HAWAI‘I’S STATE WILDLIFE ACTION PLAN

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HAWAI‘I’S STATE WILDLIFE ACTION PLAN

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November 1, 2016

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

HAWAIʻI'S STATE WILDLIFE ACTION PLAN

Prepared for

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

This document is an update to the 2005 Hawai'i Comprehensive Wildlife Conservation Strategy

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FOREWORD

Aloha! I am pleased to present the 2015 edition of Hawai‘i’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 Hawai‘i. 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 Hawai‘i’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. Hawai‘i’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 Hawai‘i’s unique and rare species continue to exist for future generations.

Suzanne Case
Chairperson
Department of Land and Natural Resources

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LIST OF ACRONYMS

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

EXECUTIVE SUMMARY

BACKGROUND

Hawai‘i’s 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 Hawai‘i 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 Hawai‘i’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 Hawai‘i 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 Hawai‘i’s SWAP, including the ten-year revision.

HAWAI‘I’S STATE WILDLIFE ACTION PLAN

Hawai‘i’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 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.*

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 Kauaʻi ʻakikiki (*Oreomystis bairdi*) and ʻakekeʻe (*Loxops caeruleirostris*), and Oʻahu 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 Kauaʻi 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 Oʻahu 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, Kauaʻi 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 Hawaiʻi'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 Hawaiʻi.

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 Hawai'i's wide range of native wildlife and the diverse habitats that support them.*

PURPOSE OF HAWAII'S STATE WILDLIFE ACTION PLAN

The purpose of 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 Hawai'i's unique native wildlife. The original plan, Hawai'i's 2005 *Comprehensive Wildlife Conservation Strategy* (CWCS), was comprehensive in scope and went beyond the legislative mandate to fully recognize the interconnectedness of Hawai'i's diverse flora and fauna to create an integrated, strategic blueprint for the protection and recovery of Hawai'i's biodiversity. 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 Hawai'i's unique species remain challenging. This SWAP will guide the next steps for improving the biological, cultural, and economic well-being of the islands and their people.

LEGISLATIVE MANDATE AND GUIDANCE

Historically, wildlife funding at the national level has been targeted towards species that were hunted or fished for sport and towards species federally listed as threatened or endangered. Declining populations of non-game, non-endangered species throughout the nation and the lack of stable funding to address the needs of these species led to the creation of the Wildlife Conservation and Restoration Program (WCRP) for fiscal year 2001 and the State Wildlife Grants (SWG) program (2002 to present) by the United States Congress. The authorizing legislation for the SWG program is the Department of the Interior and Related Agencies Appropriation Act, 2002 (PL 107-63). For Fiscal Year 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 Hawai'i Department of Land and Natural Resources (DLNR) holds the constitutional and statutory authority to protect wildlife resources and administers the use of these funds. Hawai'i's share of that funding has varied between $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. Hawai'i'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;
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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 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 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 Kaho‘olawe; Limahuli and Lumaha‘i valleys on Kaua‘i; Mo‘omomi, Moloka‘i; and Keauhou, Hawai‘i where traditional management practices such as *kapu* (taboo) and *ahupua‘a* (watershed)-scale thinking predominate.

Native wildlife is also important to all of Hawai‘i's residents. Based on a 2004 "Wildlife Values in the West" survey, a large majority of Hawai‘i'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. Hawai‘i's native wildlife and their habitats also provide hundreds of millions of dollars in important goods and services to residents. A recent University of Hawai‘i 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 Ko‘olau Mountains of O‘ahu 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 ‘ōhi‘a wilt (*Ceratocystis fimbriata*), a newly arrived fungal disease, threatens to decimate ‘ōhi‘a 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.

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CHAPTER 2: APPROACH AND METHODS

APPROACH

The State of Hawai‘i developed the first edition of its state wildlife action plan in 2005; at that time, it was called *Hawai‘i’s Comprehensive Wildlife Conservation Strategy* (CWCS). 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 Hawai‘i 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 Hawai‘i and the importance of protecting all native terrestrial animals, all endemic aquatic wildlife, other aquatic species threatened with decline, and a broad range of native flora is recognized and retained as the foundation of the plan. Identifying and protecting the best remaining native habitats and intact native 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 Hawai‘i 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, Hawai‘i’s SWAP.

The Hawai‘i Department of Land and Natural Resources (DLNR) leads the development and renewal of Hawai‘i’s SWAP, with joint cooperation by the Division of Forestry and Wildlife (DOFAW) and the Division of Aquatic Resources (DAR), the divisions primarily charged with protecting the state’s terrestrial and aquatic resources. For the 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 Hawai‘i 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 Hawai‘i traditionally have involved strong collaborative efforts. Hawai‘i’s 2005 CWCS was developed on a foundation of input from and collaboration with conservation partnerships, paired with the incorporation of management activities and strategies already established by existing species recovery plans, location-specific management plans, and other available related plans and documents. That approach was continued in the development of the 2015 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 Hawai‘i (TNC), the Hawai‘i Invasive Species Council (HISC), Hawai‘i Watershed Partnerships, the University of Hawai‘i, the Hawai‘i 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 Hawai‘i’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 Hawai‘i. The 2005 CWCS recognized the global rarity of these species or the importance of Hawai‘i to these species, and developed a broad list of Hawai‘i’s SGCN. The 2005 list included species meeting the following criteria: 1) all terrestrial indigenous animals as identified by the Hawai‘i list of indigenous species (Hawai‘i Administrative Rules Title 13 Chapter 124); 2) all aquatic endemic animals; 3) any animal taxa on the federal threatened, endangered, candidate, or species of concern list; 4) any animal protected by the U.S. Marine Mammal Protection Act; 5) any native animal on the International Union for the Conservation of Nature and Natural Resources' (IUCN) Threatened Red List or the Convention on International Trade in Endangered Species (CITES) appendices; and 6) additional animals suggested by technical experts in natural resource management agencies and informal advisory groups as deserving of attention for other reasons. Migratory species with irregular or insignificant presence in the state were not included on the list; neither were introduced species, which by their nature do not represent the natural biodiversity of Hawai‘i. Native plant species were included in SGCN list if they met the following criteria: 1) plant species federally listed as threatened, endangered, or as a candidate for listing; 2) plant species identified 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 Hawai‘i* or if there was evidence that the plant was known to be a host for native wildlife, a food source for native wildlife, or habitat for native wildlife.

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

Together, the Fauna Species of Greatest Conservation Need and the Flora Species of Greatest Conservation Need compose Hawai‘i’s SGCN. The focus of the SWAP is on habitats essential to these species, threats to these important habitats, 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."

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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 Hawaiʻi's native species persist, there has been greater awareness of the need to take action to conserve biodiversity, more assertive political will to take steps to address the problems, and wider community involvement in projects. These sentiments were evident in 2005, when the first edition of this plan was produced, and have grown even stronger today. The collective conservation efforts over the years have resulted in positive steps towards the recovery for Hawaiʻi's endangered species and towards the protection for those species that remain common so that they do not become endangered. Success stories include bringing the nēnē (*Branta sandvicensis* [Hawaiian goose]) back from the edge of extinction and establishing populations in new areas throughout the state; successfully propagating endangered forest birds like the ʻalala (*Corvus hawaiiensis*) and puaiohi (*Myadestes palmeri*) to reintroduce them back into the wild; increasing populations of honu (*Chelonia mydas agassizi* [green sea turtle]); increasing populations of humpback whale (*Megaptera novaeangliae*); protecting important habitats such as those of Hanawī and Kahikinui on Maui; establishing new areas for wildlife conservation like Kawai Nui Marsh Wildlife Sanctuary on Oʻahu and Mana Plains Forest Reserve (wetland) on Kauaʻi; constructing predator-proof fences to protect seabird breeding colonies and habitat at the Kaena Point Natural Area Reserve (NAR) in Oʻahu, the Kilauea Point National Wildlife Refuge (NWR) in Kauaʻi, and the Kahakuloa Section of the West Maui NAR; and implementing community-based restoration efforts in marine managed areas throughout the state, as well as at Waimānalo streams to encourage the return of the endangered aeʻo (*Himantopus mexicanus knudseni* [Hawaiian stilt]). Much foundational conservation work has been accomplished in the ten years since Hawaiʻi's first wildlife action plan was published. More than 1.2 million acres have been enrolled in watershed partnerships, three new marine and wildlife sanctuaries have been established, and 23,506 acres have been purchased and put into forest reserves, NARs, agricultural reserves, or perpetual conservation easements for the conservation of natural resources.

However, despite these success stories, Hawaiʻi continues to face major conservation challenges in protecting its over 10,000 native wildlife species. Since the 2005 plan was published, 25 taxa of wildlife and 113 taxa of plants have been added to the state and federal threatened and endangered species lists. New ecosystem and individual species threats and stressors have arrived and must be addressed to maintain the wildlife resources of the State. This chapter provides both a social and a biological overview of the current status of natural resources in the state. In combination with Chapter 4, this chapter addresses the essential elements 1-4 of the SWAP update, at the statewide level.

SOCIAL OVERVIEW

HUMAN LANDSCAPE

The population of the State of Hawaiʻi was estimated at 1,262,840 people in 2004, with the majority (70 percent) found on Oʻahu, in the City and County of Honolulu (899,593). It has

increased 12 percent to an estimated 1,419,561 in 2014. The majority still live on Oʻahu (991,788), and the relative percentage of the statewide population residing on Oʻahu remains the same, at 70 percent. Although nearly 7 million visitors came to Hawaiʻi in 2004, 8.17 million visited in 2013, contributing an average of 203,000 people per day, up from the 170,000 people per day in 2004. As in 2004, Oʻahu and Maui were the most frequently visited islands in 2013.

Hawaiʻi has four local governments: the City and County of Honolulu (island of Oʻahu and the Northwestern Hawaiian Islands [NWHI]), 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 8.2 million visitors and $14.5 billion in expenditures in 2013 alone. Agriculture, primarily sugar and pineapple cultivation and diversified agriculture, military expenditures, and construction are important secondary economic drivers.

LAND AND WATER USE

Nearly half of Hawaiʻi'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 Office of Hawaiian Affairs manages 11,192 hectares (27,656 acres) under its legacy program for conservation of cultural and natural resources. The federal government (NPS, the U.S. Fish and Wildlife Service [USFWS], and the Department of Defense) owns or manages, through leases or cooperative agreements, more than 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. The U.S. Forest Service recently acquired land in Hawaiʻi and owns and leases 22 hectares (55 acres) to assist with its co-management of the Hawaiʻi Experimental Tropical Forest. There are no lands managed by the Bureau of Land Management in Hawaiʻi.

The remaining land is in private ownership. Much of this land is controlled by a few owners; four private landowners own approximately 16 percent of the land in the state (Kamehameha Schools, Parker Ranch, Lanai Resorts LLC, and Alexander and Baldwin). Some of these lands are managed in cooperation with adjacent landowners for conservation purposes as part of a watershed partnership. Modeled after the first watershed partnership that began in East Maui in 1991, there are now ten watershed partnerships on five islands, involving more than 70 public and private partners and covering over 809,000 hectares (2 million acres) of forested watershed. These voluntary partnerships are the primary vehicle for conservation on private lands in Hawaiʻi (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 (Lānaʻi), west Maui, central Oʻahu, the north shore of Kauaʻi, and the Hāmākua Coast (island of Hawaiʻi).

Unlike many other states, Hawaiʻi 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 (798,787 hectares or 1,973,846 acres) is in the State Conservation District, a designation where development and commercial activity is generally limited with varying levels of restrictions based on the applicable subzone. While the State Department of Land and Natural Resources (DLNR) manages land in the Conservation District, the counties have primary responsibility for 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.

Hawaiʻi withdraws about 2 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.

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

A significant portion of the state (31%) has been designated for long-term resource protection and receives varying degrees of management: 273,567 hectares (676,000 acres) are in State Forest Reserves (DLNR), 147,710 hectares (369,000 acres) are within national parks (NPS), 50,132 hectares (123,881 acres) are in State NARs (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 NWRs (USFWS).

Hawaiʻi also has taken impressive steps for the protection of its marine resources. The state and federal governments have created the single largest fully protected conservation area in the United States and one of the largest marine conservation areas in the world, with the establishment of the Papahānaumokuākea Marine National Monument. It encompasses 362,073 square kilometers (139,797 square miles or 89,470,080 acres) of land and marine waters around the NWHI in the north Pacific Ocean—an area larger than all the country's national parks combined. In addition to that, the Hawaiian Islands Humpback Whale National Marine

Sanctuary (NOAA and DLNR) protects 3,155 square kilometers (1,218 square miles or 779,520 acres) of coastal and marine waters around the main Hawaiian Islands (MHI).

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]), ‘io (*Buteo solitarius* [Hawaiian hawk]), ‘elepaio (*Chasiempis sandwichensis*), ‘alalā (*Corvus hawaiiensis* [Hawaiian crow]), sea turtles, and sharks are believed to be ‘*aumakua* (ancestors or guardians) of certain Hawaiian families. Hawaiian names have been given to many of the native wildlife and they have been incorporated into *oli* (chants) and *mo‘olelo* (legends). Today, Native Hawaiian teachings play an increasing role in natural resource management, especially in areas of cultural significance like Kaho‘olawe or Wao Kele o Puna (island of Hawai‘i). The SWAP recognizes that the State and its agencies are obligated to protect the reasonable exercise of customarily and traditionally exercised rights of Native Hawaiians to the extent feasible, in accordance with *Public Access Shoreline Hawaii versus Hawaii County Planning Commission* and subsequent case law.

MANAGEMENT OF GAME WILDLIFE SPECIES IN THE STATE OF HAWAI‘I

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

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

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

PUBLIC SUPPORT FOR CONSERVATION

Public Perspectives on Wildlife

Based on a 2004 “Wildlife Values in the West” survey, 71 percent of Hawai‘i’s residents strongly agree that it is important to prevent the extinction of endangered species, 86 percent agree that in order to do this it is acceptable to eliminate introduced game animals from some

areas, and 87 percent find it acceptable to close some areas to human use to protect wildlife (Dayer et al. 2006). In 2011, an estimated 22 percent of the population participated in some type of wildlife-associated recreation (e.g., fishing, hunting, wildlife watching). Expenditures for wildlife-watching activities in Hawai‘i, by both residents and visitors, is estimated at $669 million dollars and at $993 million for all types of wildlife-related recreation (U.S. Department of the Interior 2011). A large proportion of the $13 billion dollar tourism sector is indirectly related to the viewing of marine wildlife, with one study estimating that snorkeling and diving alone generate $364 million dollars each year in added value for the State.

In the past ten years, new programs have evolved in which the public can pitch in and show its support for wildlife and natural resource conservation. The DLNR conservation enforcement branch created the Makai Watch program to engage local communities to help protect local natural resources. The Makai Watch recruits community members as volunteers to help manage marine resources by promoting education, monitoring, and compliance with rules. The Makai Watch approach is based on the idea that people who use, deal with, or live close to natural and cultural resources are in the best position to facilitate a greater understanding of the nature of the area. Community members are the ‘eyes and ears’ that look out for their resources, and their direct involvement reduces inappropriate uses of those resources. In 2014, eight communities on Kauai, O‘ahu, Maui, and Hawai‘i participated in the program. This program recognizes that the people who use a resource ultimately are responsible for its long-term health.
DAR has worked with local coastal communities to establish community-based subsistence fishing areas (CBSFA, also referred to as community-based marine managed areas) throughout the state. There are two CBSFA at Haena, Kaua‘i, established by statute and administrative rules. An additional 18 areas are in various stages of consideration and development.

Funding for Conservation

Hawai‘i ranks near the bottom (48th) in the nation for state spending on fisheries and wildlife, though the state forest reserve system ranks 11th in size and the state boasts the largest marine protected areas in the United States. In Fiscal Year 2015, the State Department of Land and Natural Resources was allocated $139 million of the state’s $12.1 billion dollar executive budget. With slightly more than one percent (1.14%) 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 $35 million dollars for Fiscal Year 2015. Though no comprehensive cost estimates exist for the protection and recovery of wildlife in Hawai‘i, the inadequacy of current funding levels is obvious based on costs included in recovery plans for endangered species. For example, the 2006 Revised Recovery Plan for Hawaiian Forest Birds estimates the cost of recovering 21 species of forest birds at nearly $2.5 billion dollars over 30 years—an annual cost ($83 million) that is more than twice the wildlife conservation budget

for the entire DLNR. Costs associated with the recovery for endangered whales, sea turtles, seabirds, waterbirds, and plants would add tens of millions more per year. The State switched its funding base for the natural area reserve and watershed protection program from a dedicated special fund to annual general fund appropriations in 2015. It is yet to be seen whether the long-term support needed to fund natural resource conservation can be maintained and increased to meet the needs identified in this plan, when these needs compete with other general fund programs such as public health, public safety, and education.

Funding levels from federal sources are also inadequate and inequitably apportioned. In 2014, with 28 percent of the nation's imperiled species, Hawai'i received 16 percent of the national appropriation under the Endangered Species Act, Traditional Section 6 Program and just three percent of the Nontraditional Grant Programs. Hawai'i received only one percent of the national appropriation under the State Wildlife Grants Program, which totaled $459, 950 in 2015. In recent years, through related competitive grant programs within the Section 6 program, additional funding for conservation on private lands and for land acquisition has become available. Though Hawai'i has been successful in securing a portion of these grants (3% in 2014) because of extensive and progressive partnerships with landowners, lack of sufficient overall funding to implement recovery programs, especially on state lands, leaves both critically endangered species and lesser known native species (e.g., terrestrial invertebrates) with little support. An analysis of federal funding levels in 2008 found that, on average, endangered bird species on the mainland received 15 times more funding than endangered Hawaiian birds. Hawaiian birds received only 4.1 percent of recovery funding from all sources even though they represent nearly a third of listed endangered birds (Leonard 2008).

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

BIOGEOGRAPHICAL OVERVIEW

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

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

most active volcano in the world, the wettest place on earth, the tallest 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 Hawai‘i’s dryland habitat, 61 percent of the mesic habitat, and 42 percent of the wetland habitat are estimated to be lost, with less than 40 percent of the land surface covered in native vegetation today. Similarly, much of the habitat for freshwater species has declined, with 58 percent of the perennial streams in the state having been altered in some way. The following section provides specific information on terrestrial, freshwater, and marine habitats, including associated wildlife and major threats.

Terrestrial Habitats

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

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

Alpine communities

Alpine communities are found only on the islands of Hawai‘i (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*), 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*); Hawai‘i’s only land mammal, the ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]); pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]); ‘io (*Buteo solitarius* [Hawaiian hawk]); and 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 Ni‘ihau and Kaho‘olawe. Dominant plants include ‘ōhi‘a and koa trees and mamaki (*Pipturus albidus*) and uluhe (*Dicranopteris linearis*) shrubs, and hāpu‘u ferns are an important component of the native understory. Notable native wildlife includes terrestrial invertebrates, waterbirds, migratory shorebirds and waterfowl, pueo, ‘io, and the ‘ōpe‘ape‘a. Threats include the establishment and spread of invasive plants, especially kāhili ginger and strawberry guava and degradation of the understory by feral pigs. A new threat is ‘ōhi‘a wilt (*Ceratocystis fimbriata*), a fungal disease that can kill up to 50 percent of the ‘ōhi‘a in a stand. ‘Ōhi‘a wilt is currently found only on the Hawai‘i island, but there is fear it will be spread to other islands, putting their ecosystems at risk.

Lowland mesic communities

Lowland mesic communities are found on every island except Kaho‘olawe. Most lowland mesic communities have been converted to agricultural or ranching use or lost due to logging, and the remaining native communities are threatened by a number of invasive plant species, including guava (*Psidium guajava*), strawberry guava, molasses grass (*Melinis minutiflora*), firetree (*Morella faya*), Christmas berry (*Schinus terebinthifolius*), silk oak (*Grevillea robusta*), *Eucalyptus* spp., 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, ‘a‘ali‘i, and ‘ūlei (*Osteomeles anthyllidifolia*) shrubs, and koa, ‘ōhi‘a, and lama (*Diospyros sandwicensis*) trees. Notable native wildlife species include waterbirds, migratory shorebirds and waterfowl, ‘ōpe‘ape‘a, and terrestrial invertebrates. ‘Ōhi‘a wilt is a threat in this habitat.

Lowland dry communities

Lowland dry communities occur on the leeward sides of all eight of the MHI, as well as the windward side of Hawai‘i in the Puna and Ka‘ū districts. Dominant vegetation includes ‘ōhi‘a, lama, olopua, and wiliwili (*Erythrina sandwicensis*) trees, ‘a‘ali‘i 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, guinea grass (*Panicum maxima*), 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*], Indian pulchea [*Pulchea indica*], and ironwood [*Casuarina equisetifolia*]), off-road vehicle activity, and arson.

Subterranean systems

Some of Hawai‘i’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 Hawai‘i’s native freshwater aquatic animals migrate between the ocean, estuaries, and upper reaches of streams as part of their life cycle.

Streams

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

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

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

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

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

Coral Reefs
Coral reefs develop in most of the rest of the shallow water fringe around the high islands. This results in the formation of “fringing reefs” that have coral growth near the surface of the water, very close to shore, with limited shallow water lagoons inshore of the reef. Reefs in areas with relatively recent lava flows, such as on the island of Hawai‘i, have poorly developed fringing reefs. Kāne‘ohe Bay on O‘ahu and a small area of Kaua‘i also have “barrier reefs,” where the development of coral occurs further offshore. There is a more extensive shallow water lagoon inshore of the barrier reef that has a higher degree of development of what are called patch reefs, or small sections of coral interspersed in sandy habitat in waters of one to ten or 20 meters (three to 65 feet) deep. Many of the low islands in the NWHI are “atoll reefs.” These reefs are the tops of drowned and submerged volcanic peaks that result in a ring of coral that can be many miles in circumference. They may or may not surround a small sandy island or islands somewhere inside a very extensive lagoon that also usually contains numerous patch reefs. 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 5 kilometer (3 mile) boundary of state waters, the water is thousands of meters or feet deep. In this bathypelagic or deep zone, the waters are cold and dark, with many unusual fishes and invertebrates about which little is known. In the mesopelagic or middle realm (waters of only around 100 to 300

meters (330 to 1,000 feet) depth), there is some small amount of light and the species that occur here are often different from both the shallower and deeper species. Many species in this zone are important food sources for marine mammals in Hawai‘i. The pelagic or nearshore waters on the surface above these deep water areas are home to some of the most desirable gamefishes including ono, mahimahi, ‘ahi (tunas), and marlins, which increases the importance of this habitat. Offshore aquaculture is a potential new threat to these areas.

Additional Marine Habitats

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

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

NATIVE TAXA

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

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

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 28 percent of the federally listed taxa. The decline in native species is also mirrored by the loss of native habitat, with less than 40 percent of the land surface covered with native-dominated vegetation today.

Of this great diversity, the following species or taxa are covered in the SWAP as Species of Greatest Conservation Need (SGCN): one terrestrial mammal, 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 ʻōpeʻapeʻa (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 Niʻihau. It is federally listed as endangered due to apparent population declines and limited information on its distribution, abundance, and habitat needs. Bats are affected by habitat loss, roost disturbance, collision with wind turbines, and pesticides. A group of stakeholders composed of government agencies, non-profit organizations, and private landowners, is working together to prioritize and fund needed bat research.

Birds

The avifauna in Hawaiʻi are of national and global importance, as Hawaiʻi 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 Hawaiʻi. 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 Hawaiʻi, 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 Hawaiʻi'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. Natural events such as hurricanes and severe storms can adversely affect forest birds with small populations.

As a result of these changes, especially the introduction of mosquitoes, most remaining forest birds survive in montane mesic and wet native forests dominated by ʻōhiʻa 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 Hawaiʻi and Maui, as well as remnant forest patches at high elevations on Molokaʻi, Lānaʻi, Oʻahu and

Kauaʻi. 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 (ʻalalā, puaiohi, Maui parrotbill [*Pseudonestor xanthophrys*], palila, ʻakikiki [*Oreomystis bairdi*], and ʻakekeʻe [*Loxops caeruleirostris*]), 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 Revised Recovery Plan for Hawaiian Forest Birds 2006) 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 ʻio (Hawaiian hawk) and the pueo (Hawaiian short-eared owl) are the only extant native raptors in Hawaiʻi. The ʻio (Hawaiian hawk) is listed as endangered by both USFWS and the State and is restricted to the island of Hawaiʻi. USFWS has proposed the ʻio be removed from the endangered species list because the population is secure and no longer requires federal protection. The pueo occurs on all the MHI and is listed by the State as endangered on Oʻahu only. Both birds are found from sea level to high elevations across most habitats. Primary threats include predation by introduced rodents and cats (particularly for the ground-nesting pueo) and habitat loss. Information on the distribution and abundance of these species as well as potential limiting factors (e.g., environmental contaminants and harassment by humans) is needed for both species. USFWS is particularly interested in information on the ʻio's biology, range, and population trends, including the species' use of koa plantations and exurban areas, and the positive and negative effects of current and foreseeable land management practices.

Waterbirds

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

Three of the waterbird species (ʻalae ʻula [Hawaiian moorhen], ʻalae keʻokeʻo [Hawaiian coot], and aeʻo [Hawaiian stilt]) inhabit wetland habitats including tidal flats and estuaries, playas and ephemeral basins, freshwater marshes, coastal ponds, taro patches, and human-constructed wetlands, such as irrigation ditches and sewage treatment ponds. The koloa maoli (Hawaiian duck) occurs in the above freshwater environments as well as montane streams and swamplands. Nēnē (Hawaiian goose) have been reintroduced to Kauaʻi, Maui, Hawaiʻi, and Molokaʻi, where they can be found from sea level to 2,400 meters (7,900 feet) in elevation, predominantly in dry forest, shrubland, and grassland. A translocation project begun in 2012 and has moved over 600 nēnē from near the Kauaʻi International Airport to Hawaiʻi and Maui. A pair of translocated birds that had been moved to Hawaiʻi has dispersed to Oʻahu. 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 2004, when 20 birds were translocated to Midway Atoll, and 2014, when 28 were translocated to Kure Atoll in the NWHI.

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

Seabirds

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

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

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

Migratory shorebirds and waterfowl

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

Northwestern Hawaiian Islands passerines

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

Terrestrial Invertebrates

Similar to native forest birds, Hawai‘i’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, a happy-face spider (*Theridion grallator*) and no-eyed big-eyed spider (*Adelocosa anops*), and yellow-faced bees (*Hylaeus* spp.). Twenty-seven invertebrates have been listed as endangered or threatened by the USFWS: O‘ahu tree snails of the genus *Achatinella*, two species of Lāna‘i tree snails (*Partulina* spp.), the

Newcomb's tree snail (*Newcombia cumingi*), the Newcomb's snail (*Erinna newcombi*), the Kaua'i cave wolf spider (*Adelocosa anops*), the Kaua'i cave amphipod (*Spelaeorchestia koloana*), the Blackburn's sphinx moth (*Manduca blackburni*), fourteen species of *Drosophila* flies, and five species of *Megalagrion* damselflies. Recovery Plans have been prepared for four taxa Newcomb's snail, O'ahu tree snails, Blackburn's sphinx moth, and the Kaua'i cave wolf spider, and critical habitat has been designated for the sphinx moth, some *Drosophila* and damselflies, Newcomb's snail, and the Kaua'i arthropods. Seven yellow-faced bees and one damselfly (*Megalagrion xanthomelas*) are candidates for listing by 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 Wai'anae mountains (O'ahu), the Alaka'i swamp region (Kaua'i), and other wet summit regions (e.g., Ko'olau mountains, O'ahu). Plant species that have suffered the greatest percentage of habitat loss are concentrated in very low elevation mesic habitats on Kaua'i mesic to dry habitats in the Wai'anae mountains (O'ahu), very low elevation mesic habitats in the Ko'olau mountains (O'ahu), and low elevation dry to mesic habitats on

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 300 listed plants.

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

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 Hawaiʻi'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. One species of anchialine pool shrimp (*Vetericaris chaceorum*) has been listed as endangered, and three others (*Metabetaeus lohena*, *Palaemonella burnsi*, and *Procaris hawaiana*) are candidates for listing under the Endangered Species Act. These shrimps can be found in anchialine ponds where the subterranean water system reaches the surface

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

Marine Species

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

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

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

Many of the resident whales and dolphins feed on fishes and squids that occur in the moderately deep waters off Hawai‘i’s coasts.

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CHAPTER 4: STATEWIDE CONSERVATION NEEDS

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

OVERVIEW OF THREATS

CURRENT THREATS AND CHALLENGES

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

- Loss and degradation of habitat resulting from human development, 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 Hawai‘i’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 Hawai‘i’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 Hawai‘i, extinction of one or several species might contribute to the extinction rate of other species. While the current land use zoning of the Conservation District limits further loss of forested habitat to development, this designation confers only the coarsest protection, and does not protect important forested habitat in the other land use zones. Even in the Conservation District, without active management, these lands remain threatened by invasive plants and animal species or require restoration to support native wildlife. In addition, zoning does not protect all of the remaining quality habitat from being converted to another land use.

Development and Shoreline Alterations

Many important wetland and coastal habitats 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 Ka‘ū or north shore of Kaua‘i. Shoreline alterations, including the building or expansion of harbors, seawalls, and other structures, damages marine habitats for corals and other species directly or indirectly by changing water flows or sediment deposition. Developments along the coasts also increase the number of light sources around the islands and the potential for problems caused by light attraction of nocturnally active seabirds and sea turtles.

Development of energy facilities such as wind turbines and powerlines creates collision hazards for wildlife such as seabirds, waterbirds, 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 O‘ahu, 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, Hawai‘i’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, Hawai‘i’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, Hawai‘i 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 Hawai‘i 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 Hawai‘i’s moderate climate, year-round growing season, wide range of habitats, and availability of unoccupied niches. Before human arrival, colonization of new species probably occurred every 25,000 years. Over the last two centuries alone, the rate of plant introductions to Hawai‘i has averaged more than 40 species per year. It is estimated that over 10,000 plants have been introduced into Hawai‘i and about 1,215 (roughly equal to the number of native vascular plant species in the state) have 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 Hawai‘i’s ecosystems and economy.

In addition to those introduced species that are already established in Hawai‘i, 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 Hawai‘i, screening and search protocols are in place to

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

Uncontrolled ungulates (hooved animals) are another major threat to native habitat. Ungulates in Hawai‘i include pigs (*Sus scrofa*), goats (*Capra hircus*), sheep (*Ovis aries*), mouflon sheep (*Ovis musimon*), Columbian black-tailed deer (*Odocoileus hemionus columbianus*), and axis deer (*Axis axis*), and to a lesser extent, feral cattle (*Bos taurus*). The Department of Land and Natural Resources (DLNR) has a dual mandate to conserve, manage, and protect indigenous wildlife and endangered species and their ecosystems, and to preserve, protect, and promote public hunting. These dual and often conflicting mandates involve managing indigenous wildlife and endangered species 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 Hawai‘i 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 Hawai‘i 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, Moloka‘i, and Lāna‘i 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 Kāne‘ohe Bay, Maunalua Bay, and Waikīkī, O‘ahu, 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 O‘ahu 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 Hawai‘i 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 Hawai‘i, 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 Hawai‘i for native waterbirds and a major threat due to the broad spectrum of species affected and the frequency and increasing geographic area of occurrence. The introduction of West Nile virus or avian influenza (HPAI) could have even more devastating impacts. Knemidokoptic mange has been diagnosed in Hawai‘i ‘amakihi (*Hemignathus virens* [Hawaiian honeycreeper]) on Hawai‘i 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 Hawai‘i. There is also concern that some diseases may be associated with invasive species or other introduced vectors. Research suggests that reduced resiliency of corals affected by thermal and ultraviolet (UV) stress and bleaching events may amplify or exacerbate disease prevalence, and is believed to be associated with climate change. Many bacterial, fungal, and protozoan diseases are known to affect stony corals in

Hawai‘i; 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 Kaua‘i and Maui and in Kāne‘ohe 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, Hawai‘i’s native fauna is expected to be highly susceptible to these stressors, and preventing the establishment of new diseases is a top priority need.

Plant disease can threaten an entire watershed. The fungus *Ceratocystis fimbriata* infects the vascular system of the native ‘ōhi‘a trees, causing them to die within a few weeks. This disease, aptly referred to as the “rapid ‘ōhi‘a death,” or “‘ōhi‘a wilt” is known to occur only in the Hilo and Puna districts on the island of Hawai‘i, but it has the potential to affect ‘ōhi‘a on all Hawaiian Islands. The disease can spread fast across the landscape. In 2012, it killed about 1,000 hectares (2,470 acres) of ‘ōhi‘a on Hawai‘i island, and by summer 2014 the disease had impacted nearly 6,000 hectares (14,830 acres). Invasive virulent diseases such as the rapid ‘ōhi‘a death that affect keystone forest trees like ‘ōhi‘a 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 Hawai‘i. 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. Hawai‘i 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 O‘ahu, Kaua‘i, 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 Hawai‘i’s native wildlife and habitats because of global climate change are anticipated, in many cases have already begun, and are expected to continue and intensify. The anticipated effects are discussed below.

Marine and Estuarine Ecosystems

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

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

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

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

average temperatures are 1ºC or more above average, will occur with increasing frequency and severity in Hawai‘i. Research suggests that corals affected by climate change–related bleaching events and thermal and UV stress may have reduced resiliency and be more susceptible to disease.

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

In the MHI, increased frequency of flooding events affecting coastal estuaries will result in increased salinity in coastal wetlands and may affect many existing wetland wildlife sanctuaries, with consequent changes in the flora and fauna (Keener et al. 2012). 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 O'ahu would similarly affect populations of endangered O'ahu 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 'amakihi 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 shore-birds. 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 O‘ahu prompted passage of an emergency rule to immediately stop the commercial harvest until the Division of Aquatic Resources (DAR) can better understand the impacts of large-scale removal of sea cucumbers on the fishery and aquatic environment. Commercial and recreational harvest of other reef and marine species such as cowry (*Cypraea* spp.), sea urchins (class *Echinoidea*), and ‘opihi (*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*), ‘ōhi‘a (*Metrosideros polymorpha*), and hāpu‘u 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 Hawai'i'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 Kaua'i, illegal introduction of axis deer to Hawai'i, and vandalism of 2 miles of ungulate-control fencing on Hawai'i. 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 Hawai'i, O'ahu, and Kaua'i. 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, Kaua'i, and Hawai'i, 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. Hawai'i'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 Hawai‘i, let alone effectively deal with future new threats and challenges, such as the introduction of new invasive species or impacts of climate change. It is yet to be seen if the federal government will rise to the challenge of adequately funding national programs to protect our current natural resource treasures, and also to provide the funding to meet the challenges of the future, such as mitigating the detrimental impacts of climate change. If that does happen, states will be expected to likewise rise to the challenge and meet match requirements to receive federal funds.

To fulfill the ultimate mission of this plan and the responsibilities of the natural resource management agencies to "ensure protection of Hawai‘i's wide range of native wildlife and the diverse habitats that support them," an adequate, stable, and dependable funding source is needed. There are many ways to achieve this; for example, dedicated funding sources such as a share of a national or state revenue source can be established. The selected revenue sources could be linked to the benefits of having healthy and thriving wildlife and ecosystems—for instance, a portion of tourism revenue could be dedicated to wildlife conservation programs. Another method could be securing mitigation funding from an industry or activity that has a direct or indirect impact on wildlife and habitat—a portion of revenue from the transportation sector or energy production sector in the state could be dedicated to wildlife conservation programs.

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

STATEWIDE CONSERVATION OBJECTIVES

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

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

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

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

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

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

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

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

Implementation of these seven objectives will allow resource managers and landowners to address the major conservation needs of Hawai‘i’s native wildlife. The objectives relating to the protection and restoration of habitats and the prevention and control of introduced species address many of the most direct biological threats to native 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 Hawai‘i;
- More fully integrate conservation actions for plant. algae and invertebrate Species of Greatest Conservation Need (SGCN) into other plans that are being developed for resource management, including the Forest Action Plan, State Ocean Resources Management Plan, Watershed Partnership Management Plans, Species Recovery Plans, and future updates of the SWAP;
- Develop plans to respond to natural disasters and climate change; and
- Support the development of emergency preparedness and response to natural and man-made disasters such as oil and contaminant spills and diseases.

2. Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication.
Invasive alien species have the capacity to degrade and destroy remaining native habitat and eliminate native species. A more robust biosecurity implementation plan is needed in Hawai‘i 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.

Highest priority

- 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.

High priority

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

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

Several species of Hawai‘i’s native wildlife owe their continued existence to formal and informal partnerships among natural resource agencies, military agencies, other federal, state, and county agencies, non-governmental organizations, academic researchers, private landowners, community organizations, and individuals. From watershed partnerships covering thousands of acres of land to single-species working groups, these cooperative efforts are valuable ways to share information, coordinate management actions, and pool resources for the benefit of Hawai‘i’s native wildlife.

Highest priority

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

High priority

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

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).

High priority

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

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

Highest priority

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

High priority

- Review and evaluate existing state policies and Administrative Rules for gaps in protection;
- Review and revise existing rules and regulations dealing with extractive uses of aquatic animals, plants, and terrestrial snails;
- Review and revise existing 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.

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MAUI

Maui is the second largest island in the State of Hawai‘i and is known as the Valley Isle. Thirty percent of the island is dominated by native vegetation with most of this habitat in east Maui. The upper elevation slopes and summits of both east and west Maui are typically native dominated, with coastal and lower elevation areas dominated by non-native vegetation. Three notable areas contain continuous native vegetation spanning a range of habitats, forming a landscape with a high diversity of total species: summit and leeward west Maui (wet forests and bogs transitioning to lowland mesic communities), windward east Maui (subalpine shrubland transitioning to wet forest), and leeward east Maui (subalpine community transitioning to remnant montane mesic then lowland and coastal dry communities). In addition, large tracts of intact native-dominated montane forests remain, with a canopy composed primarily of ‘ōhi‘a (*Metrosideros polymorpha*) and koa (*Acacia koa*) and a well-developed sub-canopy layer of mixed native understory trees and shrubs. Habitat types are highly diverse, including coastal and wetland habitats, lava tube caves, aeolian habitats, and bogs. Maui also has ten offshore islets that are significant habitats for seabirds. Anchialine pools and ponds, which host a unique fauna of amphipods and shrimp, are found in young lava fields on the coast. As a result of the range of habitats, a diversity of species can be found including cave insects, endangered forest birds, marine mammals, and endemic freshwater fishes.

OVERVIEW

Geology and Hydrology

At 186,163 hectares (465,408 acres), Maui was formed between 750,000 and 1.3 million years ago, as first west Maui then east Maui emerged from two large shield volcanoes (West Maui and Haleakalā). Haleakalā is the tallest peak at 3,055 meters (10,023 feet), with Pu‘u Kukui in West Maui coming in second at 1,764 meters (5,788 feet). Maui is the only island (other than Hawai‘i) 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 ‘Īao stream. Maui has 90 perennial streams, 56 of which are continuous. Waihe‘e and ‘Īao streams have the largest discharges - 60 and 43 million gallons per day (mgd) respectively. Many streams are diverted; Maui has the highest diversion of natural stream flows in the state. Kanahā Pond, historically a natural freshwater lake, is approximately 1 meter (3 feet) in depth and 16 hectares (41 acres) in size and is located wholly within the Kahului Airport boundary area.

Climate

Because of the size and elevation range of Haleakalā, climate and vegetation communities vary dramatically. Warm trade winds meet the windward side of the volcano and leave most of their moisture behind as rain or cloud drip on the windward side. At high elevations and on the leeward slopes of Haleakalā, dry conditions predominate. The geologically older West Maui mountains receive an average rainfall of 1,016 centimeters (400 inches) per year, making it the second wettest spot in the state.

Land and Water Use
Land use designations according to the State Land Use Commission are 53 percent Agricultural District, 42 percent Conservation District, five percent Urban District, and less than one percent Rural District. Major land owners in West Maui include the State of Hawai‘i, 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 Hawai‘i (including the Department of Hawaiian Home Lands), the National Park Service (NPS), Alexander and Baldwin, Ulupalakua Ranch, and Haleakalā Ranch. Fifty-seven streams are diverted and seven have altered channels. ‘Īao 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 Ka‘anapali. 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, ‘ōpe‘ape‘a (*Lasiurus cinereus semotus* [Hawaiian hoary bat]), pueo (*Asio flammeus sandwichensis* [Hawaiian short-eared owl]), waterbirds, freshwater species, and seabirds. Plant endemism for Maui is estimated at 20 percent. Beaches provide habitat for 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 (‘ākohekohe [*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 ‘ākohekohe (*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;

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- 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, ʻōpeʻapeʻa, 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 ʻuaʻu and ʻa'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 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 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*], ʻaʻo [*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 *Hawai'i Implementation Plan for Polluted Runoff Control* and *Unified Watershed Assessment*;
- Ongoing initiatives that support *Hawaii's Local Action Strategy to Address Land-based Pollution Threats to Coral Reefs* (first published in 2004);
- Bishop Museum's comprehensive species inventory database;
- The Audubon Society and others maintain Sightings database of bird species observed in 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 ahupua‘a of Maluaka, Ka‘eo, Papa‘anui, 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, Nu‘u, Pauwalu Point, Ke‘anae Peninsula, East Maui stream, lo‘i)**

Species**:** Waterbirds, migratory birds, native plants.

Basis for Priority Designation**:** These areas have been identified by USFWS and the Pacific Coast Joint Venture as areas particularly suitable for waterbird conservation and recovery.

Potential Conservation Actions: Control small mammal predators and invasive species; where private lands occur, support voluntary and incentive based programs for increased conservation.

Coastal Areas on State Lands in the north and northwest portions of West Maui; other intact coastal areas (South, East Maui)

Species**:** Wetland birds, migratory shorebirds and waterfowl, seabirds, native invertebrates, native plants.

Basis for Priority Designation**:** Hawai‘i has few remaining intact native coastal vegetation areas; these areas generally comprise diverse coastal vegetation communities. However, these communities are threatened by destructive ungulates (mostly cattle and axis deer).

Potential Conservation Actions: Identify the most intact areas and assess suitability for appropriate conservation measures, including fencing, removal and control of ungulates, and designation as special coastal conservation areas.

Kanahā Beach, **Maui County**

Species**:** Native invertebrates, seabirds, native plants.

Basis for Priority Designation**:** An area that is rich with native plants and native invertebrates, but is faced with immediate threats by human activities such as off-road

vehicles. Existing actions that have benefited ecological function include removal of invasive plants, restoration and replanting of native plants, public education, and construction of a vehicle barrier to protect sensitive habitat. This area has the potential to serve as a public education and stewardship model where measures to protect and restore coastal areas can be demonstrated and incorporated into broader programmatic community outreach strategies.

Potential Conservation Actions: Continue existing management activities and significantly increase outreach and public opportunities for hands-on volunteer stewardship experiences.

Anchialine Pond Habitat

***Species*:** Anchialine shrimp, endemic anchialine amphipods (*Grandidierella palama, Paramoera rua, Rotomelita ana*).

***Basis for Priority Designation*:** Anchialine pool habitats are experiencing degradation as a result of invasive species and human disturbance, leading to decreasing populations of anchialine species and significant, possibly irreversible ecological alteration.

Potential Conservation Actions: Prevent introduction of non-native fish (tilapia), manage human disturbance, and develop and implement effective and ongoing education and outreach.

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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.


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.

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‘O‘opu ‘akupa or Sandwich Island sleeper

Eleotris sandwicensis

SPECIES STATUS:
IUCN Red List – Data Deficient
Endemic

SPECIES INFORMATION: ‘O‘opu ‘akupa or Sandwich Island sleeper (*Eleotris sandwicensis)* is Hawaii’s only endemic eleotrid. Adult ‘o‘opu ‘akupa are ambush predators that feed on a variety of invertebrates and fishes, including other native adult and post-larval gobies and some exotic fishes. One study shows that they are also opportunistic feeders. It can grow to 33 centimeters (13 inches) in length. Unlike 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. ‘O‘opu ‘akupa usually stay hidden, but can be seen darting and diving into leaf litter or mud or searching for shelter in rocks. There are two head morphs of the species.

DISTRIBUTION: Historically, ‘o‘opu ‘akupa 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 O‘ahu. One study shows that ‘o‘opu ‘akupa are present in Pelekunu stream but rare in Waikolu stream, both on Moloka‘i. ‘O‘opu ‘akupa populations are stable in both altered and unaltered streams.

LOCATION AND CONDITION OF KEY HABITAT: ‘O‘opu ‘akupa 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 ‘o‘opu ‘akupa 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 (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.

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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.

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Courtesy Mike Yamamoto

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.

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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.


Courtesy Annette Tagawa

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

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 O'ahu.

ABUNDANCE: Their abundance is lower than it was historically in all but the most remote streams.

LOCATION AND CONDITION OF KEY HABITAT: Hīhīwai occur more in well-oxygenated lower to middle reaches of streams. They prefer streams with boulders and coarse gravel substrates. Hapawai occur in the lower reaches of streams and extend more into the estuary.

THREATS:

- Both species have been used by Hawaiians as a food source, though hīhīwai are preferred;
- Stream channelization and burial, pollution, and water diversions have affected the distribution and abundance of these snails. In particular, hīhīwai are limited in their upstream migration by low stream flows and in-stream obstructions.

CONSERVATION ACTIONS: The goals of conservation actions are to not only protect current populations, but to also establish further populations to reduce the risk of extinction. In addition

to common statewide and island conservation actions, specific actions include:

- Work to clean streams with significant pollution;
- Improve altered or diverted streams;
    - Modify or remove gratings or diversions to allow for instream passage;
    - Restore riparian vegetation to help decrease instream heating and reduce sediment loads;
    - Create pools in frequently dewatered stretches to provide safe usable habitat between flows.
- Continue developing GIS database and making it web-accessible;
- Maintain healthy populations with appropriate fishing regulations and education;
- Collaborate with the Commission on Water Resources Management and the Land Board to ensure adequate Instream Flow and biological integrity of riparian areas;
- Continue on-going partnerships focused on environmental education and conservation and expand partnerships;
- Restore habitat.

MONITORING:

- Establish survey 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.

CHAPTER 8: MONITORING, IMPLEMENTATION, AND ADAPTIVE MANAGEMENT

The need for monitoring is a consistent theme throughout Hawai‘i’s State Wildlife Action Plan (SWAP) and is referenced in several previous chapters (Chapters 4, 5, 6, and 7). Chapter 8 addresses monitoring specifically in the following ways: it provides a summary of current monitoring efforts at both the 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 Hawai‘i. 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 Hawai‘i. 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 Hawai‘i 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 Hawai‘i 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 Hawai‘i Audubon Society, which has conducted annual Christmas bird counts on O‘ahu, Kaua‘i, Maui, Hawai‘i, Midway, Laysan, and French Frigate Shoals; the yearly whale counts conducted by the Hawaiian

Islands Humpback Whale National Marine Sanctuary and the Pacific Whale Foundation during the months of January-March; and the monitoring of reef fishes by Reefcheck.

The State has several tools and resources available to assist with monitoring. Examples include databases and information warehouses such as the Hawai‘i Biodiversity and Mapping Program and the Pacific Basin Information Node. There are also inter-agency efforts, such as the Western Pacific Fisheries Information Network, the Coral Reef Information Service, and the U.S. Geological Service’s (USGS’s) Hawai‘i Forest Bird Interagency Database Project, which analyzes information collected during yearly forest bird surveys to determine conservation needs of these species.

The challenges facing implementation of effective monitoring are similar to those challenges faced in implementing conservation actions as discussed in Chapter 4: inadequate funds, lack of trained personnel to carry out monitoring, requirements for advanced technical expertise for identification of many invertebrate taxa, insufficient tools for monitoring (e.g., practical or standardized monitoring protocols and equipment), inability to use the information collected (e.g., survey forms or collected data are never entered into a database for later data analysis), and gaps in information sharing. The biggest 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.

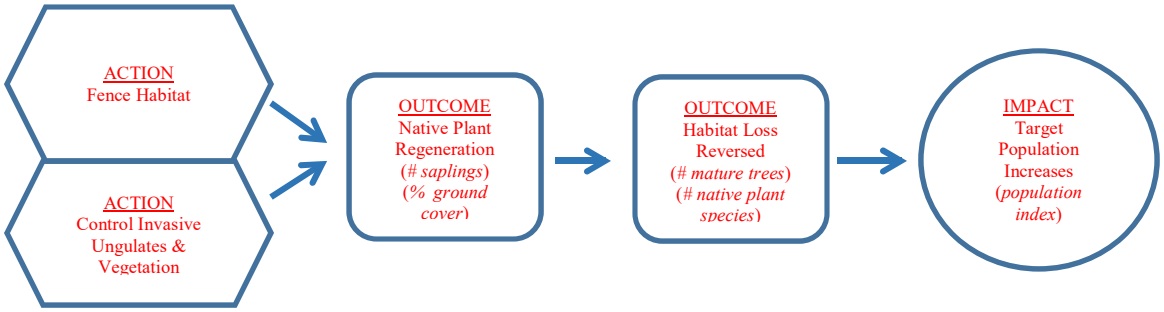

Figure 8.1Results Chain Showing Linkage Between Actions and Impact

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 iʻiwi). 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 ʻalae ʻula (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 Kauaʻi, 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 Hawaiʻi'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 Oʻahu, and in managed colonies of ʻaʻo (*Puffinus newelli* [Newell's shearwater]) on Kauaʻi, where monitoring is conducted by the Kauaʻi Endangered Seabird Recovery Project (KESRP). KESRP annually monitors known Newell's shearwater,ʻuaʻu (*Pterodroma sandwichensis* [Hawaiian petrel]), and ʻakeʻake (*Oceanodroma castro* [band-rumped storm-petrel] breeding burrows in remote locations on Kauaʻi, 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 ʻaʻo and ʻuaʻu 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 ʻuaʻu colony on Lanaʻihale, 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 Hawaiʻi Audubon counts throughout the state and at the Freeman Seabird Preserve on Oʻahu. Lastly, USFWS has developed the *Seabird Conservation*

Plan—Pacific Region that details monitoring needs at a larger scale and addresses inter-state and international levels of monitoring.

Migratory Shorebirds and Waterfowl
Regular migrants are monitored under existing programs already mentioned for other avian species groups. Examples include DOFAW's twice-annual statewide waterbird surveys, Hawai'i Audubon counts, and monitoring on various managed lands. The DOFAW statewide waterbird surveys protocol was revised in 2005 to improve its utility for monitoring populations of migratory shorebirds. Additionally, USFWS's *Seabird Conservation Plan—Pacific Region* details monitoring needs at a larger scale, including inter-state and international levels.

Northwestern Hawaiian Islands Passerines and Waterbird
Given the small population levels and restricted range of these species, monitoring is intensively conducted by USFWS through the NWR system, and on Kure Atoll by DOFAW. Monitoring programs were developed and implemented in association with translocation programs for Laysan duck (*Anas laysanensis*) and the Nihoa millerbird (*Acrocephalus familiaris kingi*). The USFWS *Revised Recovery Plan for the Laysan Duck* (2009) identifies the monitoring protocol. Monitoring in association with the translocations is ongoing 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 Pu'u Wa'awa'a and Pu'u Anahulu on Hawai'i 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 O'ahu and Hawai'i. Staff with the SEP program have begun monitoring tree and land snails in protected predator-proof exclosures in the Ko'olau and Wai'anae Mountains on O'ahu. 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 O‘ahu tree snails (*Achatinella* spp.), Blackburn’s sphinx moth, and the Kaua‘i 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 Hawai‘i, 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 Hawai‘i Biodiversity and Mapping Program and may remain solely within the control of a landowner or land management agency.

USFWS has established a Hawai‘i and Pacific Plants Recovery Coordinating Committee, which recently completed a third draft of an Integrated Plan for the Conservation of Hawai‘i’s Unique Plants and Their Ecosystems. This draft plan recognizes the importance of monitoring to rare plant conservation and identifies areas needing further field surveys to determine the current status of rare plants, totaling approximately 13 percent of the state (202,000 hectares or 500,000 acres).

Marine algae are systematically monitored in the Northwestern Hawaiian Islands by the National Oceanic and Atmospheric Administration (NOAA). Other marine plants or freshwater algae would be surveyed in association with preparation of an environmental assessment or other requirement for project development.

Freshwater Species

The State Division of Aquatic Resources (DAR), Department of Land and Natural Resources (DLNR) Water Commission, NPS, and the University of Hawai‘i conducted comprehensive surveys of 376 perennial streams across Hawai‘i for the Hawai‘i Stream Assessment Project (Commission on Water Resources Management 1990). The assessment collected data on presence of native species and evaluated the stream for developed a database on stream condition that is maintain and used today for monitoring stream conditions. In its monitoring program, DAR collects information on native and non-native species of fish, crustaceans, mollusks, insects, and algae and enters it into the database. Stream assessments are done on an individual project basis to evaluate impacts of project developments and do not occur statewide on a regular basis. DAR continues to maintain the stream assessment database. These data are used in

monitoring, assessing, managing, and protecting the freshwater aquatic resources of the state. Techniques used include point quadrat count method, drift sampling, larval trapping, and other scientific surveys (insects, algae) by other institutions or organizations. There is no systematic statewide survey of freshwater species.

Anchialine Pond Fauna

Hawai‘i has a large number of anchialine ponds, but very few (such as at ‘Āhihi-Kīna‘u, Maui, and Lua o Palahemo, Hawai‘i) have been systematically surveyed. Threats to anchialine pool ecosystems include changes in water quality and quantity because of groundwater withdrawal, accidental and deliberate introduction of non-indigenous species including alien plants, fish, arthropods, and molluscs, and historical loss of pool complexes following coastal resort development. USFWS and NPS have identified anchialine pools as priority ecosystems in need of research to better understand the habitat requirements of endemic pool biota and how they will respond to current and future changes in pool ecosystems. USGS is conducting surveys of anchialine pools, focusing primarily on three national parks on Hawai‘i island with significant pool resources: Hawai‘i Volcanoes, Kaloko-Honokōau, and Pu‘uhonua o Hōaunau. Information collected includes physical and biological habitat characteristics and the relative densities of rare anchialine pool invertebrates at individual pools. Assessments of many anchialine pond fauna and habitat have occurred over the years, but no systematic monitoring takes place.

Marine Species

Routine marine monitoring has been a component of DAR’s activities for over 50 years. Early efforts concentrated on using in-water visual assessments to measure resource fish stocks and changes to those stocks within marine protected areas and at artificial reef sites. For the past 15 to 20 years, efforts have been made to improve upon research methods, increase the frequency of surveys, expand the number of areas covered by assessments, and study changes associated with new management initiatives. Current efforts are focused on annual assessments of coral reef ecosystems across a range of management areas. Surveys document the abundance of resource fish and herbivorous fish, smaller cryptic fish and recruits, urchins and larger mobile invertebrates, benthic habitat cover, coral health, and biological diversity.

Sea turtle nesting and monk seal pupping are monitored by NOAA. The Hawaiian Islands Humpback Whale National Marine Sanctuary is responsible for long-term monitoring of humpback whales in Hawai‘i. NOAA and the Western Pacific Fisheries Management Council monitor commercial fisheries species. DAR, NOAA, and USFWS monitor resources in the Papahānaumokuākea Marine National Monument. DAR monitors fishes in Marine Life Conservation Districts, Fishery Management Areas, and Fish Replenishment Areas where the aquarium fishery and other fishing activity is closely monitored and regulated. DAR conducts statewide creel surveys of gamefish harvest by recreational and commercial fishers. Species-specific programs are in place for ulua (*Caranx* spp.), bottomfish, and precious corals. Reefcheck and other volunteer organizations gather data on reef fishes. The Hawai‘i Institute of Marine Biology (HIMB) routinely monitors reefs and marine habitats in Kāne‘ohe Bay, Oah‘u, and conducts research in Papahānaumokuākea Marine National Monument. No systematic surveys are conducted for non-commercially regulated marine invertebrates or deep water species.

HABITAT MONITORING (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 Hawai‘i 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 Hawai‘i collaboration, monitors other coral reef areas. NOAA and the Western Pacific Regional Fisheries Management Council regulate and monitor Essential Fish Habitat for managed commercial fisheries. NOAA’s National Estuarine Research Reserve (NERR) System is in the process of designating a NERR in the He‘eia estuary in Kāne‘ohe. HIMB will be conducting and coordinating monitoring at that site. Funding will become available for monitoring once the site is officially designated by NOAA. Currently, there is no monitoring of estuaries, sandy bottoms, and pelagic habitats.

Additional habitat monitoring efforts include systematic invasive species monitoring conducted by the invasive species committees and watershed partnerships on each island for targeted species. Individual project-based monitoring is conducted in connection with various other work, such as the vegetation monitoring conducted along forest bird survey transects.

MONITORING NEEDS AND RECOMMENDATIONS

Though Hawai‘i has a foundation for 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, Hawai'i Forest Bird Interagency Database Project, the Hawai'i 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 Hawai'i Conservation Conference, annual coral reef conference, and meetings of the Hawai'i 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 Hawai‘i Conservation Alliance aims to achieve many of these objectives to coordinate and standardize existing natural resource data across the state.

IMPLEMENTATION OF HAWAI‘I’S SWAP

Implementation of certain elements of Hawai‘i’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 Hawai‘i’s Species of Greatest Conservation Need (SGCN) and to implement the SWAP. These efforts will be continued and enhanced where possible during implementation of the SWAP using a variety of funding sources.

In the coming years, the State Wildlife Grant (SWG) program will specifically fund projects to implement the following objectives:

1) Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive:
- Forest bird habitat restoration on Maui;
- Development of predator-proof fencing to protect endangered land and tree snails on O‘ahu; and
- Seabird habitat management on Kaua‘i.

2) Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication:
- Predator control for O‘ahu ‘elepaio (*Chasiempis sandwichensis ibidis*) and seabirds on O‘ahu; and
- predator control for forest birds on Kaua‘i 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, Kaua‘i, O‘ahu, and Hawai‘i;
- Surveys for nest colony locations of ‘ua‘u and ‘a‘o;
- Research on Blackburn's sphinx moth populations; and
- Survey and monitoring of population status of, threats to, and the success of predator control efforts to protect native terrestrial snails on O‘ahu.

In addition, other sources of state and federal funding are being used to address all seven objectives in the next fiscal year. For example, the DLNR general fund budget supports management of existing NARs and watershed management projects, and the State Legislature included a line-item of 4 million dollars in the state budget for each of Fiscal Years 2015 and 2016 to address invasive species issues. Federal funds through grant programs administered by USFWS, NOAA, and U.S. Forest Service are used to protect habitat and control invasive species. A variety of funding sources are used to support research and outreach efforts. The successful partnerships and collaboration on SWAP projects will continue.

ADAPTIVE MANAGEMENT AND THE TEN-YEAR REVISION

Evaluation of Hawai‘i’s SWAP is 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.

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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.

Loʻi: irrigated terrace, especially for taro, but also for rice: paddy.

Maui Nui: the islands of Molokaʻi, Lānaʻi, Maui, and Kahoʻolawe.

Native: species that occur naturally in a particular area (e.g., not introduced by humans or human activity). The term "native" is commonly used to describe both endemic and non-endemic indigenous species.

Niche: the function or role of an organism in an ecosystem or the habitat an organism occupies in the ecosystem.

Non-Point Source Pollution: water pollution that comes from many diffuse sources rather than from a specific point, such as an outfall pipe, and is often the result of human activities.

Phenology: temporal aspects of a species' biology (e.g., timing of a species' reproductive cycle).

Philopatry: the characteristic of remaining near or returning to a particular area (e.g., natal territory). Used to describe species that tend to remain in, or return to, their home area.

Phytophagous: same as herbivorous (plant eating), but often associated with insects that pierce and suck liquids from plants.

Phytoremediation: the process of cleaning up pollutants especially in water or soil using plants.

PEPP: Plant Extinction Prevention (PEP) Program

Point Source Pollution: pollution from any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including, (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels.

Precocial: offspring that exhibit a high level of independent activity from hatching. Usually applies to birds or mammals.

Recovery Habitat: term used by the U.S. Fish and Wildlife Service for areas identified in Recovery Plans and determined to be necessary for long-term survival and recovery of endangered species.

Shield Volcano: defined by the U.S. Geological Service to refer to volcanoes with broad, gentle slopes, built by the eruption of fluid basalt lava.

Species: a group of closely related, interbreeding organisms that produce fertile offspring.

Stochastic: unpredictable or by chance.

Subsidence: the downward movement of the earth's surface in relation to a reference point such as sea level.

Taxa (plural of taxon): groupings of organisms given formal taxonomic names such as species, genus, family, etc.

Ungulates: hooved animals such as cattle, goats, deer, sheep, and pigs.

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	T	*Lasiurus cinereus semotus*	Hawaiian hoary bat	ʻōpeʻapeʻa	ʻŌpeʻapeʻa	**X**		**X**	**X**		**X**		**X**		**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis ibidis*	Oʻahu ʻelepaio	ʻelepaio	Oahu ʻelepaio			**X**							**E**	**E**
Forest Birds	T	*Chasiempis sandwichensis sandwichensis*	Hawaiʻi ʻelepaio	ʻelepaio	Hawaiʻi ʻelepaio								**X**			
Forest Birds	T	*Chasiempis sandwichensis sclateri*	Kauaʻi ʻelepaio	ʻelepaio	Kauaʻi ʻelepaio	**X**										
Forest Birds	T	*Corvus hawaiiensis*	Hawaiian crow	ʻalalā	Hawaiian Crow								X		**E**	**E**
Forest Birds	T	*Hemignathus flavus*	Oʻahu ʻamakihi	ʻamakihi	Oʻahu ʻamakihi			**X**								
Forest Birds	T	*Hemignathus kauaiensis*	Kauaʻi ʻamakihi	alawī kihi	Kauaʻi ʻamakihi	**X**										
Forest Birds	T	*Hemignathus lucidus affinis*	Maui nuku puʻu	nuku puʻu	Maui nuku puʻu						X				**E**	**E**
Forest Birds	T	*Hemignathus lucidus hanapepe*	Kauaʻi nuku puʻu	nuku puʻu	Kauaʻi nuku puʻu	X									**E**	**E**
Forest Birds	T	*Hemignathus munroi*	ʻakiapōlāʻau	ʻakiapōlāʻau	ʻAkiapōlāʻau								**X**		**E**	**E**
Forest Birds	T	*Hemignathus parvus*	Lesser ʻamakihi	ʻanianiau	ʻAnianiau	**X**										
Forest Birds	T	*Hemignathus procerus*	Kauaʻi ʻakialoa	ʻakialoa	Kauaʻi ʻakialoa	X									**E**	**E**
Forest Birds	T	*Hemignathus virens*	Hawaiʻi ʻamakihi	ʻamakihi	Hawaiʻi ʻamakihi				**X**	X	**X**		**X**			
Forest Birds	T	*Hemignathus virens wilsoni*	Maui ʻAmakihi	ʻAmakihi	see: Hawaiʻi ʻamakihi					X	**X**					**E**
Forest Birds	T	*Himatione sanguinea*	ʻapapane	ʻapapane	ʻApapane	**X**		**X**	**X**	**X**	**X**		**X**			
Forest Birds	T	*Loxioides bailleui*	Palila	palila	Palila								**X**		**E**	**E**
Forest Birds	T	*Loxops caeruleirostris*	Kauaʻi ʻākepa	ʻakekeʻe	ʻAkekeʻe	**X**									**E**	**E**
Forest Birds	T	*Loxops coccineus coccineus*	Hawaiʻi ʻākepa	ʻākepa	ʻĀkepa								**X**		**E**	**E**
Forest Birds	T	*Loxops coccineus ochraceus*	Mauʻi ʻākepa	ʻākepa	Maui ʻākepa						X				**E**	**E**
Forest Birds	T	*Melamprosops phaeosoma*	Poʻouli	poʻouli	Poʻouli						**X**				**E**	**E**
Forest Birds	T	*Moho bishopi*	Bishop's ʻōʻō	ʻōʻō	Bishop's ʻōʻō				X		X?					
Forest Birds	T	*Moho braccatus*	Kauaʻi ʻōʻō	ʻōʻō ʻāʻā	Kauaʻi ʻōʻō	X									**E**	**E**
Forest Birds	T	*Myadestes lanaiensis*	Molokaʻi thrush	olomaʻo	Olomaʻo			X?	X	X	X?				**E**	**E**
Forest Birds	T	*Myadestes myadestinus*	Large Kauaʻi thrush	kāmaʻo	Kāmaʻo	X									**E**	**E**
Forest Birds	T	*Myadestes obscurus*	Hawaiʻi thrush	ōmaʻo	Ōmaʻo								**X**			
Forest Birds	T	*Myadestes palmeri*	Small Kauaʻi thrush	puaiohi	Puaiohi	**X**									**E**	**E**
Forest Birds	T	*Oreomystis bairdi*	Kauaʻi creeper	ʻakikiki	ʻAkikiki	**X**									**E**	**E**
Forest Birds	T	*Oreomystis mana*	Hawaiʻi creeper	none	Hawaiʻi creeper								**X**		**E**	**E**

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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
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

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Group	Habitat*	Scientific Name	Common Name	Hawaiian Name	Fact sheet	Kauaʻi	Niʻihau	Oʻahu	Molokaʻi	Lānaʻi	Maui	Kahoʻolawe	Hawaiʻi	NWHI	**Federal	**State
Seabirds	T	*Puffinus auricularis newelli*	Newell's shearwater	ʻaʻo	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	kaʻupu	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	ʻou	Bulwer's Petrel	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Seabirds	T	*Puffinus pacificus*	Wedge-tailed shearwater	ʻuaʻu 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	koaʻe kea	White-tailed Tropicbird	**X**		**X**	**X**	**X**	**X**		**X**	**X**		
Seabirds	T	*Phaethon rubricauda*	Red-tailed tropicbird	koaʻe ʻula	Red-tailed Tropicbird	**X**		**X**		**X**		**X**		**X**		
Seabirds	T	*Sula dactylatra*	Masked (blue-faced) booby	ʻā	Masked (blue-faced) Booby			**X**			**X**			**X**		
Seabirds	T	*Sula leucogaster*	Brown booby	ʻā	Brown Booby	**X**		**X**						**X**		
Seabirds	T	*Sula sula*	Red-footed booby	ʻā	Red-footed Booby	**X**		**X**						**X**		
Seabirds	T	*Fregata minor*	Great frigatebird	ʻiwa	Great Frigatebird	**X**		**X**						**X**		
Seabirds	T	*Sterna lunata*	Gray-backed tern	pākalakala	Gray-backed Tern			**X**						**X**		
Seabirds	T	*Sterna fuscata*	Sooty tern	ʻewaʻewa	Sooty Tern			**X**						**X**		
Seabirds	T	*Anous stolidus*	Brown noddy	noio-kōhā	Brown Noddy			**X**			**X**			**X**		
Seabirds	T	*Anous minutus*	Black noddy	noio	Black Noddy	**X**		**X**	**X**	**X**	**X**	**X**	**X**	**X**		
Seabirds	T	*Procelsterna cerulea*	Blue-gray noddy	none	Blue-gray Noddy									**X**		
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**

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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**

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Invertebrates - snails	T	*Amastra cylindrica*	O‘ahu terrestrial snail	none	*Amastra cylindrica*			**X**								
Invertebrates - snails	T	*Amastra spirizona*	O‘ahu terrestrial snail	none	*Amastra spirizona*			**X**								
Invertebrates - snails	T	*Auriculella pulchra*	O‘ahu tree snail	none	*Auriculella pulchra*			**X**								
Invertebrates - snails	T	*Cookeconcha hystricella*	O‘ahu tree snail	none	*Cookeconcha hystricella*			**X**								
Invertebrates - snails	T	*Kaala subrutila*	O‘ahu terrestrial snail	none	*Kaala subrutila*			**X**								
Invertebrates - snails	T	*Laminella aspera*	Maui terrestrial snail	none	*Laminella aspera*						**X**					
Invertebrates - snails	T	*Laminella sanguinea*	O‘ahu terrestrial snail	none	*Laminella sanguinea*			**X**								
Invertebrates - snails	T	*Newcombia cumingi*	Newcomb's tree snail	none	*Newcombia cumingi*						**X**				**E**	**E**
Invertebrates - snails	T	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*	Lāna‘i tree snail	pupu kani oe	*Partulina semicarinata*					**X**					**E**	**E**
Invertebrates - snails	T	*Partulina tessellata*	Molokai tree snail	none	*Partulina tessellata*				**X**							

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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											

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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**

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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**		

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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**			

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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**			

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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											

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Species						Island Distribution (Current (bold) and historic (unbold))									Status	
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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	‘īlio-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	nai‘a	Spotted Dolphin											
Mammals	M	*Stenella coeruleoalba*	Striped dolphin	none	Toothed Whales											
Mammals	M	*Stenella longirostris*	Spinner dolphin	nai‘a	Spinner Dolphin											
Mammals	M	*Steno bredanensis*	Rough-toothed dolphin	nai‘a	Toothed Whales											
Mammals	M	*Tursiops truncatus*	Pacific bottlenose dolphin	nai‘a	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**

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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											

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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											

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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											

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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											

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Fishes	M	*Istiblennius zebra*	Zebra blenny	pāo'o	Cryptic Reef Fishes											
Fishes	M	*Kuhlia xenura*	Hawaiian flagtail (Hoover, 1993, 2003; Randall, 1996a), Mountain bass (DLNR)	āholehole	Flagtail											
Fishes	M	*Kumba hebetata*	none	none	Deep Fishes											
Fishes	M	*Lepidammodytes macrophthalmus*	none	none	Active Reef Fishes											
Fishes	M	*Linophryne escaramosa*	none	none	Deep Fishes											
Fishes	M	*Liopropoma aurora*	Sunset bass	none	Sex Changers											
Fishes	M	*Lophiodes bruchius*	none	none	Deep Fishes											
Fishes	M	*Luciobrotula lineata*	none	none	Deep Fishes											
Fishes	M	*Malacocephalus hawaiiensis*	Hawaiian softhead grenadier	none	Deep Fishes											
Fishes	M	*Microbrotula rubra*	none	none	Deep Fishes											
Fishes	M	*Nezumia ectenes*	none	none	Deep Fishes											
Fishes	M	*Nezumia holocentra*	none	none	Deep Fishes											
Fishes	M	*Ophichthus fowleri*	Fowler's snake eel	none	Eels											
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											

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Fishes	M	*Plectroglyphidodon sindonis*	Hawaiian rock damselfish	none	Active Reef Fishes											
Fishes	M	*Pleurosicya larsonae*	none	none	Cryptic Reef Fishes											
Fishes	M	*Poecilopsetta hawaiiensis*	none	none	Flatfishes											
Fishes	M	*Priacanthus meeki*	Hawaiian bigeye	'āweoweo	Active Reef Fishes											
Fishes	M	*Pristipomoides auricillia*	Glodflag jobfish	kali kali	Bottomfishes											
Fishes	M	*Pristipomoides filamentosus*	'Ōpakapaka	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											

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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	mūheʻe	Cephalopods											
Cephalopods	M	*Octopus hawaiiensis*	Hawaiian Octopus	heʻe	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	ʻalakuma	Other Crustaceans											
Crustaceans	M	*Cinetorhynchus hawaiiensis*	Hawaiian hinge-beak shrimp	none	Other Crustaceans											

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	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											

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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											

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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											

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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											

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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											

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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											

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Cnidaria	M	*Placotrochus fuscus*	none	none	Stony Corals											
Cnidaria	M	*Pocillopora damicornis*	Lace coral	ʻākoʻakoʻa	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, ʻākoʻakoʻa	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, ʻākoʻakoʻa	Stony Corals											
Cnidaria	M	*Porites lichen*	Lichen coral	none	Stony Corals											
Cnidaria	M	*Porites lobata*	Lobe coral	pō haku puna, ʻākoʻakoʻa	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	ʻākoʻakoʻa	Stony Corals											

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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											

APPENDIX C: OVERVIEW OF MANAGEMENT PROGRAMS AND EXISTING REGULATIONS

A variety of land and water management programs and existing regulations protect Hawai‘i’s native species and their habitats. This appendix provides an overview of these protections, first outlining the land and water management by federal, state, county, and private entities, then describing existing regulations in order from international, federal, state, and local protections.

LAND AND WATER MANAGEMENT PROGRAMS

National Parks

The National Park system, operated by the National Park Service of the U.S. Department of Interior, was established to preserve natural areas (including scenery, natural and historic features, and wildlife) in the United States so that they can be enjoyed by current generations and preserved for future generations. The protection, management, and administration of these areas are to be conducted in light of the high public value and integrity of the National Park System. There are nine national park units in Hawai‘i: Haleakalā National Park (Maui); Kalaupapa National Historical Park (Moloka‘i); Hawai‘i Volcanoes National Park (Hawai‘i); Kaloko-Honokōhau National Historical Park (Hawai‘i); Pu‘uhonua O Hōnaunau National Historical Park (Hawai‘i); Ala Kahakai National Historic Trail (Hawai‘i); Pu‘ukoholā Heiau National Historic Site (Hawai‘i), the U.S.S. Arizona Memorial (O‘ahu); and the most recent addition, Honouliuli National Monument (O‘ahu).

National Wildlife Refuges

Over 500 National Wildlife Refuges (NWRs) across the United States form a system of habitats managed by the U.S. Fish and Wildlife Service (USFWS) of the U.S. Department of Interior. Hawai‘i’s Refuges were established to protect the Islands’ unique native plants and animals and their habitats. There are eleven wildlife refuges in Hawai‘i: Hawaiian Islands NWR (Northwestern Hawaiian Islands, including marine waters), Hanalei NWR (Kaua‘i), Hulē‘ia NWR (Kaua‘i), Kīlauea Point NWR (Kaua‘i), O‘ahu Forest NWR (O‘ahu), James Campbell NWR (O‘ahu), Pearl Harbor NWR (O‘ahu), Keālia Pond NWR (Maui), Kakahai‘a NWR (Moloka‘i), Hakalau Forest NWR (Hawai‘i), and Midway Atoll NWR (an unincorporated territory of the United States administered as a National Wildlife Refuge).

U.S. Military Installations – Integrated Natural Resources Management Plans

The Sikes Act Improvements Act of 1997 required every military installation containing land and water suitable for the conservation and management of natural resources to complete an Integrated Natural Resources Management Plan (INRMP). The purpose of these INRMPs is to integrate the mission of the military installation with stewardship of the natural resources found there. There are several INRMPs covering military installations in Hawai‘i, including:

- Oahu INRMP (covers U.S. Army installations at Dillingham Military Reservation, Kahuku Training Area, Kawailoa Training Area, Mākua 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 Hawai‘i 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 Hawai‘i (Hawai‘i Revised Statutes [HRS] Chapter 195). The NARS are managed by the State DLNR, Division of Forestry and Wildlife (DOFAW). Each Natural Area Reserve was established based on the concept of protecting ecosystems rather than individual species, with the goal of preserving and protecting representative samples of Hawaiian biological ecosystems and geological formations. There are 21 NARs in Hawai‘i covering more than 50,000 hectares (123,000 acres): Hono o Na Pali (Kaua‘i), Ku‘ia (Kaua‘i), Ka‘ena Point (O‘ahu), Kaluanui (O‘ahu), Pahole (O‘ahu), Mt. Ka‘ala (O‘ahu), West Maui (Maui), Hanawī (Maui), ‘Āhihi-Kīna‘u (Maui) (contains both terrestrial and marine acreage), Kanaio (Maui), Nakula (Maui), Oloku‘i (Moloka‘i), Pu‘u Ali‘i (Moloka‘i), Manukā (Hawai‘i), Kīpāhoehoe (Hawai‘i), Mauna Kea Ice Age (Hawai‘i), Waiākea 1942 Flow (Hawai‘i), Kahauale‘a (Hawai‘i), Pu‘u Maka‘ala (Hawai‘i), Laupāhoehoe (Hawai‘i), and Pu‘u o ‘Umi (Hawai‘i).

State Forest Reserves
The State Forest Reserves were first established in Hawai‘i over a century ago to protect the water supply that was being threatened due to the destruction of the forest by cattle (HRS Chapter 183). The Forest Reserves are managed by DOFAW. Limited collecting for personal use (e.g., ti leaves and bamboo) and limited (no more than $3,000 value per year) commercial harvesting of timber, seedlings, greenery, and tree ferns is allowed by permit. There are 55 forest reserves on the five major islands (Kaua‘i, O‘ahu, Maui,

Moloka‘i, and Hawai‘i), 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 (Hawai‘i Administrative Rules (HAR) §§ 13-105-1 et seq.). Six restricted watersheds on O‘ahu (three) and Hawai‘i (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 Alaka‘i Wilderness Preserve on Kaua‘i, covering just over 3,600 hectares (9,000 acres) on the summit plateau of Mt. Wai‘ale‘ale, 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 (O‘ahu), Pouhala Marsh (O‘ahu), Hamakua Marsh (O‘ahu), Kawainui Marsh (O‘ahu), Kanahā Pond Wildlife Sanctuary (Maui), Kīpuka ‘Āinahou Nēnē Sanctuary (Hawai‘i), Puu Waawaa Forest Bird Sanctuary (Hawai‘i), and the Hawai‘i State Seabird Sanctuary (multiple islands offshore of the Main Hawaiian Islands and two islands of Kure Atoll in the Northwestern Hawaiian Islands).

State Parks
There are 52 state parks encompassing nearly 10,000 hectares (25,000 acres) on all the Main Hawaiian Islands. These parks are managed for outdoor recreation and heritage opportunities and range from landscaped grounds with developed facilities to wildland areas with trails and primitive facilities (HRS Chapter 183).

Leased and Unencumbered Lands
The DLNR Division of Land Management manages state lands not set aside to agencies or otherwise encumbered or designated for a specific land use. Some of these lands are leased by auction to private landowners, while lands that are not under lease are called “unencumbered lands.” Unencumbered lands are often beach or coastal areas in the Conservation District (see below under State Land Use Districting) but do not include parks, harbors, or forest reserves.

Hawaiian Home Lands
The Department of Hawaiian Home Lands manages approximately 82,000 hectares (203,000 acres) in trust for Native Hawaiians. The mission of the Department of Hawaiian Home Lands is to manage the Hawaiian Home Lands trust effectively and to develop and deliver land to Native Hawaiians. The Department will partner with others towards developing self-sufficient and healthy communities.

Commission on Water Resources Management
The Commission on Water Resources Management within the DLNR is mandated by Chapter 174C of the Hawai‘i Revised Statutes to set policies, protect resources, defines uses, establish priorities while assuring rights and uses, and establish regulatory procedures for inland surface water and ground water resources. The Commission designates and manages water management areas and is responsible for protecting instream uses of water, including maintaining the biological integrity of aquatic wildlife.

State Marine Waters
DAR manages marine and freshwater areas throughout the state under general management authority from Hawai‘i Revised Statutes Chapters 188 and 190. These areas include 11 Marine Life Conservation Districts (MLCDs), 19 Fishery Management Areas (FMAs), three Public Fishing Areas (PFA), two Wildlife Sanctuaries, and the South Kona ‘ōpelu 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 Hawai‘i 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 Hawai‘i.

Kaho‘olawe Island Reserve
In late 1990, the U.S. Department of Defense stopped using Kaho‘olawe for bombing and target practice and shortly thereafter began a Congressionally-funded clean-up of the island. In 1993, the Hawai‘i State Legislature established the Kaho‘olawe Island Reserve to protect the entire island and surrounding coastal waters extending two miles seaward and established the Kaho‘olawe 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 Hawai‘i’s biosecurity system. These include the Hawai‘i Invasive Species Council (HISC), to provide cabinet-level leadership, the Coordinating Group on Alien Pest Species (CGAPS), for interagency and non-governmental organization communications and collaborative projects, and the Invasive Species Committees (ISCs) for island-based rapid response.

HISC was created in 2003 to advise the Governor on issues regarding invasive species, create and implement an invasive species plan, review state agency mandates and commercial interests, and suggest appropriate legislation to improve the State’s administration of invasive species programs and policies. HISC, under the co-leadership of the State Department of Agriculture and DLNR, comprises the leaders of the University of Hawai‘i, the State Department of Business, Economic Development and Tourism, State Department of Health, and State Department of Transportation, with an invitation to participate issued to the Hawai‘i State Legislature, county mayors, State Department of Defense, State Department of Commerce and Consumer Affairs, State Department of Hawaiian Home Lands, federal agency representatives, and non-profit agency representatives. Hawai‘i is the sixth state in the nation to create this type of council.

CGAPS was formed in 1995 and is composed of primarily management-level participants from every major agency and organization involved in invasive species work including federal, state, county, and private entities. Members meet quarterly to discuss how to influence policy and funding decisions, improve communications, increase collaborations, and promote public awareness.

The first ISC was formed on Maui in 1997 in response to the need for an early detection and rapid on-the-ground response to an array of incipient invasive species, and one is now on every major Hawaiian island (Kaua‘i, O‘ahu, Maui, Moloka‘i, and Hawai‘i). The ISCs are voluntary partnerships of private, government, non-profit organizations, and individuals working together to address invasive species issues particular to the island. The overall goal of the ISCs is to prevent, eradicate, or control priority incipient plant and animal species that threaten Hawai‘i’s most intact federal, state, and private conservation lands.

In addition, there are working groups specific to high-priority potential invasive species. Examples include the West Nile Virus Prevention Group, the Brown Tree Snake Rapid Response Team, and the Axis Deer (*Axis axis*) Rapid Response Team. The West Nile Virus Prevention Group is composed of a broad coalition of government agencies and non-governmental organizations, including the State Department of Agriculture, DLNR, the Department of Health, the federal Department of Agriculture, USFWS, the U.S. Geological Survey Biological Resources Division, the U.S. Postal Service, the University of Hawai‘i, the

Hawaiian Humane Society, the Honolulu Zoo, Ducks Unlimited, and The Nature Conservancy (TNC) of Hawai‘i. The West Nile Virus Prevention Group has developed a plan to respond to, track, and limit the spread of West Nile virus in Hawai‘i. A multi-agency Brown Tree Snake Rapid Response Team has been formed to address potential brown tree snake sightings in Hawai‘i. Members travel to Guam for regular training in how to search for and capture brown tree snakes, as one method to prevent the establishment of this animal. The Axis Deer Rapid Response Team was funded by DLNR and HISC in 2011 to eliminate this new pest. Four deer were shot in 2012-2013 and no deer sightings have been confirmed since.

Watershed partnerships

The first watershed partnership was established in East Maui in 1991 by the State DLNR, the National Park Service, the county of Maui, the East Maui Irrigation Company, TNC, Keola Hana Maui, and Haleakalā Ranch Company in recognition that active management was needed to sustain a healthy forested watershed and that effective management is best achieved through coordinated actions of all major landowners in the watershed. Since that time, watershed partnerships have now been established on five islands: Kaua‘i Watershed Alliance (Kaua‘i, 2003), Ko‘olau Mountains Watershed Partnership (O‘ahu, 1999), Wai‘anae Mountains Watershed Partnership (O‘ahu, 2010), West Maui Mountains Watershed Partnership (Maui, 1998), East Maui Watershed Partnership (Maui, 1991), Leeward Haleakalā Watershed Restoration Partnership (Maui, 2003), East Moloka‘i Watershed Partnership (Moloka‘i, 1999), Three Mountain Alliance (Hawai‘i, 2007), the Kohala Mountains Watershed Partnership (Hawai‘i, 2004), and the Mauna Kea Watershed Alliance (Hawai‘i, 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 Hawai‘i 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 Kaua‘i 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 ‘akohekohe (*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

Hawai‘i, the Hawai‘i Department of Agriculture, USFWS, the U.S. Forest Service, the National Park Service, the U.S. Geological Survey Biological Resources Division, the U.S. Department of Agriculture, the U.S. Army Garrison Hawai‘i Natural Resources Management, Bishop Museum, HISC, the Hawai‘i Alliance of Watershed Partnerships, the Hawai‘i Wildlife Fund, the University of California Berkeley, and Cornell University. The objective of the initiative is to develop long-term strategies for the assessment, management, and conservation of invertebrate species and the habitats in which they occur. The initiative partners are also focusing on immediate tasks to:

1. Identify and prioritize invertebrate conservation needs for species and habitats of greatest concern across the state;
2. Analyze existing expertise, and research completed to date, to understand gaps in our knowledge base,
3. Identify and prioritize future research needs;
4. Develop a standard method of classifying threats to, or status of, a given species;
5. Identify and prioritize management strategies that address or mitigate current threats to invertebrate conservation;
6. Develop a means of measuring conservation successes; and
7. Examine current and future funding available to pursue action on items 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 Hawai‘i: Pu‘u Kukui (Maui), Kapunakea (Maui), Waikamoi (Maui), Waikamoi (East Maui Irrigation) (Maui), Mo‘omomi (Moloka‘i), Kamakou (Moloka‘i), Pelekunu (Moloka‘i), Kanepu‘u (Lāna‘i), and Ka‘ū (Hawai‘i).

The Nature Conservancy Preserves

TNC Hawai‘i is a private, non-profit affiliate of the national organization, with a goal to bring active, protective management to representative, viable, native ecological systems and species of the Hawaiian Archipelago, and to thereby sustain the greatest possible complement of native Hawaiian biodiversity into the future. In addition to managing seven of the nine NAP preserves, TNC manages other protected areas: ‘Ihi‘ihilauakea Preserve (O‘ahu), Wainiha Preserve (Kaua‘i), and Kona Hema Preserve (Hawai‘i). Additional conservation management is conducted through cooperation with private landowners.

National Tropical Botanical Gardens

The National Tropical Botanical Garden (NTBG) is dedicated to the conservation of tropical plant diversity, particularly rare and endangered species. The NTBG, which is

supported by private contributions, operates three gardens on 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 Hawai‘i. The Department administers the National Pollutant Discharge Elimination System (NPDES) permit program, issues Clean Water Act Section 401 Water Quality Certifications for federal permits for construction in nearshore and inland waters, and partners to develop best management practices for non-point source pollution control. The Department promotes community-based watershed management through education and voluntary compliance with environmental management standards.

State Environmental Review Requirements

Hawai‘i State law establishes a system of environmental review to ensure that environmental concerns are given appropriate consideration in decision-making (HRS Chapter 343). Similar to NEPA, Hawai‘i law requires environmental assessments or environmental impact statements (depending on the impacts of the project) to be prepared for any project occurring in the Conservation District, as well as any project using state or county lands or funds. There are six other triggers for environmental review that more rarely operate to benefit native species (e.g., construction within the Waikīkī Special District).

Enforcement of Conservation Regulations

The DLNR Division of Conservation and Resource Enforcement (DOCARE), the U.S. Coast Guard, the NOAA Office of Law Enforcement, the U.S. Navy, the U.S. Marine Corps Base Hawai‘i, and the county police departments all play a role in enforcing the conservation regulations of the state.

Coastal Zone Management

The federal Coastal Zone Management (CZM) Program was created through passage of the Coastal Zone Management Act of 1972. The program for Hawai‘i was approved in 1977 (HRS Chapter 205A), and is administered through the Department of Business, Economic Development and Tourism Coastal Zone Management Program (CZM Hawai‘i). Within a framework of cooperation among federal, state, and local levels, CZM Hawai‘i employs a wide variety of regulatory and non-regulatory techniques to address coastal issues and uphold environmental law. Among them are stewardship, planning, permitting, education and outreach, technical assistance to local governments and permit applicants, policy development and implementation, and identification of emerging issues and exploration of solutions. CZM Hawai‘i is leading the preparation of a framework for updating the Ocean Resources Management Plan. CZM Hawai‘i is mandated to develop and implement a Coastal Nonpoint Pollution Control Program which is to be approved by NOAA and the Environmental Protection Agency.

Special Management Areas

As mandated by the Hawai‘i Coastal Zone Management program, counties are responsible for administering permits for development in SMAs located along the shoreline. The intent of this permitting process is to avoid the permanent loss of valuable resources and to ensure adequate access to beaches, recreation areas, and natural reserves (HRS Chapter 205A). Although SMAs are defined to include all lands extending no fewer than 91 meters (100 yards) inland from the shoreline, counties can amend their boundaries to achieve certain Coastal Zone Management objectives. Amendments removing areas from an SMA are subject to state review for compliance with the coastal law.

County Zoning

Counties are responsible for reviewing development in the Agricultural, Rural, and Urban Districts. The Agricultural District includes both “good” farm land and “junk” land that is unsuitable for farming or ranching. “Junk” land includes gulches, steep hillsides, rocky land, and on Maui and the Big Island, even relatively recent lava flows having little or no topsoil. Crops, livestock, and grazing are permitted in the Agricultural District, as are accessory structures and farmhouses. Although land in the Agricultural District is not meant to be urbanized, it has, in practice, been used for large-lot subdivisions. These subdivisions can be designed for “residential” development (i.e., housing units targeted at Hawai‘i residents) or high-end “resort/residential” development (i.e., housing units targeted at non-Hawai‘i residents and associated with resorts). The Urban and Rural Districts in each county are subject to county land use and development (commercial, industrial, residential, etc.) regulations, including county community plans, zoning, and building code regulations.

Areas for Management of Species and Habitats on the Island of Maui