of the $10 billion dollar tourism sector is indirectly related to the viewing of marine wildlife, with one study estimating that snorkeling and diving alone generate $364 million dollars each year in added value for the State.

Funding for Conservation

Hawaiʻi ranks near the bottom (48th) in the nation for state spending on fisheries and wildlife, though the State forest reserve system ranks 11th in size and the State boasts the largest area of marine protected areas in the United States. In Fiscal Year 2006, the State Department of Land and Natural Resources was allocated approximately $76.8 million of the State's $8.9 billion dollar executive budget. With less than one percent (0.86%) of the State's budget, the Department must manage the State's marine and freshwater resources (e.g., commercial fisheries, aquaculture, aquatic resources protection, recreational fisheries), protect threatened and endangered species, manage State-owned lands (both those for lease and those set aside as forest reserves, natural areas, plant and wildlife sanctuaries, and parks), manage statewide ocean recreation and coastal areas programs (i.e., boating), oversee permitting associated with the Conservation District, implement the State's historic preservation mandates, maintain the statewide recording system for title to real property, and enforce the Department's rules and regulations.

A conservative estimate of the amount of State funds actually dedicated solely to conservation of native wildlife and their habitats is approximately $23 million dollars for Fiscal Year 2006. Though no comprehensive cost estimates exist for the protection and recovery of wildlife in Hawaiʻi, the inadequacy of current funding levels is obvious based on costs included in recovery

plans for endangered species. For example, the recently published Draft Revised Recovery Plan for Hawaiian Forest Birds (2003) estimates the cost of recovering 21 species of forest birds at nearly $2.5 billion dollars over the next 30 years – an annual cost ($83 million) that exceeds the budget for the entire DLNR. Costs associated with the recovery for endangered whales, sea turtles, seabirds, waterbirds, and plants would add tens of millions more per year.

Funding levels from Federal sources are also inadequate and inequitably apportioned. With more than 30 percent of the nation's imperiled species, Hawai'i receives less than 15 percent of the national appropriation under the Endangered Species Act, Traditional Section 6 Program and only one percent of the national appropriation under the State Wildlife Grants Program. In recent years, through related competitive grant programs within the Section 6 program, additional funding for conservation on private lands and for land acquisition has become available. Though Hawai'i has been successful in securing a portion of these grants because of extensive and progressive partnerships with landowners, lack of sufficient overall funding to implement recovery programs, especially on State lands, leaves both critically endangered species and lesser known native species (e.g., terrestrial invertebrates) with little support.

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

BIOGEOGRAPHICAL OVERVIEW

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

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

HABITATS

The Hawaiian Archipelago possesses the full range of habitats, from wet forests to extremely dry coastal grasslands. Due to evolution and extreme isolation, these native habitats were

characterized by high levels of plant endemism. With the arrival of humans and consequent introduction of invasive plants and animals and development, many of these habitats have declined. For example, 90 percent of Hawaii's dryland habitat, 61 percent of the mesic habitat, and 42 percent of the wetland habitat are estimated to be lost, with less than 40 percent of the land surface covered in native vegetation today. Similarly, much of the habitat for freshwater species has declined, with 58 percent of the perennial streams in the State having been altered in some way. The following section provides specific information on terrestrial, freshwater, and marine habitats, including associated wildlife and major threats.

Terrestrial Habitats

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

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

Alpine communities

Alpine communities are found only on the islands of Hawai'i (Mauna Kea and Mauna Loa) and Maui (Haleakalā). Conditions are dry, vegetation is sparse, and the soil is predominantly cinder or barren gravel. Native species include terrestrial invertebrates, including the wekiu bug (*Nysius wekiuicola*), a candidate for Federal listing as endangered, spiders, and a few plants, most notably the 'āhinahina or silversword (*Argyroxiphium sandwicense*). There has been relatively little invasion by alien plants, but introduced alien insects, including the Argentine ant (*Linepithema humile*), are a growing problem.

Subalpine communities

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

found on Mauna Loa, Hawai‘i. Dominant plants include māmane (*Sophora chrysophylla*), naio (*Myoporum sandwicense*), and ‘ōhi‘a (*Metrosideros polymorpha*) trees, ‘ōhelo (*Vaccinium* spp.) and pūkiawe (*Styphelia tameiameiae*) shrubs, and *Deschampsia nubigena* grass. Notable native species present include the palila (*Loxioides bailleui*), other endemic forest birds, ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]), ‘akē‘akē (*Oceanodroma castro* [band-rumped storm petrel]), nēnē (Hawaiian goose), and terrestrial invertebrates. Introduced ungulates, including mouflon sheep (*Ovis musimon*), pigs (*Sus scrofa*), goats (*Capra hircus*), sheep (*Ovis aries*), and cattle (*Bos taurus*), are the primary threat to these communities, browsing the native vegetation and spreading invasive plant species.

Montane wet communities

Montane wet communities occur on the islands of Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i. A diverse variety of montane wet communities exist, including bogs, densely vegetated shrublands and forests, cliff faces, and steep valley walls. These communities typically exhibit a richer understory development than montane dry or mesic systems. Important native plants include the ferns hāpu‘u (*Cibotium* spp.) and ‘ama‘u (*Sadleria* spp.), sedges (*Carex* spp.), *Oreobolus furcatus* (found in many bogs), and the ‘ōhi‘a tree. Notable native wildlife species include critically endangered forest birds such as the puaiohi (*Myadestes palmeri*) and po‘ouli (*Melamprosops phaeosoma*), Hawaii’s only land mammal, the ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), ‘io (*Buteo solitarius* [Hawaiian hawk]), and terrestrial invertebrates including *Megalagrion* spp. damselflies. Montane bog communities are particularly vulnerable to rooting pigs, and feral pigs contribute to the spread of habitat-modifying invasive plants such as strawberry guava (*Psidium cattleianum*) and kāhili ginger (*Hedychium gardnerianum*) in montane wet forest. Logging and then conversion to pastureland has also resulted in the loss of montane wet forest.

Montane mesic communities

Montane mesic communities occur on the islands of Kaua‘i, Maui and Hawai‘i. ‘Ōhi‘a, koa, olopua (*Nestegis sandwicensis*), and a‘e (*Sapindus saponaria*) are dominant trees, and the understory is composed of diverse trees, shrubs, sedges, and ferns. Notable native species include forest birds, ‘ōpe‘ape‘a, pueo, ‘io, and terrestrial invertebrates. Conversion to pastureland, the spread of introduced grasses, browsing by feral goats, sheep, and pigs, fires, and clearing for commercial tree planting have contributed to the loss and degradation of this habitat.

Montane dry communities

Montane dry communities are found on the leeward slopes of East Maui and of Hualālai, Mauna Loa, and Mauna Kea on Hawai‘i. Substrates are typically cinder or ash or weathered lava flows. Dominant plants include ‘ōhi‘a, ‘a‘ali‘i (*Dodonaea viscosa*), lovegrass (*Eragrostis atropioides*) and pili grass (*Panicum tenuifolium*). Notable native wildlife include terrestrial invertebrates, pueo, the ‘ōpe‘ape‘a (Hawaiian hoary bat), and forest birds. The primary threats to these communities are invasive plants, particularly

fountain grass (*Pennisetum setaceum*), and grazing by feral ungulates, including goats, sheep, and mouflon.

Lowland wet communities

Lowland wet communities are generally found on the windward side of every island except Niʻihau and Kahoʻolawe. Dominant plants include ʻōhiʻa and koa trees, mamaki (*Pipturus albidus*) and uluhe (*Dicranopteris linearis*) shrubs, and hāpuʻu ferns are an important component of the native understory. Notable native wildlife includes terrestrial invertebrates, waterbirds, migratory shorebirds and waterfowl, pueo, ʻio, and the ʻōpeʻapeʻa. Threats include the establishment and spread of invasive plants, especially kāhili ginger and strawberry guava and degradation of the understory by feral pigs.

Lowland mesic communities

Lowland mesic communities are found on every island except Kahoʻolawe. Most lowland mesic communities have been converted to agricultural or ranching use or lost due to logging, and the remaining native communities are threatened by a number of invasive plant species, including guava (*Psidium guajava*), strawberry guava, molasses grass (*Melinis minutiflora*), firetree (*Morella faya*), Christmas berry (*Schinus terebinthifolius*), silk oak (*Grevillea robusta*), *Eucalyptus* spp., and beardgrasses (*Andropogon virginicus* and *Schizachyrium condensatum*). Wildfires, feral ungulates and introduced game animals, particularly goats, pigs, and axis deer, also contribute to the degradation of these communities. In the remaining lowland mesic communities, dominant plants include kāwelu (*Eragrostis variabilis*), pūkiawe, ʻaʻaliʻi, and ʻūlei (*Osteomeles anthyllidifolia*) shrubs, and koa, ʻōhiʻa, and lama (*Diospyros sandwicensis*) trees. Notable native wildlife species include waterbirds, migratory shorebirds and waterfowl, ʻōpeʻapeʻa, and terrestrial invertebrates.

Lowland dry communities

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

Coastal communities

Coastal systems are communities subject to marine influences and include dry, mesic and wet communities. In addition, this habitat includes anchialine ponds, which are areas where fresh and saltwater mix through underground connections. These communities are found on coral atolls and island remnants in the NWHI, along coastlines of the major islands in the MHI, and on the many offshore islands in the MHI. Naupaka kahakai (*Scaevola sericea*) is an important native shrub throughout the coastal system. Notable

native wildlife includes seabirds, terrestrial invertebrates, migratory shorebirds, and marine animals that use the coastal area for basking and nesting, such as the Hawaiian monk seal (*Monachus schauinslandi*) and honu (green sea turtle). Primary threats include conversion to residential development, introduction of invasive plants (e.g., mangrove (*Bruguiera gymnorrhiza* and *Rhizophora mangle*), pickleweed (*Batis maritime*), and ironwood (*Casuarina equisetifolia*)), off-road vehicle activity, and arson.

Subterranean systems

Some of Hawaii's most unique native invertebrates are associated with lava tube and cave ecosystems. These habitats can be found from higher elevations down to the coast throughout the MHI. Cave ecosystems are divided into five distinct zones (entrance, twilight, transition, dark, and stagnant air zones) with each characterized by different vegetation and animals. Primary threats include loss of native vegetation above caves (roots provide food sources for species), degradation of habitat by human visitation and trampling as well as by non-native species (particularly non-native invertebrates), and habitat loss through development.

Aquatic Habitats

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

Streams

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

Hawaiian streams, or sections of streams, are either perennial or intermittent. Perennial streams flow year round; however, some flow continuously, discharging into the ocean, while others are interrupted, discharging into the ocean only seasonally. Perennial streams are important to most of Hawaii's freshwater fauna, because these species depend on the ocean for part of their larval life stage and would not survive without this

connection to the sea. Perennial streams are habitat to all of Hawaii's freshwater fauna including five native stream fishes or ʻoʻopu, invertebrates including mollusks and shrimps, algae, and mosses. Intermittent streams, or sections of streams, flow only seasonally, typically with high rainfalls, when these streams may reach the ocean. These streams may have water in their upper sections year-round, while their lower sections are dry. Although some recent studies suggest that viable populations of stream animals can survive in intermittent streams, intermittent stream fauna primarily consists of oligochaete worms, several crustaceans, and algae.

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

Estuaries

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

Sandy Bottom

The amount of sediment moving into the open ocean largely determines the presence of various types of marine habitats in Hawaiʻi. Too much sediment limits the presence of

corals, so coral reefs can only occur away from estuaries. Instead of coral reefs, these areas close to estuaries are dominated by various sandy bottomed habitats that are rich in animals that live in the sand, like many worms or shelled animals, and in fishes like rays and flatfishes that feed in soft sediment.

Coral Reefs

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

Bathypelagic, Mesopelagic, and Pelagic

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

Additional Marine Habitats

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

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

NATIVE TAXA

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

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

Equally impressive radiations are seen in many other taxa. For example among the cosmopolitan family of drosophilid flies, there are nearly 500 described Hawaiian species, as well as hundreds of undescribed species, all of which evolved from perhaps two colonists. Many other explosive radiations are found among terrestrial arthropod groups: more than 400 species of *Hyposmocoma* moths, 180 species of *Sierola* wasps, and 177 species of *Proterhinus* beetles.

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

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

persisted in more remote areas only to be weakened or overcome by non-native predators such as cats (*Felis silvestris*), rats (*Rattus* spp.), and mongooses (*Herpestes auropunctatus*). Native forest birds were virtually eliminated from lowland areas by the night-biting mosquito following its introduction in 1826. The mosquito spread avian malaria and avian poxvirus, diseases for which the native birds had no natural resistance.

As a result of the widespread and rapid changes brought by humans, an estimated half of the native bird species have been lost to extinction. Numbers among other taxa are far higher, including 90 percent of the native land snails, and thousands more terrestrial insects and spiders that were forever lost long prior to being described. The known extinctions alone in Hawai‘i represent 75 percent of the recorded extinctions of plants and animals in the United States. Today, Hawai‘i has the highest number of threatened and endangered species in the United States, accounting for more than 30 percent of the federally listed taxa. The decline in native species is also mirrored by the loss of native habitat, with less than 40 percent of the land surface covered with native-dominated vegetation today.

Of this great diversity, the following species or taxa are covered in the Comprehensive Wildlife Conservation Strategy (CWCS) as Species of Greatest Conservation Need (SGCN): one terrestrial mammal, 77 birds, over 5,000 known terrestrial invertebrates, over 500 plants, six species of endemic terrestrial algae, 12 freshwater invertebrates, five freshwater fishes, 24 species of endemic freshwater algae, 20 anchialine-pond associated fauna, 26 marine mammals, six marine reptiles, 154 marine fishes, 197 marine invertebrates, and 79 species of endemic marine plants or algae. A brief discussion of each species group is presented below, with more specific information presented in Chapter 7 (Species of Greatest Conservation Need).

Terrestrial Mammal

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

Birds

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

Forest birds

The ancestors of the forest passerines encountered different resource opportunities and limitations on different islands (e.g., foods and forest types). Because the distances between islands are formidable barriers to most small birds, inter-island isolation also

contributed to speciation and led to several island endemic species. As a result, within each of the five families of passerines found in Hawai‘i, there are related but distinct subspecies or species represented on different islands. Unfortunately, only one of five historic species of the family Corvidae is extant, and all members of the family Melephigidae are likely extinct.

There are only about 30 extant species of native Hawaiian forest birds--less than half the number known from historic and fossil records--and one third of those remaining are extremely rare or possibly extinct. More than half are endangered. A number of factors have contributed to this decline. Conversion of land from native forests to agricultural and other human use began with the arrival of Polynesians and accelerated with European contact. Remaining forests have been degraded by ungulates and invasive plant species. The introduction of the avian malaria virus and avian pox have proven catastrophic to Hawaii's native bird species, especially the passerines. Rats, feral cats, and mongooses prey on bird nests, nestlings, and even on incubating adults. In addition, alien bird and arthropod species may compete with native forest birds for food or nest resources.

As a result of these changes, especially the introduction of mosquitoes, most remaining forest birds survive in montane mesic and wet native forests dominated by ‘ōhi‘a and koa or in subalpine forests dominated by māmane and co-dominated by māmane and naio where cooler temperatures limit mosquitoes. These include forests on Hawai‘i and Maui, as well as remnant forest patches at high elevations on Moloka‘i, Lāna‘i, O‘ahu and Kaua‘i. Thus, some species may be persisting in marginal habitats, further complicating their recovery. Critical conservation actions include protection of remaining native forest habitats from further degradation by ungulates and non-native plant species, control and eradication of introduced predators (primarily rodents and cats); captive propagation (‘alalā, puaiohi, ‘ākohekohe (*Palmeria dolei*), Maui parrotbill (*Pseudonestor xanthophrys*), Hawai‘i creeper (*Oreomystis mana*), Hawai‘i ‘ākepa (*Loxops coccineus coccineus*), ‘akiapōlā‘au (*Hemignathus munroi*), palila, ‘i‘iwi (*Vestiaria coccinea*), ‘amakihi (*Hemignathus virens*), and Hawai‘i ‘elepaio), and the prevention of the introduction of additional predators (e.g., snakes), disease (e.g., West Nile virus), or any other habitat-modifying plants or animals.

The Hawaiian Forest Bird Recovery Team, a cooperative effort involving multiple government agencies and non-profit organizations, guides forest bird conservation work, including the development of the Draft Revised Recovery Plan for Hawaiian Forest Birds (2003) and five-year implementation plans for identified critical species, captive propagation, annual forest bird surveys, as well as other identified research and management projects.

Raptors

The ‘io (Hawaiian hawk) and the pueo (Hawaiian short-eared owl) are the only extant native raptors in Hawai‘i. The ‘io (Hawaiian hawk) is listed as endangered by both the USFWS and State and is restricted to the island of Hawai‘i. The pueo occurs on all the MHI and is listed by the State as endangered on O‘ahu only. Both birds are found from sea level to high elevations across most habitats. Primary threats include predation by

introduced rodents and cats (particularly for the ground-nesting pueo) and habitat loss. Additional research on the distribution and abundance of these species as well as potential limiting factors (e.g., environmental contaminants and harassment by humans) is needed for both species.

Waterbirds

Six species of extant, endemic waterbirds occur in Hawai‘i: the Laysan duck (*Anas laysanensis*), nēnē (Hawaiian goose), koloa maoli (*Anas wyvilliana* [Hawaiian duck]), ‘alae ‘ula (*Gallinula chloropus sandvicensis* [Hawaiian moorhen]), ‘alae ke‘oke‘o (*Fulica alai* [Hawaiian coot]), and ae‘o (Hawaiian stilt). An additional indigenous species, ‘auku‘u (*Nycticorax nycticorax* [black-crowned night-heron]), is common throughout the MHI. All of the endemic species are listed as endangered by the USFWS and by the State. A Draft Revised Recovery Plan for the Laysan duck was published in 2004, a Revised Recovery Plan for the nēnē (Hawaiian goose) is currently in preparation, and a Draft Revised Recovery Plan covering the other four listed waterbird species was published in 1999. The ‘alae ke‘oke‘o (Hawaiian coot) and ae‘o (Hawaiian stilt) have been observed on every MHI except Kaho‘olawe, the distribution of the other three endemic waterbird species is more restricted within the MHI, and the Laysan duck is limited to Laysan island and Midway Atoll in the NWHI.

Three of the waterbird species (‘alae ‘ula (Hawaiian moorhen), ‘alae ke‘oke‘o (Hawaiian coot), and ae‘o (Hawaiian stilt)) inhabit wetland habitats including tidal flats and estuaries, playas and ephemeral basins, freshwater marshes, coastal ponds, taro patches, and human-constructed wetlands, such as irrigation ditches and sewage treatment ponds. The koloa maoli (Hawaiian duck) occurs in the above freshwater environments as well as montane streams and swamplands. Nēnē (Hawaiian goose) have been reintroduced to Kaua‘i, Maui, Hawai‘i, and Moloka‘i, where they can be found from sea level to 2,400 meters (7,900 feet) in elevation, predominantly in dry forest, shrubland, and grassland. The Laysan duck utilizes all available habitats with vegetation cover and fresh water, including upland vegetation, ephemeral wetlands, mudflats, and coastal areas. Historically found in the MHI as well as the NWHI, the Laysan duck was found only on Laysan island until last year when 20 birds were translocated to Midway Atoll.

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

Seabirds

Forty different seabird species have been observed in the Hawaiian Islands, and at least 20 are known to breed in Hawai‘i. Two seabirds are endemic to Hawai‘i: ‘ua‘u (*Pterodroma sandwichensis* [Hawaiian petrel]) and of the ‘a‘o (*Puffinus auricularis*

newelli [Newell's shearwater]). Many of these seabirds are of global or national importance: over 95 percent of the world's mōlī (*Phoebastria immutabilis* [Laysan albatross]) and ka'upu (*Phoebastria nigripes* [black-footed albatross]) populations nest in the Hawaiian Archipelago. Other seabirds of conservation concern include the 'akē'akē (band-rumped storm petrel), listed as endangered by the State, the short-tailed albatross (*Phoebastria albatrus*), listed as endangered by USFWS, and the Christmas shearwater (*Puffinus nativitatis*), the Tristram's storm petrel (*Oceanodroma tristrami*), and the blue-gray noddy (*Procelsterna cerulean*), identified as "high concern" in the U.S. Seabird Conservation Plan for the Pacific Region.

Historically, high densities of seabirds nested on all Hawaiian islands, but now most are restricted to the NWHI or to predator-free offshore islands within the MHI. A few birds, such as the 'ua'u (Hawaiian petrel) and 'a'o (Newell's shearwater), nest in high elevations or in inaccessible locations (e.g., sheer cliffs) in the MHI. Primary threats to seabirds while in Hawai'i include predation by feral cats, rodents, and mongooses, loss or degradation of habitat due to habitat-modifying invasive plants or animals, and human disturbance including coastal lighting. Threats at sea include fisheries bycatch and pollution (including oil spills). Needed conservation actions are protection of existing habitat, eradication of introduced predators (cats, rodents, and mongooses) from additional offshore islands and known breeding colonies, and additional surveys to locate additional breeding colonies and monitor population status and trends, particularly at sea.

Migratory shorebirds and waterfowl

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

Northwestern Hawaiian Islands passerines

Three species of passerines are found in the NWHI: the Laysan finch (*Telespiza cantans*), Nihoa finch (*Telespiza ultima*), and Nihoa millerbird (*Acrocephalus familiaris*). Found only on their respective named islands within the Hawaiian Islands National Wildlife Refuge in the NWHI, these three species are among the rarest birds in the world. Major threats include the introduction of habitat-modifying alien plants, the introduction of habitat-modifying or predaceous non-native animals, and environmental factors, including natural disaster, drought, and long-term climate change (e.g., sea level rise).

Priority conservation actions include maintaining the integrity of the islands' habitat by preventing and responding to non-native plant and animal introductions.

Terrestrial Invertebrates

Similar to native forest birds, Hawaii's native terrestrial invertebrates are characterized by high levels of endemism – over 90 percent of terrestrial invertebrates are found nowhere else on earth. Unique invertebrates include a carnivorous caterpillar, happy-face and no-eyed big-eyed spiders, and yellow-faced bees. Several invertebrates have been listed as endangered by the USFWS: O'ahu tree snails of the genus *Achatinella*, the Kaua'i cave wolf spider (*Adelocosa anops*), the Kaua'i cave amphipod (*Spelaeorchestia koloana*), and the Blackburn's sphinx moth (*Manduca blackburni*), with Recovery Plans prepared for all four taxa and critical habitat designated for the sphinx moth and the Kaua'i arthropods. Twelve species of *Drosophila* flies are currently proposed for listing as endangered, and two species of Lāna'i tree snails (*Partulina* spp.), six species of *Megalagrion* damselflies, two species of *Drosophila* flies, one gall fly (*Phaeogramma* sp.), and the wekiu bug are candidates for listing by the USFWS. Many more native invertebrates are believed to be rare.

Native invertebrates play many critical roles in the ecosystem such as food for native birds and as pollinators for native plants. They can also be found in almost every habitat known throughout the Hawaiian Archipelago, including aeolian alpine summits, lava tube and lava cave systems, and strand and littoral habitats.

The main threats facing terrestrial invertebrates are loss and degradation of habitats, predation and competition by introduced species, and the loss of native host plants. The endemic koa tree is of particular importance as habitat for a wide range of native invertebrates, and extensive logging or the introduction of a pest or disease that attacks koa would have a significant impact on native invertebrate diversity. Further, funding to document new species or determine accurate populations or distributions of known species is insufficient; there are over 5,000 native terrestrial species currently known with new species discovered every year. Conservation actions needed for terrestrial invertebrates include improved information (e.g., species biology, population assessments, habitat needs and interactions), protection and restoration of native habitats, increased quarantine and inspection as well as assessment of pest-control and biocontrol measures to prevent further injurious alien introductions, establishment of long-term monitoring programs, and better education and outreach programs. In addition, research to gain a better understanding of the causes behind the decline in native ground-dwelling arthropods such as jumping bristletails, bees, and wasps is needed.

Plants and algae

Over 1,000 distinct flowering plant species evolved from approximately 295 successful flowering plant colonist species. In addition, Hawai'i supports over 150 recognized taxa of native ferns and fern allies. Total species richness is concentrated on older islands, primarily in mesic and wet habitats and at relatively low elevation (700 to 800 meters; 2,100 to 2,400 feet), as a function of evolutionary and ecological processes acting within the constraints of geologic history. Richness of endangered plant species is highest in mesic and dry habitats of the Wai'anae mountains of O'ahu, with somewhat high concentrations in the mesic habitats of western Kaua'i and the wet habitats of the Ko'olau mountains on O'ahu. Plant species that are

naturally rare (those projected to have had a restricted range prior to human impact) are concentrated in the mesic habitats of the Waiʻanae mountains (Oʻahu), the Alakaʻi swamp region (Kauaʻi), and other wet summit regions (e.g., Koʻolau mountains, Oʻahu). Plant species that have suffered the greatest percentage of habitat loss are concentrated in very low elevation mesic habitats on Kauaʻi mesic to dry habitats in the Waiʻanae mountains (Oʻahu), very low elevation mesic habitats in the Koʻolau mountains (Oʻahu), and low elevation dry to mesic habitats on Molokaʻi, Maui and Lānaʻi. Critical habitat has been designated on every island in the MHI and on Nihoa, Necker, and Laysan in the NWHI for over 100 listed plants.

Feral ungulates, such as cattle, pigs, goats, deer (*Odocoileus hemionus* and *Axis axis*), and mouflon sheep, pose a major threat to native plants by consuming and trampling native understory plants, creating conditions favoring non-native plant infestation and establishment, preventing the establishment of ground-rooting native plants, and disrupting soil nutrient cycling. Introduced invertebrates and disease weaken and kill native plants and compete with native pollinators, and invasive habitat-modifying plants outcompete native plants within the habitat. Conservation actions needed include protection of existing native habitats from feral animals, invasive plant control and eradication, monitoring of populations, and additional research on methods to address the role of invertebrates and disease. Extremely rare plants require additional *ex situ* (off site) conservation actions (e.g., seed banking, *in vitro* propagation, and cryopreservation).

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

Little is known about Hawaii's endemic algae and its role in the ecosystem, beyond the importance of marine algae as a food source for marine fishes, invertebrates, and green sea turtles. Over 100 species of endemic terrestrial, freshwater, and marine endemic algae have been identified.

Freshwater Species

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

Anchialine-pond Fauna

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

Marine Species

Marine ecosystems in Hawai‘i support over 1,200 species of fishes, with around 500 species adapted to live on coral reefs, and the rest adapted to the open ocean waters, deep habitats, estuaries, or areas characterized by sandy bottoms. These fishes occupy a range of niches from herbivores to carnivores that specialize on microscopic plankton, seashells, crabs, shrimp, or other fishes. At the top of the food chain are the apex predators such as the many sharks of Hawai‘i. Over 5,000 marine invertebrates are known from Hawai‘i, including over 100 species of hard, soft and precious corals, as well as hundreds of types of seashells, crabs, and shrimps and small numbers of worms, jellyfish, sponges, starfish, and tunicates. Many commercially or recreationally fished species are protected by Fishery Management Plans developed under the U.S. Magnuson-Stevens Fishery Conservation and Management Act. Stony corals, black corals, seahorses, and some sharks are protected by the Convention on International Trade in Endangered Species (CITES) Appendix II.

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

About 26 species of marine mammals are resident or occasional visitors to Hawai‘i. All are protected by the Marine Mammal Protection Act. These include the popular spinner (*Stenella longirostris*) and bottlenose dolphins (*Tursiops truncatus*), resident year-round, and the

migratory humpback whales (*Megaptera novaeangliae*) which spend a few months each year in Hawaiian waters to birth and breed. Humpback whales and the Hawaiian monk seal (*Monachus schauinslandi*) are the more commonly occurring marine mammals in Hawai'i that are listed as endangered under Federal and State law. Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawaii's coasts.

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