PACIFIC COAST JOINT VENTURE HAWAI`I

STRATEGIC PLAN FOR WETLAND CONSERVATION IN HAWAI`I

1st REVISION
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Waihe`e Wetland and Coastal Sand Dune Preserve, Maui
Photo by Dale Bonar

Photo by Sharon Reilly

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HAWAI`I

STRATEGIC PLAN FOR WETLAND CONSERVATION IN HAWAI`I

REVIEW DRAFT
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For
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In Collaboration with Conservation Partners in Hawai`i

Federal Government Agencies
U.S. Fish and Wildlife Service, U.S.D.A. Natural Resources Conservation Service, U. S. Geological Survey, National Park Service, U. S. Army Corps of Engineers, U.S. Forest Service Pacific Islands Research Institute

State of Hawaii
Department of Land and Natural Resources, Department of Health

Local Government
County of Maui, City and County of Honolulu, County of Kaua`i, County of Hawai`i

Non-governmental Organizations
Maui Coastal Land Trust, Kauai Land Trust, Trust for Public Land, The Nature Conservancy, Hawai`i Natural Heritage Program, National Tropical Botanical Garden, Bishop Museum, Gaylord Memorial Laboratory, Kamehameha Schools, and landowners who have supported conservation on private lands

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Mahalo!

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EXECUTIVE SUMMARY

The mission of the Pacific Coast Joint Venture strategic plan in Hawai`i is to facilitate ecosystem conservation through protection, restoration, enhancement and management, advocacy, and outreach.

The Pacific Coast Joint Venture (PCJV) strategic plan for Hawai`i is a plan for waterbirds and wetlands, but it is designed to address more species and broader ecosystem management. Wildlife species and habitats cannot be managed in isolation. Many species, including birds, fish, and marine mammals, are migratory and use different habitats to fulfill varying life history requirements. Effective conservation in Hawai`i will combine multiple strategies across multiple sites to fulfill archipelago-wide conservation goals.

The goal of the PCJV is to "protect, restore, increase, and enhance all types of wetlands, riparian habitats, and associated uplands throughout the Pacific Coast region to benefit birds, fish, and other wildlife." In other regions of the Pacific Coast the PCJV has proved to be a good working model for protection of fish and wildlife habitats.

To advance its goals, the PCJV employs six strategies: protection, restoration, enhancement and management, advocacy, outreach, and research.

- *Protection* involves the acquisition of land or conservation easements from private landowners who are willing to sell, donate, or exchange land interests to government agencies or conservation organizations. This strategy ensures habitats will be safeguarded from future development or other actions have permanent negative impacts.
- *Restoration* activities return degraded habitats to their "natural" ecological condition. Benchmarks for restoration of habitat in Hawai`i include pre-European contact and pre-Polynesian settlement. Successful restoration projects restore biotic communities and physical processes that control biological succession and natural disturbance regimes.
- *Enhancement & Management* strategies increase the capacity and diversity of habitats. Management is an important tool for controlling invasive vegetation and introduced predators. Water-level management is an important tool for increasing the productivity of wetlands with altered hydrologic regimes.
- *Advocacy* to promote and support issues habitat conservation. This includes, but is not limited to, seeking funding for appropriate programs, projects, and activities, participating in resource management and land use planning, and maintaining close contact with elected representatives at all levels of government.
- *Outreach & Education* help to build a strong base of public support for protection, restoration, and enhancement of wetlands and associated upland and aquatic habitats. Successful conservation cannot be achieved without community support. Outreach and education strategies are aimed at broadening the public's awareness of the importance of natural habitats. Outreach activities include, but are not limited to, school-based educational programs, agricultural extension efforts, wildlife viewing, and eco-tourism programs.
- *Research* provides managers with the best available scientific information for effective restoration and management techniques. Compared with wetland ecosystems in the

continental United States, limited information is available on the biological and physical dynamics of wetlands in Hawai`i. The PCJV in Hawai`i supports research that is applied, effectively communicated, uses new technologies, and promotes partnerships.

Habitat goals for the PCJV strategic conservation plan in Hawai`i represent long ranging concepts that provide direction for conservation objectives and actions. They are based on the strategies identified by the PCJV and support goals identified by other avian conservation plans for Hawai`i. The five habitats goals of the PCJV in Hawai`i are to:

1. Protect existing, degraded, and altered wetlands through acquisition, conservation easements, and cooperative landowner agreements to ensure natural habitats will be preserved in perpetuity.
2. Maintain, enhance, and manage existing wetlands and associated uplands that provide functional and dynamic habitats for waterbirds and wetland-associated wildlife, contribute to resilient watershed functionality, and promote ecosystem management.
3. Restore degraded and altered habitats that historically supported wetlands and associated uplands to increase the quantity and availability of native habitats to benefit populations of native birds, fish, and other wildlife.
4. Support adaptive management and applied research programs that provides managers with the best available scientific information for effective and efficient restoration and management techniques.
5. Support education and outreach programs for schools, aquaculture farmers, and the general public to increase their awareness of the importance of natural habitats, communicate best management practices for farmed wetlands, and encourage eco-tourism benefits.

Through collaborative efforts, the PCJV is currently developing quantifiable habitat objectives to achieve these goals. These objectives include areas identified as priority wetland sites by the U. S. Fish and Wildlife Service, State of Hawai`i, and numerous avian conservation plans.

In addition, this PCJV strategic goes a step beyond other management plans developed for Hawai`i. It identifies areas that do not currently provide productive habitat for native plants or animals due to invasive species and hydrological and/or substrate modifications. These areas, priorities for protection and restoration, will ultimately increase the availability of habitats for endangered waterbirds once restored and effectively managed.

Population goals for the PCJV in Hawai`i are consistent with those developed by the U.S. Fish and Wildlife Service for species listed as threatened or endangered under the Endangered Species Act and other avian conservation plans. Once habitat objectives are collaboratively developed, population goals may be increased to account for additional waterbird numbers that can be sustained on areas not currently identified by other conservation plans (e.g., potential wetlands not yet restored).

This plan provides an overview of national, regional, and state-wide avian conservation plans and describes existing habitat protection within Hawai`i (Part I). Focusing on wetland ecosystems, Part II describes the natural and cultural resources in Hawai`i. Part III describes habitat and population goals for Hawai`i, and identifies two focus areas, the main Hawaiian

Islands and the Northwestern Hawaiian Islands. Each focus area is divided into target areas listed by island. Target areas may be a single site or an assemblage of sites important for conserving natural resources in Hawai`i.

The PCJV strategic plan for Hawai`i is intended to be a working document. As conservation challenges and knowledge change, the strategic plan will be updated.

The purpose of this draft is to solicit additional information from partners pertaining to habitat and population objectives. Information on habitat acres for protection, restoration, and enhancement was compiled from published and unpublished reports and input from partners provided to date.

Cooperation is essential to developing a strategic plan for ecosystem conservation in Hawai`i. Through the PCJV we combine human and financial resources to achieve long-ranging and ambitious goals. Together we can accomplish amazing actions with multiple benefits. These benefits include:

- The preservation of biological diversity in Pacific coastal ecosystems,
- Increased recreational opportunities,
- More efficient soil, water, reef, and wildlife conservation, and
- New partnerships among wildlife, agricultural, commercial, and industrial entities.

`Ōhi`apilo Playa after restoration, Moloka`i
Photo by Sharon Reilly

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PART I: INTEGRATED CONSERVATION

Approaches to conservation change to suit the times. Over the course of the 20th century, natural resource conservation evolved from local-scale management and research actions focused on single species or single discipline questions to integrated holistic plans for regional or landscape-scale conservation.

During the past few decades this trend accelerated, as advances in technology (e.g., spatial analysis using GIS) coincided with continuing advances in our understanding of physical and ecological processes and wildlife-habitat relationships. As a result, today we can integrate multiple species, habitats, disciplines and spatial scales into our conservation efforts.

This integrated approach to conservation becomes increasingly urgent as the human population grows and human impacts on the environment escalate, forcing wildlife to rely on less land area, fewer resources and less suitable habitats. By addressing the needs of multiple species and taxonomic groups, and by drawing upon the expertise of partners in multiple disciplines, we can carry out the most efficient and effective ecosystem conservation efforts. Equally important, by combining our strengths we can leverage greater and more diverse funding sources.

Integration in conservation efforts requires 6 main components:

1. Detailed conservation plans with defensible, measurable population and habitat-based objectives.
2. Sound scientific information on conservation needs.
3. Focused efforts to look for overlapping opportunities for habitat conservation.
4. Creative management planning when needs of some species are different than other in the same habitat.
5. Cooperation between local conservation projects and regional planning efforts.
6. Strategies to evaluate the impacts of management actions, obtain missing information, and re-evaluate conservation plans as our knowledge base increase and conservation needs change.

This strategic conservation plan integrates the interests of multiple agencies in Hawai`i that share responsibility for wetland related birds and their habitats. Its goals are integrated with the goals of the chief international, national and regional plans that drive avian and wetland conservation funding. And on the ground in Hawai`i, its implementing actions can in turn be integrated with conservation efforts for other avian guilds such as forest passerines and native fishes, and on other landscape scales such as watersheds.

AVIAN CONSERVATION PLANS – NORTH AMERICAN

"Each plan contributes to the development of landscape level wildlife conservation and can contribute significantly to these larger goals as part of a broad partnership for wetland conservation."

Avian conservation efforts in the United States date to the early 1900s with the designation of Pelican Island as the first National Wildlife Refuge. Subsequent decades saw the expansion of the Refuge system and Congressional legislation to protect birds. But from an avian conservation planning perspective, a most significant shift occurred in 1986 with the signing of the North American Waterfowl Management Plan (NAWMP) by the United States and Canada.

NAWMP's strong biological foundation and focus on multiple-scale planning set it apart from most previous conservation efforts. After its inception in 1986, the plan continued to evolve and broaden. Its success provided a template for expanding conservation efforts to other avian species including wading birds, shorebirds, and seabirds. As these planning processes improved, they sparked unprecedented interest in and funding for avian conservation in the western hemisphere (Ruth et al. 2003). At the same time, American recreational enthusiasms expanded from traditional activities such as hunting and fishing to include bird watching, wildlife photography, and eco-tourism, prompting a growing recognition that successful conservation efforts can yield local social and economic benefits.

Today's avian conservation plans provide continental or regional-scale frameworks for conservation and management of diverse species for multiple purposes. They share several common elements:

- Identification of key issues for a specific region and/or guild of birds requiring conservation action
- Emphasis on coordinated implementation of local conservation projects to sustain bird populations and the habitats they depend on.
- Identification of common threats and risks including destruction or degradation of habitats, introduced predators, invasive species, increased pollution, and/or human disturbance
- Identification of information gaps and research needed for effective management of bird populations at large spatial scales
- Identification of dynamic processes for assessing species status and evaluating project effectiveness to inform setting of conservation priorities on a regional scale.
- Promotion of integration with other bird conservation initiatives, when appropriate, in order to provide the best management options for local wildlife and habitat managers.

Working together, a wide array of state, federal, non-governmental, educational, and individual partners prepare an integrated conservation plan. Implementation initiatives are then established to obtain and coordinate funding, and to identify how each partner can play the implementation roles best suited to their focus and skills. Integrated avian conservation plans applicable to Hawai`i are discussed below. Implementation initiatives are addressed in the following section.

North American Waterfowl Management Plan (NAWMP)

Originally signed by the U. S. and Canada, this plan recognized the importance of partnerships in conservation efforts, advocated a sound scientific understanding of waterfowl populations and their interactions with habitats, and identified the need for periodic updates in the future as our knowledge increases and/or threats to waterfowl change. Beginning with the initial goal of maintaining waterfowl populations at or above those of the 1970s, the NAWMP has evolved under the changing context of waterfowl conservation. In 1994, it became a truly continental effort when Mexico joined the partnership, and in 1998 it expanded its vision to recognize the changing socioeconomic context of waterfowl conservation. Over the 20 years since the plan's development, its vision of biologically driven, science-based partnerships focused on landscape-level change has become a reality.

Wetland management and restoration developed rapidly in recent years and NAWMP stimulated significant increases in funding for wetland conservation activities. It promotes a landscape approach to habitat management that seeks to balance conservation and socioeconomic objectives within a region.

United States Shorebird Conservation Plan (USSCP)

Although the USCPP is a national plan, its most recent edition was developed during 2001 in close coordination with the Canadian Shorebird Conservation Plan and with input from Mexico and Australia. The USSCP sets conservation goals at three different spatial scales to ensure that populations for shorebird species occurring in the United States are effectively conserved. Goals of the plan and strategies for each goal are listed below (Brown et al. 2001).

- *Hemispheric Goal*: Restore and maintain stable and self-sustaining populations of all species of shorebirds in the Western Hemisphere.
- *National Goal*: Stabilize populations of all shorebird species known or suspected of being in decline due to limiting factors occurring within the U.S., while ensuring that stable populations are secure.
- *Overall Regional Goal*: Ensure that adequate quantity and quality of habitat is identified and maintained to support the different shorebirds that breed in, winter in, and migrate through each region.
- *Common Regional Goal 1*: Provide sufficient high quality habitat to ensure that shorebirds in each region are not unduly limited by habitat availability or configuration.
- *Common Regional Goal 2*: Ensure that efforts to provide habitat for shorebirds are integrated into multiple species habitat management initiatives where appropriate.
- *Common Regional Goal 3*: Increase understanding of how local habitat conditions affect shorebird abundance and use of a region and, in turn, how conditions affect hemispheric shorebird populations.

North American Waterbird Conservation Plan (NAWCP)

NAWCP was prepared in 2002 by Waterbird Conservation for the Americas, an independent partnership with a vision in which "the distribution, diversity, and abundance of populations and habitats of breeding, migratory, and nonbreeding waterbirds are sustained or restored throughout the lands and waters of North America, Central America, and the Caribbean" (Kushlan et al. 2002:3). The plan includes 29 nations and covers one of the most diverse groups of 166 avian species from 23 families, ranging from herons to rails and albatrosses.

The plan covers more than 83 bird conservation regions (BCR) and outlines the importance of waterbird conservation at multiple scales. It establishes four main goals to attain the waterbird conservation vision for the Americas: 1) Ensure sustainable distribution, diversity, and abundance of waterbird species; 2) Protect, restore, and manage sufficient high quality habitat; 3) Ensure that information on conservation of waterbirds is widely available; and 4) Ensure coordination of conservation efforts that result in integrated conservation actions.

North American Landbird Conservation Plan (NALCP)

Launched in 1990 by Partners in Flight/Companeros en Vuelo/Partenaires d'Envol (PIF), the NALCP responded to concerns about declines in the populations of many land birds, emphasizing conservation of birds not covered by existing conservation initiatives. Originally the plan focused on neotropical migrants, but PIF has since expanded it to include all land birds in the continental US and Canada as well as neotropical migrants. The central premise of PIF is that the resources of public and private organizations in the Western Hemisphere must be combined, coordinated, and increased in order to achieve the greatest success in bird conservation efforts.

AVIAN CONSERVATION PLANS – REGIONAL

U.S. Pacific Islands Regional Shorebird Conservation Plan (PIRSCP)

The PIRSCP (Engilis and Naughton 2005) is one of eleven regional plans developed as part of the USSCP. This plan outlines conservation priorities for four subregions of the Pacific Islands: Hawaiian Islands, Mariana Islands, American Samoa, and Central Pacific Islands Conservation priorities for species objectives are to:

1. Document the distribution and accurately assess abundance of wintering and transient shorebirds in the Pacific Islands.
2. Coordinate with the Alaskan Shorebird Conservation Plan to develop and support population goals for the Pacific golden-plover, bristle-thighed curlew, ruddy turnstone, and wandering tattler.
3. Increase population size and the distribution of the Hawaiian stilt to meet the delisting criteria in the Draft Revised Waterbird Recovery Plan.
4. Determine trends in wintering populations of shorebird species of primary and secondary importance
5. Work with international partners to evaluate the potential for reestablishing Taumotu sandpiper within their historical range.

In addition, priorities are outlined for monitoring, research, management, outreach and education, and implementation and coordination.

Pacific Region Seabird Conservation Plan (PRSCP)

The 2004 draft Pacific Region Seabird Conservation Plan (PRSCP) includes the coastal and offshore areas of California, Oregon, Washington, Hawai`i and the U.S. Pacific Island commonwealths, territories, and possessions. This region supports the most diverse group of seabirds in the U.S. and is second only to Alaska in the total number of breeding seabirds. The PRSCP serves as the foundation for developing cooperative seabird conservation efforts. It identifies priorities for monitoring, management, research, and outreach within the Pacific Region to develop a comprehensive and coordinated regional strategy for seabird conservation.

The vision of PRSCP is to restore and sustain healthy seabird populations and the natural systems on which they depend through sound management, diverse partnerships, and science. The plan identifies five main conservation goals:

1. Maintaining and enhancing populations of seabirds,
2. Protecting and enhancing seabird habitats,
3. Eliminating threats
4. Improving coordination in conservation efforts at multiple scales, and
5. Improving opportunities for recreational and educational activities related to seabird conservation.

AVIAN CONSERVATION PLANS – HAWAI`I

USFWS Draft Revised Recovery Plan for Hawaiian Waterbirds

The objective of this recovery plan is to downlist and eventually remove four species of endangered Hawaiian waterbirds (Hawaiian duck, moorhen, coot and stilt) from the Federal list of endangered species. Downlisting and delisting criteria are established for each species. Criteria include protecting and managing all wetlands identified as core wetlands and 25% of wetlands identified as supporting wetlands, stable or increasing populations above 2,000 individuals for each species, and multiple self-sustaining breeding populations exist on identified islands. A step-down narrative outlines recommended recovery actions for:

1) Protecting and managing core and supporting wetlands,
2) Removing the threat of hybridization of Hawaiian ducks with mallards,
3) Conducting research on the ecology of the Hawaiian duck,
4) Establishing a self-sustaining population of Hawaiian moorhen on the islands of Hawai`i and either Maui or Moloka`i,
5) Conducting research to better understand population biology and limiting factors, and
6) Conducting research on Hawaiian waterbird habitat and habitat manipulation.

USFWS Draft Revised Recovery Plan for the Nēnē or Hawaiian Goose

The recovery plan objective is to "restore and maintain multiple self-sustaining nēnē populations on Hawai`i, Maui Nui (Maui, Moloka`i, Lana`i, Kaho`olawe), and Kaua`i." Criteria for downlisting and delisting include the establishment of self-sustaining populations on identified islands and the protection and management of sufficient suitable habitat to sustain the target nēnē population. Recovery actions include:

1) Identifying and protecting nēnē habitat,
2) Managing habitat and existing populations for sustainable productivity and survival,
3) Controlling alien predators,
4) Continuing a captive propagation program,
5) Establishing additional nēnē populations,
6) Addressing conflicts between nēnē and human activities,
7) Identifying new research needs and continuing research,
8) Providing a public education and information program, and
9) Validating recovery plan actions.

USFWS Draft Revised Recovery Plan for the Laysan Duck

The recovery objective for the Laysan duck is to restore multiple self-sustaining populations in suitable habitats in the Northwestern and Main Hawaiian Islands with the ultimate goal of removing the Laysan duck from the Federal list of endangered species. Due to data limitations and potential uncertainties associated with defining realistic criteria for delisting, only interim downlisting criteria have been developed for the Laysan duck. These criteria include:

1) Stable or increasing population on Laysan Island,
2) At least 920 potentially breeding adults in at least five stable or increasing populations,
3) Establishment of a captive or semi-captive breeding program using wild source eggs
4) Development and implementation of a plan to achieve gene flow between wild source populations, and
5) Creation of island-specific management plans sufficient to reduce threats and increase populations.

State of Hawai`i Comprehensive Wildlife Conservation Strategy (CWCS)

The CWCS is currently being developed by the State of Hawai`i. The intent of this plan is to create a dynamic vision for the future of wildlife conservation by identifying the location and condition of key habitats, assessing threats, and proposing conservation actions. Collaboration is currently underway between the State of Hawai`i and the Pacific Coast Joint Venture.

IMPLEMENTATION INITIATIVES

"Sound science foundation forms the link between the broad landscape-scale goals in national conservation plans and the specific conservation projects that are necessary to protect bird species."

North American Bird Conservation Initiative (NABCI)

The North American Bird Conservation Initiative (NABCI) was established in 1998 as an organizational umbrella to provide a forum for coordination of existing conservation initiatives in the United States and Canada. The NABCI addresses conservation needs of all bird species in North America and is dedicated to "delivering the full spectrum of bird conservation through regionally based, biologically driven, landscape-oriented partnerships."

A steering committee of representatives from federal and state governments and non-governmental organizations oversees NABCI. Its main role is to provide leadership for an integrated approach to avian conservation through cooperative planning, implementation, and evaluation among groups involved in avian conservation. NABCI guiding principles highlight the need for:

- Integration of management needs and actions across species and landscapes
- A standardized ecological framework for efficient planning, implementation, and evaluation
- The best available scientific information
- An adaptive approach to bird conservation to build knowledge in concert with management actions.

During 2002, NABCI participants prepared and endorsed an Action Plan to provide focus for the bird conservation community and to facilitate integrated bird conservation efforts. It identified the following important issues for bird conservation at the national level:

- Secure a source of funding for upland bird conservation projects
- Increase appropriations to federal agencies to allow them to achieve their bird conservation objectives
- Assure that state wildlife agencies have the capacity to allow them to appropriately contribute to achieving bird conservation objectives
- Achieve comprehensive national coverage by effective bird conservation partnerships such as Joint Ventures
- Maintain the health and vitality of the bird conservation initiatives
- Increase the capacity of US-based organization to contribute to effective bird conservation internationally
- Develop and implement a communication strategy
- Nurture a system capable of adequately monitoring all of the birds of the country
- Work toward an agricultural policy that provides significant benefits for bird populations

As part of the Action Plan, NABCI developed and approved Bird Conservation Regions (BCRs) as ecological units within which planning and implementation can occur. Within each BCR, they examined existing avian conservation plans and identified birds of conservation concern—that is, the species, subspecies, and populations of migratory non-game birds that, without additional conservation actions, are likely to become candidates for listing under the Endangered Species Act.

North American Wetlands Conservation Act (NAWCA)

NAWCA, signed in 1989, provides funding and administrative direction for implementation of the NAWMP and the Tripartite Agreement on Wetlands between Canada, Mexico, and the United States. It also establishes the North American Wetlands Conservation Council, whose purpose is to recommend wetlands conservation projects to the Migratory Bird Conservation Commission. NAWCA encourages partnerships among public agencies and other interests in order to:

1. Protect, enhance, restore, and manage an appropriate distribution and diversity of wetland ecosystems and other habitats for migratory birds and other fish and wildlife in North America.
2. Maintain current or improved distributions of migratory bird populations.
3. Sustain an abundance of waterfowl and other migratory birds consistent with the goals of the NAWMP and the international obligations contained in the migratory bird treaties and conventions and other agreements with Canada, Mexico, and other countries.

Two grant programs are available under NAWCA that provide cost-share funding for restoration, enhancement, and acquisition of wetland habitats and associated uplands (see Appendix A). During 1989–2002, they helped fund 487 projects. NAWCA grant and partner funding for projects during this period exceeded $1 billion (Table 1).

Table 1. North American Wetland Conservation Act (NAWCA) accomplishments during 1989–2002.

Project Type	No. of Projects	NAWCA Grant	Partner Funding	Total
Non-coastal	301	$142,488,130	$488,733,140	$631,221,280
Coastal	186	$102,232,230	$391,022,900	$493,355,130
Total	487	$244,820,370	$879,756,040	$1,124,576,420

NAWCA was unanimously reauthorized by Congress during 2002. For FY05 its appropriation authorization was increased to $65 million, with $5 million increases to occur annually through FY07 when the cap will be $75 million.

Regional Joint Ventures

Under the North American Waterfowl Management Plan, regional Joint Ventures were established to facilitate local conservation efforts that meet regional goals for waterbird populations. These have since evolved to represent the regional components of the 4 major migratory bird plans: the NAWMP, US Shorebird Conservation Plan, North American Waterbird Plan, and the North American Landbird Conservation Plan.

Joint Venture partnerships include representatives from federal, state, and tribal agencies, non-governmental organizations, and corporations. Within each Joint Venture, technical committees and management boards perform complementary roles to facilitate conservation efforts. The technical committees (science teams) develop science-based conservation strategies, including priority management areas and habitat objectives. The management boards are

comprised of administrators representing partner organizations; their role is to ensure that all parties are aware of and assisting with plan delivery.

Joint Ventures provide resources and information to managers responsible for local conservation efforts. They also play an important role in implementing NAWCA by ranking proposal applications within their program arena and forwarding their recommendations for funding grants.

Joint Ventures play a central role in the prioritization and funding of bird conservation in North America (Fig. 1). They are an integral part of a conservation infrastructure designed to:

1. Provide the best possible information to the proper decision makers to enable them to make more informed, reliable decisions about policy, and where and how to expend funding for bird conservation, to insure that continental populations are efficiently conserved.
2. Insure that adequate resources reach the field to enable you and managers like you, regardless of agency affiliation, to do what needs to be done to secure the future of birds for today's and future generations of North Americans.

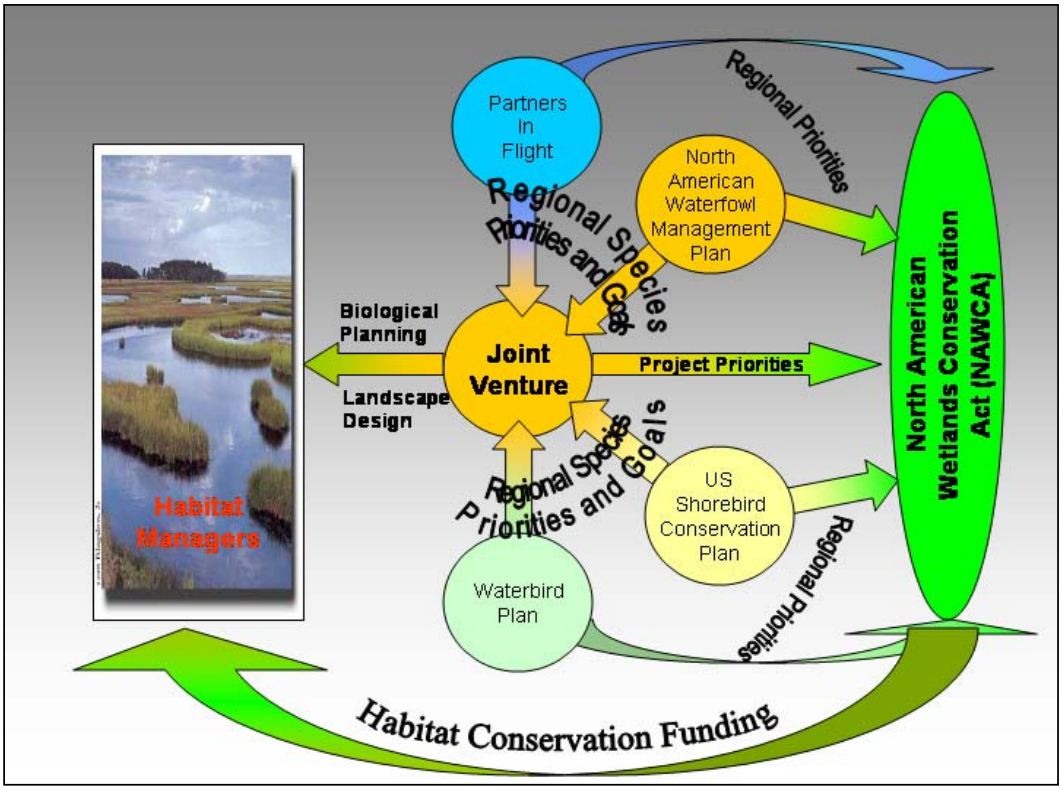

Fig. 1. Facilitation and implementation diagram of the major components of bird conservation infrastructure within North America (U. S. Fish and Wildlife Service 2004d).

PACIFIC COAST JOINT VENTURE

"The goal of the PCJV is to protect, restore, increase, and enhance all types of wetlands, riparian habitats, and associated uplands throughout the Pacific Coast region to benefit birds, fish, and other wildlife."

The Pacific Coast Joint Venture (PCJV) is one of thirteen Joint Ventures, and the first international joint venture established under the authority of the North American Wetlands Conservation Act. It brings together public and private agencies, conservation groups, development interests and others to restore wetlands and wildlife habitat in coastal areas of Alaska, Oregon, Washington, British Columbia, Northern California and Hawai`i.

Since its beginning in 1991, the PCJV has shown itself to be a good working model for watershed-level fish and wildlife habitat conservation. Goals of the original North American Waterfowl Management Plan have been broadened in the PCJV Strategic Plan to include the maintenance of biological diversity, protection of endangered and sensitive wildlife species, and maintenance and enhancement of anadromous fish and other native fish and shellfish populations.

Hawai`i State Component

The Strategic Plan for Wetland Conservation in Hawai`i establishes the framework for the Hawai`i State component of the Pacific Coast Joint Venture. Strategic conservation planning in Hawai`i poses special challenges. Although recent advances have been made in the scientific understanding of basic avian ecology throughout North America, much of this information is still lacking for Hawaiian waterbirds. And while all conservation plans are built upon incomplete understanding of ecological and physical processes that affect bird population dynamics, a relative scarcity of information exists for Hawaiian wetlands and associated wildlife.

In light of these information gaps, is especially important to establish clear research priorities for the Hawai`i component of PCJV. A USGS workshop in support of NABCI and its partner programs identified important science needs for avian conservation in North America (Ruth et al. 2003). In the list below, these are included and expanded upon to encompass needs specific to the Hawaiian Islands:

- Research on avian life history requirements and basic population and ecologic parameters
- Research and monitoring on the role of habitat quality, quantity, and distribution on bird populations, and the effects of key determining physical factors on habitat conditions, including extensive research and monitoring is required to identify the environmental conditions necessary to control invasive vegetation
- Integration of ecological information across multiple spatial and temporal scales and among disciplines using ecological and population models where appropriate
- Additional and ongoing scientific investigations to construct legitimate, defensible, and quantitative population and habitat objectives and to evaluate their effectiveness at meeting conservation goals

- Communication, dissemination, and coordinated data management of ecological information among partner organizations

To date, conservation efforts for waterbirds in the Hawaiian Islands have focused primarily on resident waterbirds, and have been carried out largely on federal lands (mainly those of the U.S. Fish and Wildlife Service) and on state lands. Strategic planning for the Hawai`i state component of PCJV emphasizes continued inclusion of all private, county, and other federal lands. It will also eventually address conservation needs for migratory populations of waterfowl and shorebirds, which declined in the 1930s but never rebounded in Hawai`i as they did elsewhere in North America.

Hanalei National Wildlife Refuge

EXISTING HABITAT PROTECTION IN HAWAI`I

United States Government

U.S. Environmental Protection Agency (EPA).—EPA plays an active role in wetlands regulation under Section 404 of the Clean Water Act. Management measures developed by EPA are also the foundation for the state-administered Coastal Non-point Pollution Control program. Under Section 404 of the Clean Water Act EPA helps regulate the discharge of dredged and fill materials into waters of the United States, including wetlands. EPA's priorities for protecting wetlands in Hawai`i are to:

- Take timely enforcement actions for unauthorized discharges,
- Review alternatives analyses for large federally funded projects,
- Improve compensatory mitigation,
- Integrate wetlands protection with other tools for watershed protection,
- Improve protection and compensatory mitigation for coral reefs, and
- Provide training.

U.S. Army Corps of Engineers (USACOE).—The USACOE is responsible for issuing Section 404 permits and it jointly develops program guidance, determines jurisdiction, and undertakes enforcement with the EPA. The Corps also holds jurisdiction over wetlands identified by the U.S. Fish and Wildlife Service's National Wetlands Inventory.

Natural Resources Conservation Service (NRCS).—Under the Farm Security and Rural Investment Act (2002 Farm Bill) NRCS administers funding programs to encourage landowners to voluntarily conserve natural resources. Farm Bill funding helps farmers and ranchers meet environmental challenges on their land and promotes conservation stewardship through provisions designed to reduce erosion, guard streams and rivers, restore and establish fish and wildlife habitat, and improve air quality. The farm bill programs are:

- Environmental Quality Incentives Program (EQIP)
- Ground and Surface Water Conservation (GSWC)
- Grassland Reserve Program (GRP)
- Wildlife Habitat Incentives Program (WHIP)
- Wetlands Reserve Program (WRP)
- Farm and Ranch Land Protection Program (FRLPP)
- Conservation Security Program (CSP)

Of these programs, WRP and WHIP have the highest potential for protecting and restoring wetland habitats in Hawai`i, since they are specifically designed to restore and enhance habitat for wildlife. Under these programs wetlands can be protected in perpetuity through a permanent easement that is acquired by NRCS. The first WRP permanent easement was implemented on Kaua`i during 2003. WRP and WHIP in Hawai`i are currently funded at a relatively low level compared to other Farm Bill Programs and cannot meet the demands of submitted applications. During 2004, three WRP applications were not funded, leaving a request of $2,200,000.

U.S. Fish and Wildlife Service (USFWS).—USFWS plays a major role in wetland and waterbird protection in Hawai`i through establishment of Safe Harbor Agreements with non-

Federal landowners, designation of Critical Habitat for endangered species, operation of National Wildlife Refuges, and preparation of the National Wetlands Inventory.

Safe Harbor Agreements (SHA) are voluntary arrangements between USFWS, DLNR and cooperating non-Federal landowners. They encourage voluntary conservation and management of habitat for endangered and/or threatened species on private lands while giving assurances that no additional regulatory restrictions will be imposed under the Endangered Species Act. USFWS, DLNR, or another approved party determines the baseline for the target species on the enrolled property. The landowner provides a net conservation benefit to the species through habitat improvements or other management activities. In turn, the landowner receives a permit to incidentally take species above the baseline. Other waterbird-related SHAs currently underway include one for Hawaiian stilt and Hawaiian coot at the Chevron Oil Refinery on O`ahu and one for Hawaiian duck in the Kohala-Mauna Kea region of Hawai`i. NRCS is currently underwriting a statewide programmatic SHA for participants of Farm Bill Programs who improve habitat for nēnē, koloa, Hawaiian moorhen, Hawaiian coot, and Hawaiian stilt.

Critical Habitat Designation by USFWS occurs under the Endangered Species Act and can result in protection of wetlands and waterbird areas. The Act requires USFWS to designate critical habitat for threatened and endangered species whenever it is shown to be prudent and determinable. In 2003 the USFWS designated critical habitat for endangered plants on O`ahu (101 species), Kaua`i and Ni`ihau (95), Maui and Kaho`olawe (60), Hawai`i (46), Moloka`i (42), and Lana`i (3)., as well as for five species in the Northwestern Hawaiian Islands. Animals with designated critical habitat include the Kaua`i cave wolf spider, Kaua`i cave amphipod, Blackburn's sphinx moth, and the O`ahu `elepaio.

National Wildlife Refuges (NWRs) operated by USFWS offer important habitat protection on five of the eight main Hawaiian Islands and all the Northwestern Hawaiian Islands except Kure Atoll. Ten NWRs on the main islands protect over 16,195 ha (40,000 ac) of coastal habitats (wetlands and associated uplands) and high elevation forested habitats. Eight of the NWHI were designated as what is now the Hawaiian Islands National Wildlife Refuge in 1909 to protect the large colonies of seabirds, sea turtles, Hawaiian monk seals and coral reefs. Midway National Wildlife Refuge was originally established as an overlay refuge while the U.S. Navy still operated NAF Midway Islands. Currently all U. S. military operations have been removed from Midway Atoll. Kure Atoll, the northernmost island, is a wildlife sanctuary managed by State of Hawai`i.

Department of Defense (DOD).—DOD prepares Integrated Natural Resource Management Plans (INRMPs) for DOD installations to carry out landscape-level management of their natural resources. As management tools, INRMPs ensure that military operations and natural resources conservation on land and waters under DOD control are integrated and consistent with stewardship and legal requirements. INRMPs require a comprehensive approach to ecosystem management on a watershed and/or physiographic region scale. This improves on traditional management plans that lacked integration and focused on the installation scale. An INRMP was completed for Nu`upia Ponds Wildlife Management Area at the Marine Corps Base Hawai`i during 2001.

National Oceanographic and Atmospheric Administration (NOAA).—NOAA influences habitat conditions in Hawai`i coastal areas through its operation of National Marine Sanctuaries and through its oversight role with the federal-state-local Coastal Zone Management Program.,

The Hawaiian Islands Humpback Whale National Marine Sanctuary was established during 1992, following initial recommendations of NOAA dating back to 1982. It protects shallow offshore waters used for breeding, calving and nursing activities by two-thirds of the humpback whale population in the North Pacific. The sanctuary is comprised of 1,370 square miles in five separate nearshore areas abutting six of the major islands of the main Hawaiian islands. It is jointly managed by NOAA with the State of Hawai`i.

A second National Marine Sanctuary may be established in Hawai`i to coordinate protection of reef resources in the Northwestern Hawaiian Islands (NWHI). In 2000, an NWRI Coral Reef Ecosystem Reserve was created protecting 99,500 square miles (almost 4 million acres) of federal waters 3 to 50 miles offshore. Since 2000 a process has been underway to designate a broader National Marine Sanctuary that could include non-federal waters. If approved, this will enable coordinated management and protection of marine resources in the NWHI, and could bolster efforts to protect native and migratory birds and their habitats.

National Park Service (NPS).—Stateside funding under the federal Land and Water Conservation Fund, which may be used for wetland protection, is administered by the NPS. Since 1988, the National Park Service in Hawai`i has managed the 25-acre `Aimakapā fishpond as part of Kaloko-Honokōhau National Historical Park on the island of Hawai`i. The fishpond provides wetland habitat for endangered Hawaiian stilts and coots.

State of Hawai`i

No statute designed specifically for the protection of wetlands exists within the State of Hawai`i. However, wetland protection is partly addressed in several state laws. These include the Natural Areas Reserve Act, the Wildlife Act, the Hawai`i Endangered Species Act, the Acquisition of Resource Values Land Act, the Conservation Easements Act, and the Land Use Commission Act (Hoffman 1991). Wetlands are also protected under the Water Quality Act and the Coastal Non-point Pollution Control Program.

The protection and management responsibilities for Hawai`i wetlands are spread throughout several state agencies. The Hawai`i Coastal Zone Management Program oversees county-level permitting and approval programs for shoreline management, as well as the state's Coastal Non-point Pollution Program. The Department of Land and Natural Resources (DLNR) is responsible for land acquisition and management activities, focusing its expertise on state wildlife sanctuaries, the Natural Area Reserves system, and state parks; it also administers funding for a recent statewide movement to establish regional Watershed Councils. The Department of Health (DOH) reviews federal Clean Water Act Section 404 permit applications for consistency with state water quality standards.

Following the National Wetlands Forum (1988) and the National Wetlands Priority Conservation Plan (1989) that promoted a more cohesive approach to wetlands planning at all levels, Hawai`i officials noted the lack of a lead agency for wetland management in the state, and began to emphasize the need for better coordination and an integrated approach to wetlands issues. (Hoffman 1991).

Planning documents produced since that time include the Hawaiian Islands Wetland Conservation Plan (State of Hawai`i 1995), Hawai`i Wetlands Management Policy (Hawai`i Wetland Management Policy Workgroup 1999), and the State Wetlands Resource Plans prepared as part of the State Comprehensive Outdoor Recreation Plan (State of Hawai`i 2003).

The 1999 Hawai`i Wetlands Management Policy provides guidelines for protecting, maintaining, enhancing, restoring, and creating wetlands in Hawai`i, and it summarizes applicable laws and provides a flow chart for wetland related permits or approvals. The vision of the policy states: "*Hawai`i's wetlands shall be integrated into the watershed, or ahupua`a, extending from the uplands to the coastal waters. They shall be preserved, conserved, restored, and created in order to maintain habitat, support species biodiversity, nurture fisheries, control floods, improve water quality, sustain cultural resources, and provide scenic vistas*." Goals identified to attain this vision are:

- Promote better understanding of the functions and values of wetlands.
- Promote the preservation, conservation, restoration, and creation of wetlands.
- Improve public participation in wetland management process.

In 2002 and 2003 conferences on "Wetland Management in the Hawaiian Islands," sponsored by the Hawai`i Chapter of the Wildlife Society, attracted wetland managers and advocates from around the state—including state officials—seeking information exchange, funding ideas, and a more unified approach to wetlands issues.

Most recently, the 2003 State Wetlands Resource Plan reviews wetland sites that may be appropriate for state acquisition. It highlights significant agency roles and relationships, updates recent wetland activities in the state, and offers a brief strategic plan for integrating wetlands protection with recreation planning. Recommended strategies for wetland protection in the plan are the same as those identified by the Pacific Coast Joint Venture: restoration, acquisition, management, and education/interpretive programs.

City and County Governments

Unlike most states, Hawaii has no independently governed cities or towns; local government occurs at the County level. On the most populous island of O`ahu the governance structure for the city of Honolulu (population of over one million) is synonymous with that of the island, which in turn constitutes the County of O`ahu.

Each County establishes a general plan intended to guide development, which may be supplemented by more specific regional development plans. All of the plans for Hawai`i counties include language that emphasizes the value of coastal ecosystems, ecologically sensitive lands, open space and in some cases specifically wetlands. Most advocate implementing land use management practices that extend from the mountain to the sea (ahupua`a) and encompass traditional Hawaiian conservation and management values. City and County of Honolulu includes a wetlands protection ordinance within its land use regulations and manages five wetlands within the boundaries public parks.

Most county action on wetland issues occurs through the counties' role in the state's Coastal Zone Management Program. Each county implements the intent of federal and state

coastal zone management laws through assessment permitting processes for land use activities near the shoreline. Assessments must address both site-specific and cumulative impacts. One of the objectives of the multi-layered CZM process is to "provide for protection of marine and coastal ecosystems, and establish a comprehensive system of marine and coastal protected areas within an integrated program which protects, preserves and enhances marine species and areas of exceptional resource value on each island" (State of Hawai`i, Coastal Zone Management Program, http://www.state.hi.us/dbedt/czm/marine.html).

PART II: NATURAL & CULTURAL RESOURCES OF HAWAI`I

GEOLOGICAL ORIGIN

Main Hawaiian Islands

The main Hawaiian Islands consist of eight large islands on the southeastern end of a 6100 km (3800 mi) chain of volcanoes in the central Pacific Ocean. A "hot spot," an upwelling of hot rock fixed beneath the Pacific Plate, has fed magma through the earth's crust as the Pacific Plate has drifted west-northwest approximately 9 cm (2.5 in) a year (Clague 1998), creating a chain of 129 volcanoes.

The 15 youngest of these volcanoes form the eight main Hawaiian Islands. The largest and youngest main island, Hawai`i, is made of five volcanoes dating from 0.43 million years ago (mya). Maui, Lana`i, Kaho`olawe, and Moloka`i date from 0.7 to 1.8 mya, O`ahu from 2.6 to 3.7 mya, and the oldest islands, Ni`ihau and Kaua`i from 4.9 and 5.1 mya. Each island has evolved from the same sequence of volcanic activity, beginning with the submarine preshield stage, where deep underwater volcanic eruptions form "pillow" lava which accumulate until the volcanic edifice is near sea level (Clague 1998).

Explosive eruptions, created by the mix of magma and seawater, continue to build volcanic mass until the volcano reaches approximately 1200 m (4000 ft) above sea level and the subaerial phase begins (Clague 1998). During this phase land building continues, but at the same time erosion of volcanic mass occurs due to weathering and from landslides of large unsupported seaward flanks.

Slowly the eruptions taper off and eventually they stop. The slopes of the volcano become steeper as flows pile up near vents and previously active rift zones. At this point erosion becomes the main force sculpting the landscape, and the volcanic island begins to subside as its weight causes the earth's outer layer to flex downward.

Northwestern Hawaiian Islands

The Northwestern Hawaiian Islands (NWHI) consist of 10 island complexes extending for about 1,100 miles from Nihoa Island to Kure Atoll. The land mass of the NWHI comprise about one-tenth of one percent of that of the entire Hawaiian archipelago, or approximately 1347 ha (3328 ac) of dry land (Rauzon 2001). Nihoa and Necker Islands, the two youngest islands have the most exposed volcanic basalt. The remaining eight complexes of older islands consist of coral reefs and atolls built on submerged volcanic foundations.

The youngest of the NWHI is Nihoa, estimated to have formed 7.2 mya. Continuing northwest, the islands get progressively older until Kure Atoll, the oldest of the NWHI formed approximately 60 mya. Kure Atoll is also the highest latitude coral reef in the world and across Darwin's Point. Darwin's Point, named after Charles Darwin who first explained the theory of atoll development in 1842, is the point where coral growth is surpassed by island subsidence and has remained with two degrees of 29^{o} N for 20 million years (Rauzon 2001). Once Kure Atoll sinks beneath the ocean surface, it will become the youngest seamount in the Hawaiian archipelago.

BIOGEOGRAPHY

Because the Hawaiian Islands were built from volcanic eruptions within the sea floor, they have never been connected to continents as were islands such as Fiji or New Zealand. More than 3200 km (2000 mi) from the nearest continent and other emerged volcanic islands and 1610 km (1000 mi) from the nearest Pacific atolls, the Hawaiian Islands are extremely isolated (Carlquist 1970, Carson 1998). Therefore, all native flora and fauna that colonized the islands arrived by long-distance dispersal mechanisms, resulting in a "disharmonic" biota that is not representative of flora and fauna groups that populate continental source areas (Carson 1998).

CULTURAL & HUMAN GEOGRAPHY

Native Hawaiians.—Small groups of people from western Melanesia or southeast Asia migrated to the western part of Polynesia around 1000 B.C. They subsequently spread to other islands within the region, forming 7 main branches; Hawaiians, Samoans, Tongans, Cook Islanders, Marquesans, and Maori of New Zealand. Some evidence suggests that initial colonization of the Hawaiian Islands may have been by people of the Marquesas Islands (Kirch 1998). Immigrants brought subsistence items from various Polynesian settlements and adapted and modified traditional practices and the Hawaiian landscape to sustain settlement communities. Distinct Hawaiian culture developed during and after the final migratory period as contacts with other areas of Polynesia ceased after A.D. 1200 (Kirch 1998).

The Northwestern Hawaiian Islands have been used by native Hawaiians for other a thousand years. Nihoa and Necker were uninhabited at time of European contact, but an extensive heiau complex exists on Necker. Agricultural terraces and other Hawaiian archaeological features occur on Nihoa.

Ancient Hawaiian Values.—Values of ancient Hawaiian cultures have been inferred from oral traditions, early writings by Hawaiian historians, Hawaiian proverbs, and archaeological research. Several values identified as important in ancient Hawaiian societies can be related to modern conservations ethics (Table 2; Burrows 1989).

Table 2. Values identified as important in ancient Hawaiian culture and their relationship to modern conservation concepts. Summarized from Burrows (1989).

Ancient Hawaiian Value	English Translation	Modern Conservation Concept
Mana`o`i`o	Faith, Respect for Nature	
Kapu and Noa	Sacred and Profane	Prevent over-exploitation of resources
`Ike	Knowledge	Informed decision making
`Aina	The Living Earth	
Lokahi	Unity, Balance, Harmony	Homeostasis in an ecosystem
Malama	Caring or Stewardship	Wise resource use

WATERSHEDS

*Ahupua`a*.—Ancient Hawaiians used the concept of territorial custody rather than ownership of lands. Island kingdoms were divided into districts (moku), which were further divided into minor chiefdoms (ahupua`a). An altar of stones (ahu) with an image of a pig (pua`a) were placed at the boundary of each ahupua`a (Quensell 2001). Boundaries of the ahupua`a generally extended from the high mountain ranges to the coast and provided all the necessary resources for Hawaiian inhabitants. These ahupua`a boundaries are still recognized today and generally follow modern small-scale watershed boundaries.

Modern Watersheds.—The U. S. Geological Survey has identified 551 watersheds on the 8 major Hawaiian Islands (Table 3). During 1998, watersheds in Hawai`i where characterized based on water quality and overall health of aquatic systems within the watershed (State of Hawai`i 1998). Based on these rankings, restoration priorities were determined within the scope of existing efforts. Five priority regions (i.e., watersheds or groups of watersheds that affect the same waterbody) were selected from watersheds in need of restoration (Category I) based on the following criteria: 1) historical and cultural significance; 2) presence of mixed land uses; 3) presence of important natural resources; 4) presence of waterbodies on Department of Health's 303(d) list of Water Quality Limited Segments; 5) watersheds that capture the "uniqueness" of Hawai`i; 6) agency and community interests that promotes partnerships; and 7) high probability of success (State of Hawai`i 1998).

Table 3. Area, number of watersheds, and priority regions based on Hawai`i's Unified Watershed Assessment (State of Hawai`i 1998).

Island	Total Watershed Area (ha)	Number of Watersheds		Priority Regions (Number of watersheds included)
		Total	Category I	
Ni`ihau	18,752	13		
Kaua`i	143,778	74	11	Nawiliwili (3)
O`ahu	155,222	86	54	Koolaupoko-Windward Koolau Mtns (22)
Moloka`i	67,547	50	20	South Moloka`i (20)
Maui	188,841	112	10	West Maui-West Maui Mountains (8)
Lana`i	36,550	32		
Kaho`olawe	11,553	24	24	
Hawai`i	1,046,306	160	8	Pelekane Bay-Kohala Mountains (1)

WETLANDS

Descriptions of wetland habitats, with the exception of montane bogs, are relatively lacking from natural history accounts of the islands. Polhemus et al. (1992) classifies tropical inland waters into 18 classes and sub-classes based on physical and chemical factors.

Although wetlands compromise a small percentage of the land mass on the islands, coastal areas such as windward O`ahu and the Mānā Plain on Kaua`i were dominated by extensive wetland habitats. The most predominant wetlands in Hawai`i are associated with groundwater discharge on coastal plains and broad river valleys.

Estimates of wetland area in the state of Hawai`i range from 1.3 to 2.7% of the total land area (Hoffman 1991). Lowland freshwater marshes and associated deep-water habitats, cultivated wetlands, shallow margins of anchialine ponds, estuaries, and other marine dependent wetlands are the most important habitats for native waterbirds in Hawai`i (Burrows 1989). Estimates of wetland loss in Hawai`i have ranged from 12 to 31%, but detailed analysis of pre-historical and historical land use patterns are needed to accurately quantify wetland loss. Published estimates likely underestimate the original extent of wetland habitats as large-scale land use changes occurred shortly after European contact before many historical records were maintained. Approximately 75% of the remaining 6,190 ha (15,474 ac) wetlands are degraded by non-native invasive plant species and altered hydrology due to urbanization and agriculture.

Development and non-wetland agricultural crops (e.g., sugar cane) have likely dissected and compartmentalized what used to be extensive complexes of coastal wetlands. Due to the heterogeneity of volcanic and alluvial substrates and distribution of springs, perched water tables, and aquifers, these coastal wetland complexes likely contained differentially flooded wetlands that provided resources for waterbirds, other resident wetland associated wildlife, and migratory birds. Ephemerally and temporarily flooded wetlands within wetland complexes are easily filled, and in some instances not mitigated, as political definitions of wetland habitats often do not include ephemeral wetlands.

Different aged volcanic islands, different aged lavas within each island, and different stages of weathering and erosion create diverse wetland habitats, many of which are unique to only 1 island. Agricultural production of wetland related crops such as taro also provide habitats for Hawai`i's waterbirds. Wetlands are an important part of native Hawaiian culture.

Flooding Regime and Ecological Function

Ephemeral Wetlands.—Ephemeral wetlands in Hawai`i are often described as marginal (Elliot and Hall 1977, Shallenberger 1977), likely due their infrequent and inconsistent occurrence and the associated transient waterbird numbers that use them. Some ephemeral wetlands flood only a few times a years during the highest tides. Other ephemeral wetlands flood only following above average rainfall. Although the presence ephemeral wetlands is highly variable across a landscape and through time, these ephemeral wetlands may provide high concentrations of food resources, such as invertebrates, for resident and migratory waterbirds in the Hawaiian Islands.

The Hawaiian Islands evolved highly diverse ecological communities, providing different optimal foraging habitats at different times of the year that mobile fauna, such as the still extant

native waterbirds, can utilize. Conservation of these important wetlands may be difficult to implement due to the exclusion of this wetland type from some wetland definitions and high development pressures facing the Hawaiian Islands.

Temporary Wetlands.—Temporary wetlands are flooded for short time periods except during years of extreme drought. As with ephemeral wetlands, temporary wetlands provide a high abundance of food resources during a short time period, but have a higher probability of annual reflooding than ephemeral wetlands.

Seasonal Wetlands.—Wetlands with seasonal flooding regimes in Hawai`i were likely very common prior to human settlement due to the seasonal distribution of rainfall throughout the islands. These wetlands likely provided large quantities of high-quality foods during the rainy season, which coincides with the breeding season of most resident waterbirds. Seasonal wetlands also provide important resources to wintering migratory waterfowl and shorebirds. When reflooded after a dry period, seasonal wetlands provide a high availability of seeds and invertebrates with short life cycles. Exposed mud flats also provide available habitat for germination of emergent vegetation such as sedges, which have high seed production.

Semi-permanent Wetlands.—Semi-permanent wetlands are characterized by areas of emergent vegetation and open water kept in balance due to inter-annual variation in depth, duration, and extent of flooding.

Permanent Wetlands.—Permanent wetlands are characterized by open water and submergent or floating aquatic vegetation that lack well-developed structural support. Many species of submergent vegetation provide important food sources for waterfowl and other waterbirds and species with fine leaved dissected provide habitats for aquatic invertebrates, also important food sources for waterbirds. On the Hawaiian Islands, permanent wetlands occur in areas of high rainfall and surface runoff that sustain permanent water throughout the year and in areas where impermeable substrates slow the recharge of surface water to the water table.

Geomorphic Characteristics of Marine Influenced Wetlands & Aquatic Habitats

Anchialine ponds.—Anchialine ponds, commonly found on geologically newer islands, have no surface connection to the ocean, but porous rock walls maintain subsurface hydrological connections. These ponds show tidal fluctuations and salinity gradiesnt. In addition, salinity varies according to seasonal differences in rainfall, evaporation, and ground water, and daily and seasonal fluctuations in tidal rhythms (Burrows 1989). Anchialine ponds occur alone or in groups with subterranean water connections (Polhemus et al. 1992). Having a greater percentage of endemic species than other anchialine ponds worldwide (Maciolek 1986), Hawaiian anchialine ponds are biologically important systems for maintaining unique ecosystem functions at regional (state) and landscape-level (tropical Pacific ecosystems) scales. Anchialine ponds are most abundant on the islands of Hawai`i (600-650 ponds) and Maui (50 pools), but also occur on O`ahu (3 ponds) and Moloka`i (1 pond; Burrows 1989).

Tide pools.—Tide pools are continuous are connected to oceans by surface flows and flood during rising tides.

Beaches and Sand Dunes.—Wave action determines the configuration and extent of beaches on the Hawaiian Islands. Storms and tide swells cause can cause large redistribution of

beach sands. Beaches on the main Hawaiian Islands are heavily impacted by human use. Most of the remaining ecologically important beaches occur on the Northwest Hawaiian Islands that are mostly uninhabited and protected as a National Wildlife Refuge. These habitats are dominated by nalpaka and heliotrope species.

Coastal Strand.—These habitats contain plant communities that are unique compared to other coastal beach habitats.

Rocky Shorelines.—These habitats are restricted to the main islands and remain relatively unaltered compared to other coastal habitats. Rocky shorelines provide important habitats for seabirds, as well as roost sites for shorebirds.

Coastal Plains.—Coastal plains are most developed on geologically nature islands. Coastal Plain wetlands vary in salinity from fresh to brackish depending on freshwater inputs and connections to the ocean.

Estuaries, Coastal Salt Marshes, and Tidal Flats.—Three types of estuaries, characterized by herbaceous salt marsh vegetation, developed in the Hawaiian Islands: large embayments as at Pearl Harbor; stream mouths where fresh surface water and ocean water meet, and in shoreline areas with abundant springs and groundwater discharge. Salt marshes can occur on silt, sand, and/or coral rubble substrates (Stemmermann 1981). Salt marshes, influenced by saline or brackish water, are characterized by herbaceous vegetation and are divided into low and high marsh areas differing by depth and frequency of tidal inundation and dominant vegetation species. *Paspalam distichum*, *Sporobolis virginicus*, several species of sedges, *Bacopa monnieri*, and *Sesuvium portulacastrum*, characterize low salt marshes (< 25 cm) in the Hawaiian Islands (Stemmermann 1981). A non-native invasive species, *Batis maritima*, characterizes high salt marshes (25-75 cm) in the Hawaiian Islands periodically exposed to tidal to tidal influences.

Although not numerous on all the islands, these tidal influenced wetland are highly productive systems due to a high frequency of water level fluctuation and associated nutrient cycling. These wetlands are also among the most degraded in the Hawaiian Islands due to invasion of non-native plants (i.e., mangroves) non-point source pollution, oil spills, and sedimentation due to land uses within watersheds.

Playas.—These seasonal lowland wetlands occur in shallow basins and are characterized by saline to hypersaline conditions (Polhemus et al. 1992). Common biota include primitive crustaceans and insects (Polhemus et al. 1992).

Coastal Forested Wetlands.—Paleoecological evidence suggests that native coastal forested wetlands covered a much greater extent than represented by their current distribution. Currently coastal forested wetlands are dominated by non-native mangrove species, introduced to Hawaii in 1902.

Throughout the Pacific, mangrove swamps are important for protecting coastal areas from storm and wave damage and act as a land-building agent as suspended silt settles and accumulates around mangrove swamps (Stemmermann 1981). But no mangrove species are native to the Hawaiian Islands. Two non-native invasive species of mangroves have become increasing widespread altering the ecological function of native coastal salt marshes, tidal flats, and ancient Hawaiian fishponds. Mangroves, in addition to other invasive species such as California grass, have caused increased siltation in natural and man-made connections between

wetlands or between fresh and saline water sources, thereby further altering hydrological processes.

Fishponds.—More than 350 fishponds have been identified on coastal lowlands and shorelines on all 8 of the main islands (Burrows 1989). Most fishponds were constructed along the coastal plains, ranged in size from 0.2 to 200 ha (0.5–500 ac), had varying salinity, areas of open water, and vegetated marshlands.

Saline loko kuapa ponds had walls which extended in a semicircle seaward from the shoreline or walls which crossed the narrowest part of an entrance to a small bay or inlet, whereas saline loko `umakai ponds were surrounded by a low wall submerged at high tide. Three types of brackish and freshwater fishponds also occur on the Hawaiian Islands: loko pu`uone, brackish ponds connected to the sea by a ditch by stream or ditch; loko i'a kalo, freshwater taro fishponds; and loko wai, natural freshwater ponds.

Shallow reef seagrass flats.—Seagrass flats, extensive and diverse throughout the Pacific, occur close to shore below the tidal zone where wave action is reduced. They generally occur in less than 7 m of water and are continuously submerged regardless of tidal stage. Seagrasses, strictly marine flowering plants, and diverse communities of micro and macro algae create highly productive marine environments that support a diverse marine fauna (Stemmermann 1981). Although not as common on the Hawaiian Islands as in Micronesia and often excluded from discussions of Hawaiian wetlands, sea grass beds are important marine wetland ecosystems and are affected by adjacent land uses (Stemmermann 1981).

Coralline atolls and reefs.—Atolls develop when sufficient coral growth occurs along an islands' flanks to enclose a lagoon, pond, and/or lakes of varying salinity.

Geomorphic Characteristics of Terrestrial Freshwater Wetlands & Aquatic Habitats

Palustrine Freshwater Marshes.—Freshwater marshes are primarily fed by subsurface springs associated with underground aquifers and runoff from montane watersheds.

Cultivated Agricultural Wetlands.—Irrigated wetlands date back to 600 AD on Kaua`i and 1200-1400 AD on O`ahu and Moloka`i. By European contact nearly all lowlands with perennial streams contained irrigation systems, creating large areas of managed agricultural wetlands (Kirch 1982). Currently, cultivation of taro, lotus, & watercress provide wetland habitats for waterbirds while supporting local economies.

Riparian.—Hawai`i has 366 perennial streams, most of which drain relatively small areas discharging on average less than 50 million gallons per day (1.2 $m^2$/sec). Only 2 streams discharge over 150 million gallons per day (6.6 m2/sec): Hanalei River on Kaua`i; and Wailuku River on Hawai`i. Parrish et al. (1978) estimated that less than 14% of Hawaiian streams were physically pristine and far fewer are biologically intact due to water diversion, alteration, or invasive species (Burrows 1989). Aquatic, riparian, cultural, and recreational resources were assessed for perennial streams in Hawai`i during 1993 (State of Hawaii and National Park Service 1993).

The volume of flow in intermittent steams is highly variable due to seasonal rainfall patterns, high permeability of the streambed substrates, steep gradients, and short stream lengths (Burrows 1989). Therefore the native flora and fauna that inhabit these dynamic streams are

adapted to extreme variations in temperature, turbidity, flow rates, nutrients and amount of available habitat.

Springs and Seeps.—Rheocrenes form when perennial seeps flow over rocks or in indistinct channels and are typically found along banks of deeply incised streams or along coastal rock faces (Polhemus et al. 1992).

Cave Pools and Cave Streams.—Although these wetlands do not provide habitat for extant waterbirds, cave pools and streams provide habitat for some of the state's most highly endangered wildlife, including the Kaua`i cave wolf spider and the cave amphipod.

Vernal (spring season) Pools.—Vernal pools, which only have seasonal water inundation during heavy rains and are characterized by the endemic water fern `ihi`ihi lauakea (*Marsilea villosa*), are restricted to a few locations on the island of O`ahu (Burrows 1989). They occur in craters or depressions on the dry, leeward lowlands of O`ahu.

Plunge Pools.—

Natural Lakes.—Due to the high permeability of basalt, few natural lakes have formed on the Hawaiian Islands. Only 5 natural lakes occur on the Hawaiian Islands (Meier et al. 1993).

Montane Bogs.—Montane bogs are present in high elevations where substrates are characterized by very dense basalt and/or impermeably clay at high elevations causing rainfall to exceed runoff. Bogs are found primarily on domes of old volcanoes. Kanaele Bog on Kaua`i, is unique in that it is located at approximately 305 m (1000 ft). Unlike bog systems in most regions of the world, Sphagnum moss is only found in bogs on the Kohala bogs on the island of Hawai`i (Carlquist 1970). Most bogs in Hawai`i contain mud, small pockets of standing water, and tussocks formed from grasses and sedges (Carlquist 1970). Dwarf varieties of tree and shrub species common in Hawaiian forests are frequently found in bog environments (Ziegler 2002).

Artificial Wetlands.—Examples of these wetlands include wastewater treatment plants, water reclamation facilities, reservoirs, and stockponds. These site are managed primarily for anthropogenic uses. Management strategies that incorporate wildlife as secondary objective will increase the value of these wetlands to waterbirds and wetland associated wildlife.

Anchialine Pond

CHANGES AND CURRENT THREATS TO WETLANDS

Prehistoric.—Human modification of wetland habitats in Hawai`i began as early as 1500 years ago when agriculture and aquaculture techniques were used to sustain Polynesian settlers whose population is estimated to have peaked during 1650 AD at 1 million inhabitants (Kirch 1982). Construction of taro fields (kalo lo`i), diversion of stream water for taro cultivation, and construction of rock-walled fishponds accounted for most of wetland modifications during Polynesian settlement. Many of these cultivated wetlands and fishponds were associated with natural wetlands, but the affects of these practices on the extent, type, and ecological function of wetlands prior to human settlement are unknown.

It has been hypothesized that the expansion of Polynesian irrigation systems allowed permanent colonization of the Hawaiian Islands by waterbirds (Olson and James 1982). Whether or not prehistoric irrigated wetlands provided additional wetland habitats enabling waterbird populations to expand, or reduced the impact of converting natural wetland areas to agriculture during Polynesian settlement, these habitats were likely used by native Hawaiian waterbirds as they are today.

Recent paleoecological studies have documented pre-human and prehistoric habitat changes by examining patterns of sediment development and their fossil contents. This research has shown that a diverse biota was present in coastal areas and consisted of strand plants and graminoids and tree and shrub species currently restricted to higher elevations (Burney et al. 2001).

Historical.—Modification of wetland habitats increased exponentially after European contact. Expansion of plantation style agriculture including sugar cane and pineapple drastically altered the landscape. Coastal wetlands are were drained, irrigation ditches were installed to divert water from perennial streams to more arid agricultural areas, and large land areas were flattened and graded (Meier et al. 1993). Increased soil erosion caused by deforestation and livestock grazing also filled coastal wetlands. During the early 20th century many abandoned taro fields and remaining marshes were farmed for rice cultivation.

Navigation projects, port development, and military developments during and after World War II destroyed numerous fishponds, estuarine marshes, and coral reefs, and altered the water quality of surrounding areas (Meier et al. 1993). Housing developments, resort, and civil works projects, including the well-known Waikiki area of O`ahu, further destroyed and altered coastal ecosystems.

Indirect modification of wetland habitats occurred as a result of introduced plant and animal species. Mangrove (*Rhizophora mangle*), California grass (*Brachiaria mutica)*, and pickleweed (*Batis maritima*) have encroached on fishponds, marshes, and riparian corridors altering vegetation structure and sedimentation patterns. Introduced mammals have caused declines and sometimes extinctions in populations of endemic birds, including passerines and waterbirds.

Current.—The largest threat to wetland habitats today is development. Agriculture has declined since World War II. More than half of Hawai`i's economy is based on tourism and military expenditures (Meier et al. 1993}. With the decline of the sugar cane industry the future of many coastal areas is uncertain because these coastal plains are prime areas for high dollar

resort and/or housing development. Indirect threats from increased development include non-point source pollution and increased human disturbance.

Invasive vegetation still plagues many coastal and high elevation habitats. Until seed sources are removed on a regional scale and more effective long-term control methods are identified, wetlands require continual maintenance and management.

Natural hydrological regimes have been altered due to lowering of freshwater aquifers, channelization and diversion of perennial streams, and flood protection projects. Direct threats to endemic waterbirds include disease and predation. For koloa, the most immediate threat is hydridization with domestic and feral mallards.

Kawaiele Pumping Station, Mānā Plain, Kaua`i

Encroachment on invasive non-native vegetation, Waihe`e, Maui

PART III: STRATEGIC WETLAND CONSERVATION

HABITAT GOALS

Habitat goals for the PCJV strategic conservation plan in Hawai`i represent long ranging concepts that provide direction for conservation objectives and actions. They are based on the strategies identified by the PCJV and support goals identified by other avian conservation plans for Hawai`i. The five habitats goals of the PCJV are to:

1. Protect existing, degraded, and altered wetlands through acquisition, conservation easements, and cooperative landowner agreements to ensure natural habitats will be preserved in perpetuity.
2. Maintain, enhance, and manage existing wetlands and associated uplands that provide functional and dynamic habitats for waterbirds and wetland-associated wildlife, contribute to resilient watershed functionality, and promote ecosystem management.
3. Restore degraded and altered habitats that historically supported wetlands and associated uplands to increase the quantity and availability of native habitats to benefit populations of native birds, fish, and other wildlife
4. Support adaptive management and applied research programs that provides managers with the best available scientific information for effective and efficient restoration and management techniques
5. Support education and outreach programs for schools, aquaculture farmers, and the general public to increase their awareness of the importance of natural habitats, communicate best management practices for farmed wetlands, and encourage eco-tourism benefits

Through collaborative efforts, the PCJV is currently developing quantifiable habitat objectives to achieve these goals. These objectives include areas identified as priority wetland sites by the U. S. Fish and Wildlife Service and State of Hawai`i. The U.S. Fish and Wildlife Service identified restoration and/or management of core and supporting wetlands area as critical to the recovery of endangered waterbirds (U. S. Fish and Wildlife Service 2004a). The number of core and supporting wetland sites is summarized in Table B-1. Habitat status, threats, and management goals are identified for seven habitat types important for shorebirds in Hawai`i. Table B-2 summarizes information on management goals from the U. S. Pacific Islands Regional Shorebird Conservation Plan (Engilis and Naughton 2005).

In addition, this PCJV strategic goes a step beyond other management plans developed for Hawai`i. It identifies areas that do not currently provide productive habitat for native plants or animals due to invasive species and hydrological and/or substrate modifications. These areas, priorities for protection and restoration, will ultimately increase the availability of habitats for endangered waterbirds once restored and effectively managed (see Table 4).

Table 4. Habitat conservation objectives (in acres) for target areas in the Main Hawaiian Islands. Acres are compiled from mapped wetlands, conservation and/or restoration plans, and input received to date from interested partners. Additional information and assessments are being sought for target areas with no acreages listed.

	Conservation Action (ac)			Habitat Type (ac)	
Target Area	**Protect**	**Restore**	**Enhance**	**Wetland**	**Associated Uplands**
Ni`ihau					
Playa Lakes	400		400	400	
Subtotal	**400**		**400**	**400**	
Kaua`i					
Mana Plain	1000	1200	50	1250	200
Wailua River Valley	200	100	100	100	100
Waimea River Valley	159	100	163	163	100
Koloa Reservoirs & Coast	388	30	376	386	17
Hanalei River Valley	164	936	98	246	836
Wainiha River Valley	60	50	10	10	50
Hanapepe Coastal Ponds	60	20	40	50	10
Waikaea Watershed	160	100	60	60	100
Kilauea River	91	28	763	119	700
Huleia Stream & Watershed	239	126	205	205	331
Lumahai Valley	100	100		25	75
Subtotal	**2621**	**2790**	**1865**	**2614**	**2519**
O`ahu					
Waimanalo	400	1278	663	1141	500
Koolaupoko & Kahana	25	400	25	425	50
Kahuku Region	1076	759	412	1158	47
Haleiwa Region	281	281	25	281	25
Pearl Harbor	27	131	266	395	2
Subtotal	**1809**	**2849**	**1391**	**3400**	**624**
Moloka`i					
Southern Coast	240	59	286	310	35
Kualapuu Reservior	100		100	75	25
Subtotal	**340**	**59**	**386**	**385**	**60**
Maui					
Kihei Coast	80	70	10	80	
Kealia Pond NWR			692	692	
Ukumehameha	55	55		55	
North Shore	217	217	235	233	219
Cape Hanamanioa	10	0	10	10	10
Keanae Point	130	110	20	30	100
East Maui	400	350	50	25	375
Subtotal	**892**	**802**	**1017**	**1125**	**704**
Subtotal (5 islands)	**6062**	**6500**	**4659**	**7924**	**3907**

Table 5 (con't). Habitat conservation objectives (in acres) for target areas in the Main Hawaiian Islands. Acres are preliminary estimates compiled mapped wetlands, conservation and/or restoration plans, and input received to date from interested partners.

	Conservation Action			Habitat Type	
Target Area	**Protect**	**Restore**	**Enhance**	**Wetland**	**Associated Uplands**
Lana`i					
Lana`i Sewage Trt. Pond			5	5	
Subtotal			**5**	**5**	
Kaho`olawe					
Honokanaia		6	1	1	5
Kaukaukapapa		15	10	10	5
Lau Kealialalo		125	125	25	100
Subtotal		**146**	**136**	**36**	**110**
Hawai`i					
N. Kohala & Hamakua Coast	57	30	108	108	30
South Kohala Coast	61	61		11	50
Kona Coast	8	245	333	178	500
Mauna Kea & Kohala Mtns.	500	100	5000	100	5000
Hilo Region	28	10	67	67	10
Subtotal	**654**	**446**	**5508**	**464**	**5590**
Subtotal (3 islands)	**654**	**592**	**5649**	**505**	**5700**
Subtotal (previous page)	**6062**	**6500**	**4659**	**7924**	**3907**
GRAND TOTAL	**6716**	**7092**	**10380**	**8429**	**9607**

Coastal Plain wetland complex in Hawai`i

POPULATION GOALS

Population goals are consistent with those developed by the U. S. Fish and Wildlife Service for species listed as threatened or endangered under the Endangered Species Act and other avian conservation plans. Once habitat objectives are collaboratively developed, population goals may be increased to account for additional waterbird numbers that can be sustained on areas not currently identified by other conservation plans (e.g., potential wetlands not yet restored).

Population goals for the delisting of endangered and threatened waterbirds are established on a state-wide basis in draft recovery plans by the U. S. Fish and Wildlife Service (Table 5). Although some species of listed waterbirds are currently estimated to be at or above established population objectives, delisting requires that this trend be maintained for 10 years. In addition, many of the demographic parameters for the endemic Hawaiian waterbirds remain unknown. Therefore population goals should be closely tied to habitat objectives to ensure that resource needs of endangered waterbirds are met throughout their annual cycle.

No population estimates are available for shorebirds that over-winter and migrate through the Hawaiian Islands (Engilis and Naughton 2005). Thus, sub-regional population goals for shorebirds (not including Hawaiian stilts) on the Hawaiian Islands were established to:

- Protect and enhance populations of wintering bristle-thighed curlews
- Maintain or enhance populations of priority shorebird species
- Accurately assess population size and trends of over-wintering and migrating Pacific golden plovers, bristle-thighed curlews, and wandering tattlers

Table 5. Range-wide population objectives, current status, and occurrence of endemic waterbirds in the Hawai`i Region of the Pacific Coast Joint Venture. Information was compiled from the Draft Revised Recovery Plan for Hawaiian Waterbirds, the Draft Revised Recovery Plan for the Nēnē or Hawaiian goose, and the Draft Revised Recovery Plan for the Laysan Duck.

Species	Overall Objective	Recent Estimate	Main Islands	NW Islands	Comments
Anatidae					
Nēnē (Hawaiian goose)	2000	1300	H, M, Mo, K		Island-specific population objectives established
Koloa (Hawaiian duck)	> 2000	337 2200	H, M, O, K		High occurrence of hybridization on O`ahu & Maui
Laysan duck	> 920	459		Laysan, Midway	Experimental translocation to Midway during Oct. 2004
Rallidae					
Hawaiian moorhen	> 2000	N/a	O, K		
Hawaiian coot	> 2000	Avg=2100 (1500-3000)	All except Kah		
Recurvirostridae					
Hawaiian stilt	> 2000	Avg=1350 (1200-1500)	All except Kah		

GEOGRAPHICAL INFORMATION SYSTEM

A geographic information system (GIS) database has been compiled to help effectively achieve habitat and population goals for wetland conservation in Hawaii. This GIS includes information on biological, physical, environmental, cultural, and political features related to resource conservation at the landscape level. A unique advantage for the state of Hawaii is the correlation between ecological scale and political boundaries.

Table 6. Biological, physical, environmental, cultural, and political data layers compiled to date the Hawaii Wetland Information Network GIS and information-sharing database.

Biological	Physical	Environmental
Biannual Waterbird Survey Data	Soils	Median Rainfall
Endangered/Threatened Species	Aquifers	Solar Radiation
Critical Habitat	Streams	
Native Plant Distributions	Anchialine Ponds	**Cultural**
Extent of Mangrove	Land Use/Land Cover	Fishponds
Riparian Stream Resources	National Wetland Inventory	Cultural Stream Resources
Aquatic Stream Resources	Ditches	Recreational Stream Resources
Vegetation	Coastline	Birding Sites
	LANDSAT	Census Data
	Hydrography	
	Watersheds	**Political**
	Ahupuaa	Planning Boundaries
	Digital Elevation Models	Ownership
	Hypsography	Zoning
	Prior Agricultural Lands	TMK
	Major Land Resource Areas	Judicial Districts
	Water Quality Monitoring Sites	

A comprehensive GIS database strengthens the landscape and biological foundation for effective decision making in accordance with NAWMP and PCJV goals. It will help achieve two long-term goals; 1) objective, landscape-level, scientific assessment to identify the most important areas for sustaining populations, and 2) timely and efficient allocation of resources to conserve habitats.

Recommended Actions

- Continue collaboration with partners that have GIS capabilities
- Review other GIS assessments for coastal and inland wetlands
- Develop comprehensive and accurate map of existing wetlands
- Use standard criteria for mapping existing wetlands; develop additional criteria when needed
- Integrate site-specific data layers for each wetland
- Solicit funding for continued maintenance and updating of GIS and information-sharing network
- Evaluate GIS priority-setting strategies used by other Joint Ventures
- Develop spatial program to quantify and compare wetland rankings when different rankings are assigned to each data layer depending on stakeholder interest
- Use GIS priority-setting strategies as a method to engage and gain support of multiple partners with different interests

18.0 MAIN HAWAIIAN ISLANDS FOCUS AREA

TARGET AREAS

This section shows a draft list of wetland areas in the main Hawaiian islands targeted for conservation action as part of the Hawai`i component of Pacific Coast Joint Venture. Information on the target areas shown in this draft was compiled from avian conservation plans, written documents, and comments received to date from partners.

Each target area for the main Hawaiian Islands features a brief site description, known accomplishments, and draft recommended actions. Some items are blank pending further input from partners. Information on priority target areas and wetland sites includes:

- Designations given to existing wetland sites in the Draft Revised Waterbird Recovery Plan (U. S. Fish and Wildlife Service 2004a),
- Ecological importance of sites for groundwater protections (Miller et al. 1989a, Miller et al. 1989b), and
- The presence of current conservation efforts, projects and/or interested parties.

This is a collaborative working document that will be added to as we gather additional input from interested parties. Our ultimate goal is to develop a working database and geographic information system (GIS) that can quantify elements needed to prioritize sites for enhancement, outreach, acquisition, and restoration.

NI`IHAU

Playa Lakes

USFWS Designation: Core

This 760 ha (1900 ac) wetland complex could be one of the most important seasonal wetland habitats in the state of Hawai`i. Playa Lakes is used by Hawaiian coots, stilts, and ducks.

Accomplishments.—

Recommended Actions.—These wetlands should be protected in perpetuity to ensure the availability of seasonally flooded habitats.

KAUA`I

Mānā Plain

USFWS Designation: Supporting (81 ha of current habitat)

The Mānā Plain historically supported approximately 1,700 ac of permanent and seasonally flooded wetlands referred to as the "Mānā Swamp." Although this area receives limited rainfall, abundant groundwater discharge historically maintained areas of permanently-flooded wetlands. This area was ditched and drained for sugarcane production. With the fall of the sugarcane industry in Hawai`i marginal agricultural lands on the Mānā Plain were left fallow and are currently dominated by invasive vegetation species.

Wetland sites on the Mānā Plain area classified as supporting wetlands that provide habitat important for smaller waterbird populations or that provide habitat needed seasonally by waterbirds (U. S. Fish and Wildlife Service 2004a). Existing wetland areas on the Mānā Plain include approximately 81 ha (200 ac) of ponds, ditches, reservoirs, and flooded pastures.

Accomplishments.—Wetland conservation in this area is currently focused on public lands, primarily those managed by the Hawai`i State Division of Forestry and Wildlife. Accomplishments to date include:

1. Designation of 136 ac of prior-converted sugar cane agricultural fields into conservation status.
2. Creation of 14 ha (35 ac) Kawaiele Waterbird Santuary to provide habitat for 4 species of endangered waterbirds

Recommended Actions.—Conservation efforts should focus on ensuring that wetland and associated upland habitats are maintained in perpetuity through conservation easements and/or acquisition. Actions that will fulfill habitat objectives for this area include:

1. Identifying and mapping marginal agricultural lands where restoration efforts would create a mosaic of coastal wetland habitats.
2. Continuing long-term monitoring that examines the effect of hydrologic alterations (i.e., groundwater pumping) on current and restored biological communities.
3. Remove and/or control tilapia and other invasive fish species in Kawaiele Waterbird Sanctuary to increase the availability of wetland and aquatic food resources for waterbirds and other wetland-associated wildlife.
4. Restore 136 ac of newly designated conservation lands to high quality wetland habitats, where wetland function can exceed that provided by the current systems of ditches and reservoirs.

Wailua River and Associated Watershed

USFWS Designation: Supporting (Ōpaeka`a Marsh & Smith's Tropical Paradise)

Prior to Eurpoean contact, the Wailua River was characterized by flooded bottomlands with abundant fresh water, fertile soil, plentiful fish, and a long sandy beach. During Polynesian times, farming along the river supported a large human population and this area, was a center for ali`i and kahuna (chiefs). Several heiau (temples) were built, the remnants of which are still

present today in the archeological record. Ditches were constructed to divert water from the river to terraced taro fields. These ancient terraces are still present today, though concealed by the vast overgrowth of invasive grasses.

Accomplishments.— Ōpaeka`a Marsh, adjacent to the Wailua River, supports 3 species of endangered waterbirds.

Recommended Actions.—Actions which create a mosaic of wetland habitats throughout the Wailua River watershed will be the most beneficial to endangered waterbirds.

1. Protect additional private land to provide habitat for endangered waterbirds in perpetuity through conservation easement and/or acquisition.
2. Restore and enhance habitat on wetland management units on state lands at Ōpaeka`a Marsh.
3. Protect Smith's Tropical Paradise in perpetuity as habitat for endangered waterbirds through cooperative agreements with the private landowner. This area is the lowest flatland along the Wailua River that was a tidal marsh prior to modification for a tropical garden.
4. Develop a restoration and management plan for Smith's Tropical Paradise that includes outreach and public education.

Waimea River and Taro Fields

USFWS Designation: Supporting

The Waimea River, Kaua`i's largest river system, was another area used by Hawaiian Royalty prior to European contact. Taro fields support koloa during wet periods. Currently unused and unfarmed fields are overgrown with invasive species including *Pluchea* spp. and California grass.

Accomplishments.—

Recommended Actions.—This area could be used as a demonstration area for managing taro on private lands on a rotational basis for waterfowl and waterbird populations while supporting local economies.

1. Cooperate with local landowners to reestablish old taro fields currently overgrown with invasive vegetation.
2. Develop guidelines for management of taro to benefit wildlife through on-site demonstration plots and incorporate knowledge gained from other research in Kaua`i including that at Hanalei National Wildlife Refuge.
3. Secure additional federal funds available for wildlife habitat improvement work and/or restoration on private lands.

Koloa District Reservoirs and Coast

Waita Reservoir

USFWS Designation: Supporting

Waita Reservoir is the largest freshwater reservoir on Kaua`i, currently managed for commercial fishing and is surrounded by cane fields. This reservoir is unique in that it has shallow-sloped sides which support emergent wetland vegetation.

Accomplishments.—

Recommended Actions.— With the ability to manipulate water levels through the reservoir outlet, water-level management that benefits both commercial fishing interests and waterbird habitat should be explored.

1. Cooperative efforts with the landowner should focus on habitat manangement through water-level manipulations that are beneficial to waterbirds as well as commercial fishing.
2. Keep disturbance to coots and other waterbirds at a minimum.

Lawa`i Kai Estuary

USFWS Designation: Other

Prior to human settlement, estuarine wetlands and riparian habitats along the Lawa`i Kai likely supported many waterbirds. The remote, protected bay also provided important breeding habitats for sea turtles. An ancient Hawaiian fishpond, tidal mud flats, and lotus pond characterize the lower valley. Sedimentation has filled in much of the fishpond that is dominated by dense stands of emergent vegetation.

Accomplishments.—The National Tropical Botanical Garden received funding to research and monitor water quality and overall stream health. The results of this project with will provide baseline information for developing restoration plans to improve watershed health. They have begun restoration of sandy beach habitats along the Lawa`i Bay by out-planting native vegetation and controlling invasive species, concentrating on using organic methods whenever possible. The ulitimate goal of beach restoration activities is to provide secure nesting habitat for sea turtles.

Recommended Actions.—

1. Develop a restoration plan and secure funding to restore important cultural and natural resources, including estuarine wetlands, riparian habitats, and the ancient Hawaiian fishpond.

Waiopili Stream, Maha`ulepu

USFWS Designation: None (Makauwahi Cave is designated as critical habitat for endangered cave invertebrates)

This are contains important natural and cultural resources including the Makauwahi Cave, habitat for the endangered Kaua`i cave wolf spider and the Kaua`i cave amphipod. The cave is an important geological feature where examination of sediment and fossil contents increased our understanding of the composition, dynamics, and human-induced changes of ecological communities dating back to pre-human settlement (see Burney et al. 2001).

Riparian areas and grasslands provide nesting and foraging habitat for koloa and nēnē. Kapunakea Pond drains through a channelized ditch with flow containing high sediment loads

detrimental to coral reefs along the southern coast of Kaua`i. Wiaopili Stream is also important nursery habitat for native fish. Impoundments and managed wetlands would improve habitat for waterbirds and fish as well as serve as experimental management units to research control techniques for invasive wetland vegetation.

Accomplishments.—Research and restoration have been ongoing in this area since 1992. Fifteen acres of habitat, including abandoned cane fields, mine spoil areas, Makauwahi Cave, riparian habitats, and an isolated freshwater marsh are currently leased from the private landowner and managed as a restoration project. Funds have been secured to restore native grasslands on abandoned cane fields and sand dune habitats around the cave. Site managers have solicited a large network of volunteers and provided educational outreach programs for community residents and visitors.

Recommended Actions.—

6. Protect this unique area in perpetuity through conservation easements, cooperative agreements with the landowner, and/or direct acquisition.
7. Develop a restoration plan for riparian habitats, estuarine wetlands, and managed wetlands along Waiopili Stream.
8. Continue community outreach and educational programs.
9. Develop research program to assess control techniques for invasive species in managed wetlands and grasslands.

Hanalei River Valley and Taro Fields

USFWS Designation: Core (Hanalei NWR), Supporting & Other (Hanalei Valley)

Taro cultivation in the Hanalei Valley dates back more than 1300 years ago, therefore making it difficult to assess pre-human habitat conditions. The Hanalei River Valley contains abundant fresh water and the valley's taro cultivation that accounts for 60% of Hawai`i's taro production. Waterbird use of this area is high and it has been documented that waterbirds move between the Hanalei Valley and other habitats on Kaua`i and Ni`ihau.

Accomplishments.—In 1972, the U. S. Fish and Wildlife Service acquired 367 ha (917 ac) of land in the Hanalei Valley. Currently, taro loi and managed wetlands provide habitat for 5 species of endangered waterbirds. These areas are protected in perpetuity to continue providing long-term habitat for endangered waterbirds. Nēnē were re-introduced to the Hanalei Valley during 2000.

1. Research that quantifies the wetland condition of taro loi and managed wetlands in creating suitable habitats for waterbirds during each life cycle event was funded during 2003.
2. Managed wetlands at the Hanalei National Wildlife Refuge were re-designed to facilitate water-level management that maximizes the available habitat for endangered waterbirds. Construction is expected during Fall 2005.

Recommended Actions.—Ongoing monitoring and research that examines ecosystem function of taro loi and managed wetlands will increase the ability of land managers (private and public) and natural resource planners to develop management guidelines that provide the highest quality habitat for Hawai`i's endangered waterbirds.

1. Protect additional areas of taro loi and managed wetlands in perpetuity through conservation easements and/or acquisition.
2. Expand outreach and educational opportunities for taro farmers on best management techniques for Hawai`i's endangered waterbirds.
3. Coordinate and implement valley wide predator control to increase adult and juvenile survival of endangered waterbirds.

Wainiha River Valley and Taro Fields

USFWS Designation: Supporting

The Wainiha Valley contains a diversity of wetland habitats including estuarine marshes, palustrine freshwater marshes, and ephemeral flooded pastures and taro fields.

Accomplishments.—

Recommended Actions.—Develop a cooperative agreement with multiple landowners that ensures maintenance of stream flow throughout is normal course in the valley and mimics the variability of the rivers natural hydroperiod.

Hanapēpē Coastal Ponds

USFWS Designation: Supporting (Hanapēpē Salt Ponds)

Three areas on the Hanapēpē Coast provide habitat for Hawaiian waterbirds. Hanapēpē Salt Ponds are identified as supporting wetlands in the Draft Waterbird Recovery Plan (U. S. Fish and Wildlife Service 2004a). Hanapēpē Salt Ponds provide a continuum of available habitat for Hawaiian stilts along the southern coast of Kaua`i from Lihue to Mānā. Other sites along the Hanapepe Coast include Kaumakani Gulch Ponds and Olokele Settling Ponds.

Accomplishments.—

Recommended Actions.—

1. Manage Hanapēpē Salt Ponds to encourage year-round use by Hawaiian stilts and/or restore/manage additional habitats to use when conditions at Hanapēpē Salt Ponds are not suitable.

Waikaea Watershed, Kawaihau

USFWS Designation: Other

Accomplishments.—The first perpetual wetland conservation easement in Hawai`i was implemented within the Kaikaea watershed near the town of Kapaa. Private landowners had also show interest in managing agricultural lands for taro production. Portions of prior converted agricultural lands that were abandoned when the sugarcane industry declined have naturally restored to seasonally flooded mud flat and semi-permanently flooded emergent vegetation habitats.

Recommended Actions.—Financial incentives would increase the attractiveness for private landowners to manage taro fields where waterbird habitat is considered a primary objective.

Kilauea River

USFWS Designation: Other

Accomplishments.—Kilauea Point National Wildlife Refuge (82 ha, 203 ac) was established to secure habitat for nesting seabirds and endangered plants along the rocky coast of northern Kaua`i. The refuge boundary was recently expanded in hopes of acquiring lowland habitats on the Kilauea River, including estuarine wetlands. Extensive habitat restoration efforts have established many native Hawaiian plant populations on the refuge. Thirty-eight nēnē have been re-introduced to Kilauea River area since 1991. Combined with Crater Hill, this population of nēnē successfully expanded to an estimated 238 birds during 2002 (U. S. Fish and Wildlife Service 2004c). The ocean waters off of Kilauea Point were designated as a National Marine Sanctuary in 1992 to protect endangered humpback whales.

Recommended Actions.—

Hulē`ia Stream and Associated Watershed, Lihue District

USFWS Designation: Core (Huleia NWR only)

Waterbird habitats along Hulē`ia Stream include mid to high elevation reservoirs, riparian habitats, river bottom emergent wetlands at Hulē`ia National Wildlife Refuge, and Menehune Fishpond.

Accomplishments.—Hulē`ia National Wildlife Refuge was established in 1973 to provide wetland habitats for Hawaiian waterbirds.

1. Habitat on a portion of Hulē`ia National Wildlife Refuge is managed to control invasive vegetation species through disking and water-level manipulation.

Recommended Actions.—Habitats along Hulē`ia Stream should be managed to provide a complex of wetland habitats ranging from permanently flooded mid-high elevation ponds and reservoirs to seasonally flooded emergent vegetation and mud flat habitats on the river bottom.

1. Improve water delivery at Hulē`ia NWR so that wetland habitats are managed to provide maximum benefit for Hawaiian waterbirds.
2. Remove mangrove from Hulē`ia Stream to a) open up habitat for endangered Hawaiian waterbirds and b) restore at preserve the ancient cultural resources at Menehune Fishpond.
3. Regrade mid to high elevation reservoirs to promote growth of emergent vegetation along shallow-sloped sides.

Lumaha`i Valley, Hanalei District

USFWS Designation: Core

Lumaha`i Valleu provides approximately 121 ha (300 ac) of relatively undisturbed high quality habitats for 4 species of endangered waterbirds.

Accomplishments.—

Recommended Actions.—Protect and preserve Lumaha`i in perpetuity through conservation easements and/or cooperative agreements with the private landowner.

1. Protect preserve Lumaha`i in perpetuity through conservation easements and/or cooperative agreements with the private landowner.
2. Develop research and monitoring protocols to assess and compare habitat use, distribution, and reproductive success of waterbirds at Lumaha`i, which is relatively undisturbed, to regions which are moderately and highly disturbed.
3. Develop educational opportunities.

O`AHU

Windward O`ahu, Waimanalo Aquifer

Urbanization on windward O`ahu has had a profound negative effect on watershed health. Accelerated siltation and polluted storm water runoff impairs watershed function, and threatens marine coral reef habitats.

Kawai Nui Marsh, `Ahahui Mālama I Ka Lōkahi

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Kawai Nui marsh is the largest remaining wetland in the state of Hawai`i. The 336 ha (830 ac) marsh is primarily fed by surface runoff from Maunawili and Kahanaiki Streams. Historically this area contained a 180 ha (450 ac) fishpond. A flood control levee along the makai portion of the swamp has greatly altered the natural hydrology of the marsh, promoting conditions that are favorable to dense stands of emergent vegetation. Under natural hydrologic conditions, the marsh went through cycles of fresh water and brackish water, but under current conditions remains fresh.

Accomplishments.—Kawai Nui marsh is owned by the City and County of Honolulu and the State of Hawai`i Division of Forestry and Wildlife. The entire marsh is managed by the State of Hawai`i and planning efforts have been underway since 1993 for restoration and long-term management of wetland habitats. The state and the U.S. Army Corps of Engineers have developed an 1135 cost-share program; funds from this program will be focused on restoration efforts within 304 ha (750 ha) of wetland habitats. Funds from the North American Wetlands Conservation Act were awarded during 2002. These and partner contributions will be used to assist with native upland forest restoration.

A community volunteer project has been started to restore wetland habitats at Na Pohaku o Hauwahine. Removal on thick non-native vegetation and accumulated underlying peat created an open pond that was then planted with native vegetation. Problems arose due to the tendency of organic sediments to refill the open ponds. A Kailua Bay Advisory Council grant was obtained to study sediment properties, water quality, and biological interactions.

Recommended Actions.—Quantitative assessment of the impacts of hydrological alterations on wetland habitats is necessary for restoration efforts to be effective.

1. Develop and implement hydrological monitoring to assess the current hydroperiod (depth, duration, and frequency of flooding), and compile historical data to assess prior hydrological conditions.
2. Evaluate potential water-level management tools that would create hydrological conditions that mimic the natural hydrology of the site, including installing a water control structure that would allow drainage of water through the marsh's natural outlet.

Nu`upia Ponds

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Sensitive Habitat

Nu`upia Ponds are located on the Marine Corps Base Hawai`i (MCBH) in Kaneohe Bay. Prior to construction of the base, 30 ancient fishponds occupied the peninsula.

Accomplishments.— MCBH has also received funding through the Congressional Legacy Program for projects aimed at stewardship of natural and cultural resources on lands with current or historical military value. A watershed manual, Mōkapu: Manual for Watershed Health and Water Quality, was developed during 1998 to explain the ecology of the Mōkapu Peninsula, provide specific guidance for planning, develop specific data-gathering procedures, and provide standards for evaluating management actions and watershed health.

Nu`upia Ponds Integrated Natural Resources Management Plan was developed during 1996–2001 to meet the challenges of balancing combat readiness, quality of life, and conservation activities through a set of goals, objectives, and linked management actions. Components affecting wetland resources include designs to naturalize stream corridors and relieve flooding, doubling the population of Hawaiian stilts in MCBH wetlands over 20 years, improving GIS capabilities, and collaborating with the community.

Recommended Actions.—

Hāmākua Marsh

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: None

Twenty three ac (9 ha) of wetland habitats have been restored at Hāmākua Marsh and the site is managed by the State of Hawai`i, Department of Land and Natural Resources.

Accomplishments.—

1. Restoration activities included removing invasive mangroves along the canal and wetland edge
2. A website, www.hamakuamarsh.com was established as part of an outreach project to educate students about wetland restoration. Illustrations, photographs and writing for the website was completed by over 350 students from 3 schools. This gave students a voice to speak on community issues and act on their ideas.
3. Research projects are examining water quality and vegetation characteristics of the site.

Recommended Actions.—

1. Continue management of wetland habitat to control invasive vegetation.

Ka`elepulu Fishpond and Wetland

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Historically Ka`eleulu Pond and associated wetlands covered 113 ha (280 ac). Of this area, an estimated 36 ha (90 ac) of emergent marsh surrounded the pond. Early alteration of natural Ka`elepulu wetlands included conversion to taro, rice, and sugar cane fields. However, the greatest impacts to wetland habitats around the pond occurred after 1950 and include filling for urban development, a flood control project that permanently diverted daily flows of fresh water from the pond, and dredging to lower the surrounding water table. These activities reduced the original wetland habitats to 2.4 ha (6 ac). Following development of area, the pond was renamed Enchanted Lake.

Accomplishments.— This wetland is privately owned and is protected and managed by the landowners under a U.S. Army Corps of Engineers Permit. On-going intensive management includes the removal of invasive plants, creating open areas, planting native vegetation, and predator control. The landowners have developed a website (http://www.kaelepuluwetland.com) to provide information on the wetland.

Recommended Actions.—

1. Continued management by the owners in cooperation with the USFWS and DOFAW.

Bellows Air Force Wetlands

USFWS Designation: None
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Waterbird habitats include ditches, streams, and wetlands.

Accomplishments.—

Recommended Actions.—

Windward O`ahu, Koolaupoko and Kahana Aquifers

USFWS Designation: Supporting (Waihe`e Marsh & He`eia Fishpond Marsh)
Groundwater Protection Strategy Assessment: Varies by site

This region includes wetlands associated with 5 fishponds, riparian wetlands along perennial streams, University of Hawai`i Mariculture Research Center, Hoomaluhia Botanical Gardens, Baskerville Spring, and Waihe`e Marsh. He`eia Fishpond and associated wetlands (160 ha [400 ac]) were formerly part of a complex of tidal marshes and open water that likely extended across most of the windward Coastal Plain. Extensive modification to this site has resulted from invasive vegetation, cattle grazing, increased sedimentation from He`eia stream resulting from urban development in Kaneohe, water diversions along He`eia stream, and an overall reduction in the height of the water table in the Kaneohe area. Waihe`e Marsh is a 10 ha (25 ac) wetland that supports a limited number of waterbirds.

Accomplishments.—He`eia Fishpond and Wetlands are owned by the Hawai`i Community Development Authority and Bishop Estate. It is also on the Hawai`i State Register of Historic Places.

Recommended Actions.—

1. Ensure long-term protection of Waihe`e Marsh
2. Integrate enhancement of wetland habitats at Waihe`e Marsh with environmental education opportunities through the City and County of Honolulu.
3. Assess hydrological modifications at He`eia Marsh, including human induced and those caused by invasive vegetation to effectively restore wetland habitats.
4. Identify additional wetlands in need of restoration that, if restored, would create a mosaic of wetland habitat types along the windward coast of O`ahu.
5. Ensure long-term protection and management of He`eia Fishpond and wetlands through a transfer or cooperative agreement with the State of Hawai`i, Department of Land and Natural Resources.

Pearl Harbor, Ewa District

The shoreline pattern of Pearl Harbor, characterized by its narrow entrance and varied lochs, is a system of eroded watercourses developed when sea level was approximately 18 m (60 ft) lower than present levels (Ziegler 2002).

Pearl Harbor National Wildlife Refuge, Honouliuli and Waiawa Units

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Honouliuli and Waiawa wetlands are constructed wetlands on West and Middle Lochs of Pearl Harbor that were built as mitigation for construction of the Honolulu Airport reef runway.

Accomplishments.—Funding from the North American Wetlands Conservation Act was secured during 2002, in conjunction with partner funding from the U. S. Fish and Wildlife

Service and Natural Resources Damages Assessment, to enhance 14 ha (35 ac) of coastal wetland and 0.8 ha (2 ac) of associated uplands at the Waiawa Unit.

Recommended Actions.—

Pouhala Marsh Waterbird Sanctuary

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Pouhala Marsh is an estuarine wetland, located adjacent to Waikele Stream, that supports emergent vegetation and mudflats. It is the largest intact wetland (42 ha [104 ac]) in the Pearl Harbor basin. Tidal water level fluctuations provide ephemeral foraging habitats for endangered waterbirds. Mangroves occur along the harbor.

Accomplishments.—Funding from the North American Wetlands Conservation Act was received during 2002 to help restore 28 ha (70 ac) of degraded and non-functioning tidal wetland habitats by removing 66,000 cubic yards of fill, clearing trash and debris that was dumped into the wetland. Invasive vegetation will also be removed and controlled from 8 ha (20 ac) of wetland habitats by contouring additional basins, installing water control structures and removing mangroves from Waikele and Kapakahi Streams.

Recommended Actions.—

Waipahu, West Loch, Pearl Harbor

USFWS Designation: None
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

This area is characterized by coastal mudflats, coral reef flats, and salt flats that are overgrown with mangrove and other species of invasive vegetation. Restoration of tidal mudflats and shoreline habitats will greatly benefit resident and migratory waterbirds, by contributing to the existing mosaic of wetland habitats in Pearl Harbor.

Accomplishments.—Funding from the North American Wetlands Conservation Act was received during 2002 to restore 11 ha (27 ac) of coastal habitats by removing invasive species of vegetation. The Waipahu Community Foundation has selected this site as a target area for the city's Pearl Harbor Historic Trail restoration project.

Recommended Actions.—

1. Pursue additional funding for future phases of mangrove removal through city and state programs that will be associated with delivering the Historic Trail project.

Waiawa Springs, Middle Loch

USFWS Designation: None
Groundwater Protection Strategy Assessment: Ecologically Sensitive Habitat

Accomplishments.—

Recommended Actions.—

East Loch, Pearl Harbor

USFWS Designation: None
Groundwater Protection Strategy Assessment: Ecologically Sensitive Habitat

Small agricultural wetlands are located on inland spring-fed patches on the East Loch of the Pearl Harbor Coastal Plain. Poorly drained deltaic sediments are underlain by muck, peat, and/or reef deposits. These farmed wetlands are surrounded by dense mangroves.

Accomplishments.—

Recommended Actions.—

Kahuku Region, Northern O`ahu, Koolauloa District

The terrestrial coastal ecosystem on northern O`ahu has been highly modified. An extensive freshwater marsh complex separated from the ocean by sand dunes was maintained by ground water discharge from the confined basal Koolau aquifer, intermittent storm runoff. Historical marsh areas were modified for sugarcane production and prawn and shrimp aquaculture. Eight wetland areas have been identified on the Kahuku coastal plains and one wetland is located at the northern terminus of the Koolau Mountains.

Ki`i Unit, James Campbell National Wildlife Refuge

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

When used by the sugarcane industry, Ki`i Pond expanded up to 186 ha (460 ac) when filled with water. The substrate of Ki`i Pond has been altered due to accumulated silt and organic material from processing sugarcane. Invasive non-native vegetation is a threat to wetland and associated upland habitats at Ki`i. Still in use today, an artificial outlet to Ki`i Pond was constructed to provide drainage for the Kahuku area.

Accomplishments.—Management of the Ki`i Unit of James Campbell National Wildlife Refuge has restored 28 ha (70 ac) of coastal wetlands and 19 ha (47 ac) associated uplands, previously used as effluent settling basins and waste disposal for fibrous sugarcane waste (Shallenberger 1977). Funding from the North American Wetlands Conservation Act was received during 2002 to enhance 28 ha (70 ac) of wetlands by installing new water control structures and repairing dike impoundments. Prescribed burning, tilling, and water level manipulations have been developed to successfully control bulrush and other invasive vegetation, providing an interspersion of open water, mud flats, and emergent vegetation habitats for endangered waterbirds. Water-level management was facilitated through a well that provides a reliable source of water.

Recommended Actions.—

Punamanō Unit, James Campbell National Wildlife Refuge

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Punamanō is located about 1 mile west of Ki`i. A freshwater spring, located just off the refuge, supplies some of the water to this 15 ha (38 ac) natural wetland. Ditching on the Kahuku plain has likely altered the natural hydrologic regime of this wetland by shortening one or more aspects of its hydroperiod (depth, duration, and/or extent of flooding). The availability of wetland habitats changes seasonally in response to increased precipitation during winter months that result in increased surface runoff and increased groundwater discharge. Punamanō provides important shallow to moderately flooded habitats (<45 cm, [18 in]) for endangered and migratory waterbirds.

Accomplishments.—The U. S. Fish and Wildlife Service currently leases this property and hopes to acquire the fee title during 2005. Planning is underway by the U. S. Fish and Wildlife Service to acquire an additional 34 ha (85 ac) of land adjacent to the Punamanō Unit, and an additional 600 ac of habitat that would restore part of the historical Kahuku wetland corridor, thereby connect Ki`i and Punamanō Units.

Recommended Actions.—

1. Manage seasonal habitats to compliment other areas of semi-permanently and permanently flooded habitats.
2. Remove exotic vegetation from non-agricultural habitats dominated by invasive species.

Punaho`olapa Marsh

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Shallenberger (1977) reported that the 1977 extent and configuration of this wetland are similar to that depicted on topographic maps from the early 1940s. This wetland provides a diversity of habitats ranging from permanently flooded open-water habitats to temporally flooded mudflats. A portion of this area was modified and converted into the Kuilima Golf Course during the early 1990s. The elevation of the golf course area was raised several feet above its historical elevation. The remaining portion is overgrown with ironwood trees and has lost most of its potential value to waterbirds

Accomplishments.—

Recommended Actions.—

1. Protect remaining area from future development.
2. Assess whether adjacent land use modifications have altered the natural hydrologic regime and substrate, and what affect, if any that has had on native vegetation.
3. Remove non-native invasive vegetation.

Kahuku Aquaculture Farms and Wetlands

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Water supply to these artificial wetlands managed as prawn and shrimp farms is pumped from wells that extract basal water from the Koolauloa aquifer and saltwater from another zone. Although these sites are located on the Kahuku Coastal Plain, sediments form a cap rock on the Koolauloa aquifer preventing natural groundwater discharge in some areas. Natural wetlands occur where springs located along the coastal plain supply groundwater.

Accomplishments.—

Recommended Actions.—

Laie Prawn Farms

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Accomplishments.—

Recommended Actions.—

Kahuku Airstrip Ponds

USFWS Designation: Other
Groundwater Protection Strategy Assessment: None

Previous waterbird surveys indicate that these shallow and somewhat ephemeral ponds are valuable for waterbirds. Low mats of native and introduced vegetation characterize pond habitats.

Accomplishments.—

Recommended Actions.—

Kuilima (Turtle Bay) Sewage Treatment Pond

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Sensitive Habitat

This artificial wetland has become an important area for waterbirds. Endangered species and migratory waterbirds have regularly been documented on the area.

Accomplishments.—

Recommended Actions.—

1. Ensure long-term protection of this site through cooperative agreements with the land owner.

Coconut Grove Wetlands

USFWS Designation: Other
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

These wetlands are adjacent to aquaculture farms in the Kahuku region. Water levels are determined by groundwater discharge and runoff from rainfall; they lack surface water connections except during periods of high rainfall. Undulating topography provides varied habitat utilized by a myriad of resident and migrant waterbirds. Most of the area is presently overgrown with invasive vegetation including *Batis maritima*, bulrush, and *Pluchea* spp.

Accomplishments.—

Recommended Actions.—

1. Protect the area from future development
2. Remove species of exotic, invasive vegetation
3. Manage the area for optimal endangered waterbird and shorebird habitat

Kalou Fishpond and Marsh

USFWS Designation: None
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

This inland, spring-fed pond is approximately 0.4 ha (1 ac) in size and supports a total of 6 ha (15 ac) of wetland habitats. Hydrological modifications include a retaining wall and culvert built through the sand dunes, which connects it to the ocean. As the western-most wetland on O`ahu's northern tip, it is located at the termination of the northern rift zone of the Koolau volcano, where lavas are intersected by vertical dikes. Previously used to grow taro, water from this pond was used to irrigate pastures during the late 1980s (Miller et al. 1989b). The wetland is located within the University of Hawai`i Agricultural Experiment Station.

Accomplishments.— Kalou Marsh is recognized by the County and City of Honolulu as a significant wetland in their Revised Ordinances. The Kalou Fishpond is on the Hawai`i Register of Historic Places.

Recommended Actions.—

1. Remove and control invasive vegetation species.
2. Increase staffing and/or available funds to manage the entire wetland
3. Ensure that this habitat is protected in perpetuity through conservation easements and/or cooperative agreements with the land owner

Halei`wa Region, Waialua District

`Uko`a Marsh and Loko Ea Fishpond

USFWS Designation: Supporting (`Uko`a Marsh), Other (Loko Ea)
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

The `Uko`a Marsh and Loko Ea wetland complex is the third largest existing wetland on O`ahu. Cultural resources include two historical fishponds and historical taro fields. Taro fields have not been maintained since the 1950s and have become overgrown with invasive vegetation as has most of the 101 ha (250 ac) wetland. Invasive vegetation in the wetlands outlet to Loko Ea Fishpond has increased causing the accumulation of organic matter and sediments. This has effectively blocked the flow of surface water through the natural outlet, except during periods of heavy rains, and altered the hydroperiod of `Uko`a Marsh creating conditions favorable to invasive species of vegetation.

Accomplishments.—

1. A vegetation management plan was developed in 1999 that incorporated landowner goals and objectives for education and community outreach.
2. Funding has been secured to draft a restoration plan that includes GIS analysis of historical and current habitat types and changes and monitoring of current hydroperiod characteristics.

Recommended Actions.—

1. Secure funding to implement restoration activities that restore the natural hydroperiod and promote conditions favorable to native vegetation.
2. Ensure that the land is protected in perpetuity to preserve cultural and natural resources.

Halei`wa Marsh, Taro, and Lotus Fields

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

This natural marsh, fed by surface water from perennial streams and groundwater discharge from the Koolau aquifer, was divided into 150 impoundments prior to the 1940s. Currently cultivated areas support lotus and taro. Uncultivated areas have been overgrown with invasive non-native vegetation.

Accomplishments.—

Recommended Actions.—

1. Ensure long-term protection of these wetland habitats through conservation easements and/or cooperative agreements with the landowners.
2. Remove invasive vegetation and accumulated organic matter and sediments to restore the natural substrate to uncultivated areas.
3. Assess hydrologic regime of the area to determine effects of impoundment on the natural hydroperiod of the area.

4. Develop a restoration plan that incorporates geomorphic criteria for controlling invasive vegetation.
5. Work with landowners and lessees to educate them on how to coexist with nesting waterbirds in their crops.

Western Halei`wa Coastal Plain

USFWS Designation: Other (Mokule`ia), None (Dillingham and Crowbar Ranch)
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Wetlands identified on this portion of the Haleiwa Coastal Plain are ephemerally flooded pastures or artificially built ponds/quarries that have exposed underlying ground water. Coastal sediments in this region consist of fossil coral reef that is highly permeable. The primary grazing area at Dillingham Air Field includes extensive mudflats that flood after heavy rains. Crowbar Ranch Pond is a small artificial pond that was a former rock quarry. It is surrounded by pastureland and is currently used by Hawaiian coots and moorhen. A second rock quarry, Mokule`ia was discontinued in the 1970s.

Accomplishments.—

Recommended Actions.—

1. Identify other areas of ephemerally flooded habitats that would compliment seasonal, semi-permanently, and permanently flooded habitats to the east.
2. Develop grazing management strategies that promote habitat conditions favorable to Hawaiian stilts and migratory shorebirds.
3. Enhance habitats at rock quarry ponds by re-contouring pond sides to create shallow-sided slopes and increase microtopographic variation.

MOLOKA`I

Southern Coast

Kakaha`ia National Wildlife Refuge

USFWS Designation: Core

Kakaha`ia National Wildlife Refuge is located at the bottom of the watershed on the south side of Moloka`i. The 18 ha (44.6 ac) refuge encompasses an inland Hawaiian fishpond (Old Pond = 8 ha [20 ac]) that provides deep-water habitats for Hawaiian coots and migratory ducks, and a shallow-water pond (New Pond = 2 ha [5 ac]) for Hawaiian stilts and migratory wading birds and shorebirds. Old Pond is fed by groundwater; however, New Pond requires waster from an outside source, particulary during summer months.

The refuge is located at the base of the watershed and below Kawela Plantation (housing development), resulting in concentration of stream flow and high sedimentation. Kakaha`ia NWR is a satellite refuge (no staff on-site) that is managed by the Maui National Wildlife

Refuge Complex office on Maui. Staff makes a minimum of two trips per month for maintenance and habitat restoration activities.

Accomplishments.—This site was protected and established as a National Wildlife Refuge in 1977. New Pond was constructed in 1985 to provide shallow water habitats for Hawaiian stilts and migratory wading birds and shorebirds. Following the establishment of dense thickets of kiawe and Pluchea sp., invasive species were removed to open up wetland habitats. U.S. Fish and Wildlife Service has partnered with Federal Highways Administration Central Federal Lands Highway Division to improve drainage and roads to help restore wetland habitats. They have also partnered with The Nature Conservancy, U.S. Geological Survey, and private landowners to improve watershed management

Recommended Actions.—

1. Remove accumulated sediment to restore natural substrate and reduce the prevalence of invasive vegetation species.
2. Remove and control invasive plant species in Old and New Ponds.
3. Remove vegetation on Old Pond radials and reshape to provide topographical diversity.
4. Rehabilitate Old and New Pond levees and replace water control structures.
5. Rehabilitate Kamehameha V culvert to provide proper drainage from upper watershed.
6. Drill shallow-water well, install pump and water delivery system to provide alternative water source for ponds.
7. Replace fences and gates.
8. Grade and resurface refuge road entrance to accommodate drainage.

Kaunakakai Sewage Treatment Plant

USFWS Designation: Supporting

Accomplishments.—

1. Artificial nesting platforms encouraged nesting by Hawaiian stilts.
2. On-going predator control

Recommendations.—

1. Long-term protection
2. Restoration of the natural wetland area.
3. Development of a constructed wetland using recycled water from the treatment plant.

`Ōhi`apilo Playa

USFWS Designation: Core (`Ōhi`apilo Wetland)

The `Ōhi`apilo Playa covers approximately 25 ha (60 ac) of coastal habitats along the southern cost of Moloka`i. A 10 ha (25 ac) wetland is managed by the County of Maui for Hawaiian stilts, Hawaiian coots, and migratory waterfowl.

Accomplishments.—Habitat enhancement was completed in 1999 to provide nesting habitat for Hawaiian stilts, an additional 4 ha (10 ac) of seasonally-flooded mudflats, and an additional 1 ha (3 ac) of semi-permanently flooded ponds and channels. The wetland is surrounded by a 90 m (300 ft) fenced buffer zone.

Recommended Actions.—On-going management is necessary to control non-native vegetation.

Koheo Wetland

USFWS Designation: Other

Koheo Wetland is a privately owned wetland that has been reduced in size from 11.5 ac to 9.5 ac due to erosion. On-going management is increasing the available habitat for waterbirds.

Accomplishments.—

1. Management plan with private landowner has been developed
2. Volunteers removed non-native vegetation and clean-up the site
3. Documentation of historical changes to the site compiled using aerial photos dating back to 1931.
4. On-going out-planting of native vegetation to stabilize the shoreline.

Recommended Actions.—

1. Continue management actions to reduce erosion and stabilize the shoreline.

Coastal Fishponds

USFWS Designation: Supporting (Paialoa Fishpond only)

Four fishponds along the southern coast of Moloka`i provide habitat for Hawaiian waterbirds.

Accomplishments.—

Recommended Actions.—

1. These fishponds should be protected in perpetuity to conserve cultural and natural resources of the region.

Kualapuu Reservoir

USFWS Designation: Supporting

This reservoir, located in north-central Moloka`i, periodically supports large numbers of coots.

Accomplishments.—

Recommendations.—

1. Long-term protection
2. Monitor bird populations and habitat use relative to environmental conditions at the site and on other wetlands on Moloka`i.

Mana`e (Southeast Moloka`i)

USFWS Designation:

This area of Moloka`i has extensive natural wetlands, taro fields, spring fed fishponds, and healthy near shore ecosystems in a largely in-tact and contiguous condition. This area faces high development pressures that have the potential to reduce and fragment aquatic and terrestrial resources along the coast.

Accomplishments.—A local community group, Malama Pono O Ka Aina is advocating a pro-active assessment of the area to provide critical tools for planners, regulatory agencies, and neighbors so that informed decisions can be made regarding land use proposals. They have initiated efforts to map "community knowledge of wetlands and associated natural and cultural resources.

*Recommended Action*s.—

1. A survey of wetlands and aquatics resources in the area to accurately document the extent and condition of existing habitats.
2. An assessment of the cumulative impacts of individual development projects on inland waters, aquatic resources, cultural uses and resources, and recreational activities.

MAUI

Kihei Coast

USFWS Designation: Other

Groundwater Protection Strategy Assessment: None

The Kihei coast on Maui used to support an expansive coastal estuarine coastal system that has been "cookie-cut" by development. Urban encroachment on these wetlands has reduced the availability of wetland habitats as well as compromised remaining habitats due to disturbance and pollution.

Accomplishments.—An assessment of wetland change was completed in early 2000 by the Natural Resources Conservation Service. During 1965, approximately 80 ha (200 ac) of wetland habitats were identified on the Kihei coast. Currently only 32 ha (80 ac) remain, 4 ha (10 ac) of which are mitigation sites. This assessment showed that individual permits to degrade and fill wetlands were not significant on their own, but created a cumulative negative effect over time. In addition, some compensatory mitigation was not completed.

Recommended Actions.—

1. Work with landowners to protect these areas from future development.
4. Increase the support of restoration efforts through community education and eco-tourism incentives.

5. Increase pressure on developers to deal with non-point source pollution
6. Redesign mitigation ponds that are currently too deep to provide productive waterbird habitat.
7. Remove and control invasive vegetation at existing mitigation ponds.
8. Ensure that all compensatory mitigation is completed.

Keālia Pond National Wildlife Refuge

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

This 280 ha (692 ac) wetland and pond complex provides habitat for 31 species of birds, including Hawaiian stilts and coots. Three inlets drain 56 mi^2 from West Maui. The refuge also receives water from Haleakala on East Maui. Under natural hydrologic conditions, freshwater accumulates from seasonal surface runoff. Wells driven into the Kula aquifers provide a constant water supply, but the refuge is subject to upper watershed changes and urbanization at its boundaries.

The north shore is shallow and provides good potential nesting habitat for Hawaiian stilts. During 2001, a wildfire that burned relatively hot opened up habitat that was colonized previously by dense thickets of pickleweed. Ma`alaea Flats supports both fresh and brackish water habitats. One of the main goals for the refuge is to gain more information about wetland ecology to make informed management decisions.

Accomplishments.—This area was established as a National Wildlife Refuge in 1992. Since then, the U.S. Fish and Wildlife Service has completed 4 years of comprehensive hydrological monitoring (groundwater, surface water, & streamflow) and water quality analyses; geomorphic sampling was also completed at Ma`alaea Flats.

Currently, 5 studies are on-going to assess: 1) response of vegetation and waterbird to mechanical control of *Batis maritima*; 2) response of invertebrates to mechanical control of *Batis maritima*; 3) impacts of fish on invertebrate communities and abundance; 4) invertebrate composition, seasonal occurrence, and relative abundance at Kealia Pond NWR; and 5) fish composition, diet, and recruitment. Research results will provide guidelines for the treatment of invasive vegetation and other biological and ecological parameters to improve wetland function and benefit Hawaiian waterbirds.

Construction of a 2,200 ft boardwalk at Ma`alaea Flats was initiated in 2003 to provide public access into an ecologically sensitive area. Interpretive panels will provide information on the ecology, biology, and cultural history of the area.

Recommended Actions.—

1. Drill shallow-water well, install pump and water delivery system at Ma`alaea Flats to maintain water for nesting Hawaiian stilts.
2. Acquire a donation of 10–34 ac of remaining wetland habitats at Ma`alaea Flats from Alexander and Baldwin Properties, Inc.
3. Create shallow berm to retain water in the Ma`alaea Flats for nesting and foraging Hawaiian stilts.
4. Restore North Kihei Road culvert (pond outlet) to facilitate management of water levels.

5. Remove red mangrove stand and California bulrush along northeast edge of the main pond
6. Control non-native pickleweed in the north shore flats to increase habitat available for endangered and migratory birds.

Ukumehame Firing Range

USFWS Designation: Other
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Approximately 22 ha (55 ac) of seasonally flooded habitats at this site provides an alternate site for Hawaiian stilts and other waterbirds to use when habitats at Kealiā Pond National Wildlife Refuge are unsuitable due to high water or when disease outbreaks (i.e., botulism) occur. Nēnē also use this lowland wetland complex. Nearby ditches that drain the area have altered the natural hydrology of the site. This area has the potential to become a major breeding site for nēnē.

Accomplishments: This site will be an anchor for the Pali to Puamana Park that is planned to stretch for 7 miles along the west Maui coast. Restoration of native habitats is planned for the portion of this site that is owned by the Army National Guard.

Recommended Actions:

1. Remove non-native vegetation and out-plant with native species.
2. Relocate County facilities from the wetland to nearby higher ground.
3. Install a predator-proof fence that keeps out cats, dogs, mongoose, and rats, creating a potential breeding area for nēnē.
4. Test the area for lead and other items from munitions.
5. Once enhanced, this area could be an additional release site or re-location site, to complement the current population of nēnē re-introduced in the nearby uplands at Hana`ula on west Maui.

Cape Hanamanioa

USFWS Designation: Other
Groundwater Protection Strategy Assessment: None

This area contains some of the richest anchialine ponds in the state. These permanently-flooded ponds fluctuate daily with the tide and seasonally with winter rainfall. A native damselfly, pinau ula (*Megalagrion xanthomeles*), previously thought to be extinct on Maui, was rediscovered breeding in these ponds in 1996. Although this site only gets occasional use by Hawaiian stilts, its conservation is important to maintaining native biological diversity on Maui. This site also provides habitat for shorebirds and 2 species of native plants, ihi (*Portulaca villosa*) and ruppia (*Ruppia maritima*).

Accomplishments.—Non-native vegetation was removed by the Native Hawaiian Plant Society.

Recommendations.—

1. To ensure that this land is not developed or otherwise compromised, a conservation easement could be developed with the landowner.
2. Human disturbance is an increasing threat to this area. Closing the exisiting road to vehicles at the beginning of the Ahihi-Kinau Natural Area Reserve would help to alleviate disturbance.

North Shore of Maui

Only three significant wetlands remain on the North Shore of Maui; Kanahā Pond, Waihe`e Wetland, and Paukukalo Wetland. Although Kanaha Pond covers only half of its historical extent, protection of Kanahā and Waihe`e ensure that these wetland habitats will be maintained in perpetuity for wetland associated wildlife. Urbanization and degradation of native habitats imminently threatens the 3rd wetland, Paukukalo, and no protection or restoration actions are currently planned.

Kanahā Pond Waterbird Sanctuary

USFWS Designation: Core
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Kanahā Pond is an important breeding site for Hawaiian stilts, coots and ducks, as well as the endangered sphinx moth (*Manduca blackburni*). Up to 40% of the Hawaiian stilt observations and up to 60% of Hawaiian coot observations in the bi-annual waterbird surveys have been recorded at Kanahā Pond. It is one of the few brackish-water wetlands remaining on Maui important for resident and migratory waterbirds. Salinity at Kanahā Pond ranges from brackish to hyper-saline. High chlorinates result from sewage injection nutrients. This area is culturally significant as it was the site of an ancient, royal Hawaiian fishpond.

Accomplishments.—This area was designated as the first State Wetland Sanctuary in 1952 and designated as a National Natural Landmark by the Secretary of the Interior in 1971. The sanctuary boundary was extended from its original 57 ha (143 ac) to include a total of 95 ha (235 ac) of open water, wetland, and upland sand dune habitats. The area is owned by the Hawai`i Department of Transportation and managed by the Hawai`i Department of Land and Natural Resources.

Restoration activities started on a 2-ac test site, where native vegetation and waterbirds exhibited a positive response within 3–15 months of initial restoration activities. Successful actions were implemented and applied as an ecosystem restoration concept for the entire sanctuary beginning in 1999. Over a 4-year time span volunteers from the Native Hawaiian Plant Society and Maui Police Department removed 326 tons of non-native *Pluchea* spp. by hand. Over 9600 hours of volunteer labor provided $144,465 of partner match funds to leverage additional money for conservation activities.

Recommended Actions.—

1. Upgrade the existing fence to keep all non-native mammalian predators and ungulates from destroying wetland habitats and preying on endangered waterbirds.
2. Pursue funds for predator proof fencing that would keep rats out. Removing rats will reduce further degradation of sand dune vegetation and increase effectiveness of restoration efforts.

Waihe`e Coastal Dunes and Wetland Preserve

USFWS Designation: Supporting

Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

The coastal dunes at Waihe`e are the only remaining stretch of sand dunes that once spanned the north Maui coast. These sand dunes were mined and leveled while the associated coastal edge wetlands were filled for development of residential and industrial purposes. The sand dunes provide habitat for several species of endangered plants and act as a buffer to reduce human disturbance from the adjacent Waihe`e village. Ground-nesting seabirds such as wedge-tailed shearwater and bulwer's petrel are known to nest in the dune area.

The wetland complex at Waihe`e includes 10 ha (25 ac) of palustrine freshwater wetland habitats and 3 ha (8 ac) of riparian habitats along four streams. Approximately 7 acres of the freshwater wetland is an ancient Hawaiian fishpond. Other cultural resources such as heeia (temples) are present on the preserve as well. Restoration of wetland habitats will help meet objectives for waterbird recovery as well as provide habitat for migratory waterfowl and shorebirds. This wetland could be a potential reintroduction site for the endangered Hawaiian moorhen, not currently found on the island of Maui.

Accomplishments.—The Maui Coastal Land Trust purchased the property during 2004 through funding from the County of Maui, U. S. Fish and Wildlife Service Coastal Wetlands and Endangered Species grants, and private donations. Funding has been secured from the Natural Resources Conservation Service Wetlands Reserve Program to implement large-scale restoration activities on 88 ha (217 ac) of wetland and associated upland habitats. The habitat will be protected in perpetuity through a conservation easement and contribute to a regional mosaic of wetland habitats, including Kahanā and Keālia Ponds.

Recommended Actions.—Funding has been secured to begin restoration activities at Waihe`e Preserve, including:

1. Hydrologic assessment of the site to re-establish and/or mimic natural hydrologic regimes and control invasive vegetation.
2. Engineering grade topographic survey
3. Removal of invasive plants from wetland and sand dune habitats
4. Expanding the area of mudflats available adjacent to open-water wetland habitats
5. Predator control
6. Removal of debris and old structures within and adjacent to the wetland
7. Plantings of native rare and endangered plant species on selected upper dune areas and wetland habitats to complement natural regeneration.

Paukukalo Wetland

USFWS Designation: None

Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

This property, located between the mouths of Iao and Waiehu Streams, has been extensively degraded due to urbanization and the current landowners intend to develop

residential housing complexes and condominiums on the property. Over 75% of the wetland is choked with invasive non-native vegetation.

Accomplishments.—

Recommended Actions.—

1. Ensure long-term protection and eventual restoration through acquisition and/or a conservation easement.
2. If #1 is not possible, cooperate with the owner to incorporate open space with the potential for wetland restoration activities into their development plans. Development could also include eco-tourism and environmental education plans.

Ke`anae Point

USFWS Designation: Supporting
Groundwater Protection Strategy Assessment: Ecologically Vital Habitat

Ke`anae Valley drains into an open ephemeral marsh adjacent to extensive taro fields. Spring seepage from perched aquifers in the Hana formation and surface runoff from Waiokamilo and Palauhula Streams sustain wet conditions.

Accomplishments.—

Recommended Actions.—

1. Support research to find economically, ecologically sound control methods for apple snail and alternatives to using domestic ducks.
2. Work with farmers to implement NRCS Farm Bill Programs that integrate wildlife areas on taro farms (e.g., shallow-water management for wildlife).
3. Remove feral mallards.

East Maui

USFWS Designation: None (Haleakalā identified as recovery site for nēnē)
Groundwater Protection Strategy Assessment:
Ecologically Sensitive Habitat (KauKaua`i Marsh, Moulea)
Ecologically Vital Habitat (Lower Kawaipapa & Lower Maunawainui Streams)

Streams and associated wetlands in this region have fewer alterations than streams in more developed areas due to the remoteness and rugged terrain of the area. Stream openings and relatively low-gradient pools provide habitat for koloa.

This area currently supports a population of nēnē first released during 1962 at Palikū in Haleakalā National Park. Over 500 birds have been released on East Maui since the 1960s, but the population was estimated at 250 birds during 2002 (U. S. Fish and Wildlife Service 2004c). Nēnē currently use habitats at 2,000–2,300 m (6,300–7,700 ft) within the park.

Accomplishments.—

*Recommended Action*s.—

1. Protection and restore private land in East Maui through conservation easements and cooperative agreements to provide additional habitats for koloa and nēnē and encourage dispersal of nēnē.
2. Expand restoration activities to lowland areas, allowing nēnē to re-establish seasonal migration routes to lowland habitats.
3. Protect riparian habitats along perennial and intermittent streams to ensure habitats and water quality is not negatively affected by land use changes.

LANA`I

Lana`i Sewage Treatment Plant

USFWS Designation: Supporting

Located southwest of Lana`i City, two sewage treatment ponds provide breeding and foraging habitats for Hawaiian stilts and Hawaiian coots. One pond is under the jurisdiction of the County of Maui, the other is owned by Castle and Cooke.

Accomplishments.—

Recommended Actions.—

1. Cooperative agreements between DOFAW or USFWS and the managing agencies to improve habitats for endangered waterbirds.

KAHO`OLAWE

Compared to the other main Hawaiian Islands, Kaho`olawe has relatively low relief with its highest point at 450 m (1,477 ft) above sea level. Lack of topographic relief creates an arid environment where native dry forests used to be abundant. Anthropogenic fires, introduced feral and domestic ungulates, and naval and aerial bombardment training dramatically reduced the cover of native vegetation.

Removal of cats and other introduced mammalian predators from the island of Kaho`olawe would increase the potential for these wetlands to become suitable habitat for endangered waterbirds. Combined with appropriate management of wetland habitats, these wetlands could serve as release sites for nēnē and Laysan ducks. These and other endangered waterbird species would benefit from restoration actions in a way that is unparalleled on the other main Hawaiian Islands.

Honokanaia (Base camp)

USFWS Designation: None

Honokanaia is one of the largest coastal wetland areas (approx. 0.4 ha, [1 ac]) on Kaho`olawe and is currently used by shorebirds and seasonal migrants. It is the closest wetland to the base camp and due to logistics would be the easiest to manage. An artificial crater on the

shoreline was created from simulated atomic bomb exercises. The crater now provides aquatic habitats for opae ula and other organisms.

Accomplishments.—Honokanaia has been cleared of ordnance to Tier II, the highest level of clearance done on the island. It has also been roped off to prevent bulldozing. This site is owned the State of Hawai`i Department of Land and Natural Resources, and overseen by Kaho`olawe Island Reserve Commission.

Recommended Actions.—

1. Remove pickleweed (*Batis maritima*), which currently infests the area.
2. Plant native vegetation (e.g., akulikuli [*Sesuvium portulacastrum*]) to increase the quality of available habitat for resident and migrating waterbirds.
3. Re-route the road that goes through the wetland to reduce disturbance.
4. Modify hydrology to provide year round wetland habitats.
5. Install predator-proof fencing.
6. Establish baseline biological data for the artificial crater to determine the priority for management and restoration actions.

Kaukaukapapa

USFWS Designation: None

This site is probably one if the least visited wetlands in the state and is not as heavily impacted as other areas on Kaho`olawe. The 4 ha (10 ac) wetland is predominantly seasonally flooded with a small part near the coast that remains flooded year-round. This wetland therefore has the longest annual hydroperiod of all wetlands on Kaho`olawe. Once restored, this site could serve as a reintroduction site for nēnē and Laysan ducks.

Accomplishments.—This site has had some ordnance removed and doesn't appear as heavily altered as other sites on the island. It is owned by the State of Hawai`i Division of Land and Natural Resources and overseen by the Kaho`olawe Island Reserve Commission.

Recommended Actions.— All wetland sites on Kaho`olawe, wetland-associated wildlife would benefit greatly from the removal of cats and other introduced mammalian predators island-wide. Other actions include:

1. Clear the area of ordnance to Tier II
2. Remove non-native invasive vegetation and out-plant with native and indigenous species.
3. Install predator-proof fencing.

Lua Kealialalo

USFWS Designation: None

This wetland is a unique seasonal wetland created by a parasitic cone that includes approximately 10 ha (25 ac) of flooded habitats and 40 ha (100) ac of associated uplands. It can stay wet well into the summer months and may provide a cooler retreat for nēnē and Laysan

ducks if they were reintroduced to Kaho`olawe. This area currently provides native grass habitats for migrating shorebirds and waterfowl.

Accomplishments.—This area was cleared of ordnance to Tier II after it was bombed for 50 years.

Recommended Actions.—As with other wetland sites on Kaho`olawe, wetland-assocaited wildlife would benefit greatly from the removal of cats and other introduced mammalian predators island-wide.

1. Remove fountain grass on east rim of wetland
2. Restore habitat for and out-plant *Marsillea villosa*, an endangered fern species.
3. Install predator proof fencing.

HAWAI`I

North Kohala and Hamakua Coasts

This region of the Island of Hawai`i has some of the most abundant surface water and perennial streams. Perennial streams in provide relatively remote riparian habitats for Hawaiian ducks and support relatively intact aquatic fauna. This area is currently the focus of a watershed partnership.

The only four amphitheater-headed valleys present on the island of Hawai`i formed on the wet, windward slopes of the island's oldest volcano, Kohala (Ziegler 2002). Two of the four valleys, Waipio and Waimanu, have extensive wetlands and farmed taro fields along their the mid and lower reaches.

Waipio Valley

USFWS Designation: Supporting

Waipio Valley is surrounded by steep, lush green cliffs. At it's mouth is an extensive black sand beach. Innumerable intermittent and perennial streams flow into Waipio Valley. The central portion of the valley is dominated by taro loi. The lower valley is characterized by wetlands with emergent vegetation, fallow/abandoned rice and taro paddies, silted fishponds, and numerous significant cultural sites. A pond at the north end of the valley provides permanent water.

Accomplishments.—

Recommended Actions.—

1. Ensure long-term protection of natural wetlands, ponds, and taro fields.
2. Assess feasibility of enhancing fishponds and emergent wetlands at the mouth of the valley for Hawaiian waterbirds.
3. Work with farmers to implement NRCS Farm Bill Programs that integrate wildlife areas on taro farms (e.g., shallow water management for wildlife).
4. Remove feral mallards.
5. Assess site potential for Hawaiian moorhen reintroduction.

Waimanu Valley
USFWS Designation: Supporting

Accomplishments.—

Recommended Actions.—

Polou Valley
USFWS Designation:

Accomplishments.—

Recommended Actions.—

South Kohala

This coastal region has the highest density of anchialine ponds on the islands of Hawai`i. These ponds are threatened by high dollar developments that are planned for this region.

Waipuhi Ponds (1,2)
USFWS Designation: Other

Accomplishments.—

Recommended Actions.—

Kiholo Springs Pond & Marsh
USFWS Designation: None

The north portion of the pond is relatively remote and therefore has greater potential for waterbird habitat than other ponds surrounded by development. Adjacent uplands are characterized by sparse scrubby vegetation on recent lava rock. This pond has a permanent connection to the ocean and likely supports a large number of fish. Salinity of the pond and marsh varies with freshwater seepage, rainfall, and tides. No streams flow into Kiholo Bay, but several springs are present along the coast.

Accomplishments.—

Recommended Actions.—

1. Protect the surrounding uplands from future development through conservation easements and/or cooperative agreements with the landowner
2. Increase the availability of food resources for endangered waterbirds by removing invasive species such as *Casuarina* spp., *Thespesia* spp., and *Pluchea* spp. to allow germination of native vegetation from the natural seed bank.
3. Locate spring flow and remove *Prosopis* spp. From upper lava fields to improve hydrology.

Kona Coast

Due to previous problems encountered with the location of restored and created wetland habitat along the Kona coast, a thorough evaluation of regional land-use planning is required for this area of Hawai`i island. This coordinated effort will result in the best long-term appropriation of funding and expertise to benefit populations of endangered waterbirds. Restoration and management of wetlands and associated uplands along the Kona coast may also encourage nēnē from the Pu`uwa`awa`a region to re-establish traditional seasonal migrations from upslope to lowland habitats, where nēnē populations were once abundant.

`Aimakapā Pond (Kaloko-Honokōhau National Historic Park)

USFWS Designation: Core

Management of `Aimakapā Pond currently emphasizes restoration of the pond as a demonstration fishpond for cultural preservation. This 10 ha (25 ac) pond and wetland complex supports many Hawaiian coots and stilts in the region.

Accomplishments.—NPS has worked with Ducks Unlimited (DU) to begin preliminary restoration planning efforts. A topographic-bathymetric survey has been completed.

Recommended Actions.—

1. Incorporate habitat management practices that enhance wetland habitats adjacent to the fishpond for endangered waterbirds.
2. Acquire funding and implement existing MOU between NPS and DU to restore wetland habitats and develop a management plan.

Kealakehe (Kona) Sewage Treatment Plant

USFWS Designation: Supporting

Accomplishments.—Designs for man-made wetlands for treatment of tertiary sewage effluent have been designed for the wastewater treatment plant. Plans include a predator-proof fence, water management system, nesting islands for Hawaiian stilt and Hawaiian coot, out-planting of native vegetation, and interpretive trails and signs. This project integrates habitat creation for wildlife with the needs of the County of Hawai`i.

*Recommended Action*s.—Pursue additional projects that incorporate water needs and wildlife habitats.

`Opae`ula Pond

USFWS Designation: Supporting

`Opae`ula Pond is a 3 ha (8 ac) wetland along the north Kona Coast that is privately owned. Inlets and peninsulas along the pond edge support communities of emergent vegetation. Water levels fluctuate with ocean tides, rainfall, and freshwater seepage. This fresh to brackish

water wetland is of primary importance to Hawaiian stilt, Hawaiian coot, and migratory waterfowl and shorebirds.

Accomplishments.—A cooperative agreement DOFAW and the landowner was established to allow access for studies and to remove goats. Other accomplishments include predator control, water-level monitoring, vegetation mapping, and control of California bulrush to open up mudflats for stilts.

Recommended Actions.—

1. Construct predator-proof fence.
2. Establish native shrub barrier along beach side.

Kealakekua Bay Pond

USFWS Designation:

Accomplishments.—

Recommended Actions.—

Koloko Pond

USFWS Designation:

Accomplishments.—

Recommended Actions.—

Montane Stock Ponds (Mauna Kea and Kohala Mountains)

Hakalau National Wildlife Refuge

USFWS Designation: Supporting

Hakalau National Wildlife Refuge is located on the windward slope of Mauna Kea. Encompassing 13,252 ha (32,733 ac), this refuge protects some of the best remaining stands of native rain forest in Hawai`i. Bogs and fern patches are common below 4,000 ft where rainfall exceeds 250 in. Spring-fed montane ponds and numerous streams that dissect the area provide habitat for Hawaiian ducks. Further upslope, native forest merges into abandoned pastureland dominated by introduced invasive vegetation as rainfall decreases to 100 in annually. Long-term objectives for the refuge include reforestation of all areas, except for those maintained as grassland for Hawaiian geese. Land above the refuge is owned by the State Department of Hawaiian Homelands and is currently managed for a variety of land uses including grazing and reforestation efforts.

Accomplishments.—This large track of native forest was established as a National Wildlife Refuge in 1985. Nēnē were reintroduced to refuge lands and have established localized

migration routes around Mauna Kea and Mauna Loa between the refuge and Volcano National Park.

Recommended Actions.—

1. Manage additional habitat for nēnē to expand their distribution on refuge lands.
2. Enhance spring-fed montane ponds and abandoned stock ponds to provide high quality habitat for koloa. Enhancement activities must include measures that reduce the threat of increased mosquito populations that are disease vectors for native forest birds.
3. Complete removal of non-native ungulates from refuge lands.
4. Remove and/or control introduced mammalian predators that threaten reproductive success of forest birds, koloa, and nēnē.
5. Acquire additional funding for long-term monitoring and research of habitat conditions and bird populations.

Montane Ponds on Private Lands

USFWS Designation: Supporting & Other

Accomplishments.—Restoration, creation, and enhancement of 28 montane wetlands were completed on the slopes of 3 properties in the Kohala-Mauna Kea region in partnership with NRCS, FWS, NAWCA, and DU. Restoration of 4 additional seasonal wetlands is scheduled for 2006. In addition, 140 ha (345 ac) of associated riparian and upland habitat were fenced to exclude introduced ungulates and large mammalian predators and allow for controlled livestock grazing.

Recommendations.—

1. Sample koloa population to determine extent of hydribization with feral mallards.
2. Conduct outreach and control of feral mallards
3. Explore possibility of koloa propagation and release program to supplement population once feral mallards are controlled.
4. Encourage additional landowner participation in restoration efforts through Farm Bill programs and Safe Harbor Agreements.

Hilo Bay and Coast

Lokoaka Ponds

USFWS Designation: Core

Lokoaka Ponds are under private and state government ownership. Privately owned portions are managed for fish aquaculture, while publicly owned portions are managed for recreational fishing.

Accomplishments.—

Recommended Actions.—

1. Coordinate pesticide use with the State of Hawai`i Division of Aquatic Resources.

2. Provide technical assistance to private land owners to enhance habitats for endangered waterbirds, especially for Hawaiian coots.
3. Assess hydrologic conditions of the ponds to determine the most appropriate water level management strategies that meet goals and objectives for aquaculture as well as waterbird habitat.

Waiākea Pond

USFWS Designation: Core

Accomplishments.—

Recommended Actions.—

1. Remove feral mallards.

Ke`anae (Kea`au) Pond

USFWS Designation: Supporting

Ke`anae Pond is a spring-fed pond with connection to the ocean. Hydrologic modifications include construction of a rock wall and gate system.

Accomplishments.—

Recommended Actions.—

1. Protection of this habitat should be ensured in perpetuity through conservation easements and/or cooperative agreements with the landowner.
2. Develop a restoration and management plan to improve habitats for waterbirds.
3. Conduct predator control.

Ka`u Region

Honu`apo Coastal Area

USFWS Designation: Other

Hunu`apo Coastal Area, approximately 89 ha (220 ac), has the only estuarine wetland area in the Ka`u Region of Hawaii as this region is characterized by steep coastal habitat. Honu`apo supports an ancient Hawaiian fishpond with numerous original kuleana land plots and was the former site of an area Pu`uhonua, or area of refuge. The area is surrounded by public land; it's protection and restoration will contribute to landscape level conservation efforts on the island of Hawai`i.

Accomplishments.—This area was protected through acquisition by the Trust for Public Land during 2005. The local community is very active in trying to protect the Ka`u coastal lands and has formed a non-profit organization to facilitate protection, restoration, and enhancement of the area.

Recommended Actions.—

1. Develop and implement a monitoring program to identify baseline information on the biological, physical, environmental, and cultural resources present.
2. Develop a restoration and management plan to restore native ecosystems based on the best available science.
3. Identify partners and available funding sources to implement restoration.

Ka`u Preserve

The Ka`u Preserve, owned by The Nature Conservancy, protects 1436 ac (3,548 ac) of native closed-canopy koa and `ohi`a forest. This nearly pristine native forest is adjacent to native alpine and subalpine forests above. It provides habitat for the native Hawaiian forest birds including the `io, `apapane, `i`iwi, `elepaio, and `amakihi.

Accomplishments.—

1. The preserve was purchased by The Nature Preserve from a subsidiary of C. Brewer and Co., Ltd. to ensure protection of native forest habitats and increase landscape level conservation efforts in the Ka`u Region
2. Consisting of four parcels, adjacent to state-owned lands provides increased access to state-owned lands by providing 4 different entry points for management.

Recommendations.—

1. Actively manage the land to prevent new weed invasions.
2. Increase education and outreach efforts with the local community to reduce threats to the larger landscape.

19.0 NORTHWESTERN HAWAIIAN ISLANDS FOCUS AREA

TARGET AREAS

Nihoa

Nihoa is the most pristine of NWHI and is considered a potential release site for Laysan ducks. Freshwater seeps provide necessary water.

Accomplishments.—

Recommended Actions.—

1. Assess impacts of Laysan duck reintroduction on native invertebrates and vegetation present on Nihoa
2. Eradicate introduced ants

Laysan Island (Kauo)

Laysan Island, the largest of the NWHI, covers 415 ha (1025 ac), of which 187 ha (462 ac) is vegetated, 105 ha (259 ac) is open water and mud flats, and the remaining 123 ha (304 ac) is coastal dune and beach habitat (U. S. Fish and Wildlife Service 2004b). The interior lake is hypersaline, with salinities that are three to four times that of the ocean. Groundwater seeps occur around the lake and along the coast, providing fresh to brackish water habitats.

Introduced rabbits decimated the native vegetation soon after they were introduced to the island in 1903. Although seabird populations recovered, 3 out of 5 land and waterbirds went extinct within 20 years. Ten species of plants and numerous associated invertebrates also went extinct. Loss of vegetation also increased wind erosion and caused drifting sands to fill the lake and several freshwater seeps, thereby creating a shallower lake environment and altering the natural hydrology of the island.

The current natural distribution of Laysan ducks is limited to Laysan Island. Estimated at fewer than 100 individuals at the turn of the century, the population of Laysan ducks increased to 459 adult birds during 2001 (U. S. Fish and Wildlife Service 2004b).

Accomplishments.—A comprehensive restoration plan was developed for Laysan Island. Identified measures that are necessary to restore the ecosystem include controlling invasive vegetation, identifying and controlling non-native invertebrates, propagating and out-planting species of native vegetation, and eradicating the snake-eyed skink, monitoring, and implementing paleo-ecological studies. As of August 2004, these measures could not be implemented to their fullest extent due to funding, time, and logistical constraints. A summary of existing restoration efforts follows.

1. Eradication efforts initiated during 1991 to remove the non-native grass *Cenchrus echinatus* were successful and no individuals of this species has been observed since 2002.
2. Current native plant propagation programs are in place for eight species.

Recommended Actions.—

1. Assess hydrologic regime of the interior lake and associated seeps to improve restoration of seep habitats and increase the availability and/or quality of habitats in the interior lake.
2. Develop improved methods for permanent eradication of ants from Midway Atoll and other islands.
3. Examine the relationship between environmental conditions, brine fly abundance, and population viability parameters for Laysan ducks.
4. Re-introduce Laysan ducks to other NWHI, including Lisianski Island.
5. Further explore the possibilities and problems with re-introducing the Laysan duck to the Main Hawaiian Islands, including the potential of hybridization with other species of ducks (domestic, feral, or naturally occurring).

Lisianski Island (Papaapoho)

Lisianski Island is approximately 140 ha (346 ac), 1/3 the size of Laysan Island. It's geology and history are similar to Laysan Island, as is the denudation of native vegetation from the introduction of non-native mammals, including mice and rabbits. Mice were brought to the island in 1944 and by 1916 mice and rabbits on the island died of starvation. Loss of vegetation caused shifting sands to fill the fresh to brackish water wetland located in the interior of the island; the wetland had disappeared by 1857.

Accomplishments.—

Recommended Actions.—

Midway Atoll (Pihemanu)

Midway Atoll encompasses approximately 1,540 ac (624 ha) of land area. It is a national wildlife refuge and is surrounded by waters included in the NWHI CRE Reserve.

Accomplishments.—Wetlands were created to provide habitat for Laysan ducks. Laysan ducks were translocated from the natural population on Laysan Island to Midway Island during October 2004. Non-native ants have been successfully controlled using the toxicant Maxforce.

Recommended Actions.—

1. Control and/or eradicate introduced invasive vegetation
2. Control and/or eradicate fire ants and big-headed ants

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APPENDIX A: Available Funding Sources

Environmental Protection Agency

The basis for funding provided by the Environmental Protection Agency (EPA) for wetland restoration is through the Clean Water Act. All projects must involve water, which includes wetlands adjacent to navigable waters and their tributaries, the terrestrial sea, and rivers and tributaries. This is an important funding source as they can fund monitoring programs and planning, not often included in other restoration grants, in addition to on the ground restoration activities. Several of these grant programs are highlighted below.

EPA List of Available Grant Programs
http://www.epa.gov/epahome/grants.htm.
Information on grants available for Region 9 (including Hawai`i) is at
http://yosemite.epa.gov/r9/fsfc.nsf/fundingsources?ReadForm.

EPA Wetland Grants Program.—Assist state, tribal and local wetlands protection efforts. Funds can be used to develop new wetlands protection programs or refine existing protection programs to build capacity to protect manage and restore wetlands

EPA Watershed Funding.--
http://www.epa.gov/owow/watershed/funding.html

EPA National Center for Environmental Research (NCER).— The mission of NCER is to support high-quality research by the nation's leading scientists that will improve the scientific basis for decisions on national environmental issues and help EPA achieve its goals.
http://es.epa.gov/ncer/

EPA Environmental and Information Exchange Grant Program.—The Exchange Network Grant Program provides funding to States, Territories, and Federally Recognized Indian Tribes to support the development of Environmental Information Exchange Network. The Exchange Network is an Internet- and standards-based, secure information systems network that supports the electronic collection, exchange, and integration of high-quality data. Funding for the grant program has been provided through annual congressional appropriations for the EPA.
http://www.epa.gov/Networkg/

EPA Environmental Education Grants.—The goal of this EPA program is to support environmental education (EE) projects which enhance the public's awareness, knowledge, and skills to make informed and responsible decisions that affect environmental quality.
http://www.epa.gov/enviroed/grants.html and
http://www.epa.gov/enviroed/pdf/grants_fs.pdf

EPA Brownfield Cleanup and Redevelopment Grants.—Brownfield sites are abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.
http://www.epa.gov/swerosps/bf/mmatters.htm

U. S. Fish and Wildlife Service

North American Wetlands Conservation Act (NAWCA) Small Grants
http://www.fedgrants.gov/Applicants/DOI/FWS/FA/NAWCASM-05/Grant.html

North American Wetlands Conservation Act (NAWCA) Standard Grants
http://birdhabitat.fws.gov/NAWCA/USstandgrants.html

National Coastal Wetlands Conservation Grant Program.—This grant program was established to acquire, restore and enhance coastal wetlands. U.S. Fish and Wildlife Service have been working with coastal States to acquire, restore, manage, or enhance coastal wetlands through a matching grants program. To date:

- $32 million in grant monies have been awarded to 23 coastal States and 1 U.S. Territory
- 40,000 acres of coastal wetlands have, or will be, acquired, protected, or restored

http://www.fws.gov/cep/cwgcover.html

Pacific Coast Joint Venture Discretionary Funds

Funding is provided annually for projects benefiting coastal habitats in 1 of the following categories:

- Coordination
- Planning
- Project Development and Implementation
- Monitoring, Evaluation, and Applied Research
- Communications

Contact the Pacific Coast Joint Venture Coordinator for more information.
www.pcjv.org

National Fish and Wildlife Foundation

Five Star Restoration Matching Grants Program.—This program supports community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities.
http://www.nfwf.org/programs/5star-rfp.htm

Natural Resources Conservation Service

Farm Bill Programs in Hawai`i.— http://www.hi.nrcs.usda.gov/programs/index.html

Wetlands Reserve Program (WRP)
http://www.hi.nrcs.usda.gov/programs/wrp.html

Wildlife Habitat Incentives Program (WHIP)
http://www.hi.nrcs.usda.gov/programs/whip_2005.html

Environmental Quality Incentive Program (EQIP)

http://www.hi.nrcs.usda.gov/programs/eqip.html

Grassland Reserve Program (GRP)
http://www.hi.nrcs.usda.gov/programs/grp.html

Conservation Security Program (CSP)
http://www.hi.nrcs.usda.gov/programs/csp.html

Table A - 1. Program Goals, project examples, and funding allocated for USDA Farm Bill Programs in Hawaii during Fiscal Years 2004 and 2005. Data summarized from http://www.hi.nrcs.usda.gov. More information on qualifications and applying for these programs is available at http://www.hi.nrcs.usda.gov/programs/index.html.

Program	Goal	Examples	2004 Funding	2005 Funding
EQIP	Address significant natural resource concerns that are locally identified	Noxious weed control Brush management Pasture hayland planting Terracing Groundcover	$4,659,937	$5,244,000
GSWC	To implement contracts that install irrigation related conservation practices on agricultural lands	Water catchment basins Micro-irrigation Roof runoff Irrigation water management	$805,470	$1,184,000
GRP	Restore and protect grassland	Rangeland Pastureland	$1,321,300	$1,295,000
WHIP	To develop or improve fish and wildlife habitat on private land.	Wetland habitats Riparian habitats Upland habitats	$512,022	$1,084,000
WRP	To enhance and restore wetlands on private lands	Coastal wetlands Montane ponds Freshwater marshes	$700,000	$770,000
FRLPP	To help state, tribal, or local government entities purchase development rights to keep productive farm and ranch land in agricultural use			$1,917,000
CSP	To reward the best conservation producers with selected watershed areas	Conservation, protection, and improvement of soil, water, and related resources		

National Oceanic and Atmospheric Administration

NOAA Community-based Restoration Program (CRP).—Provided funding for habitat restoration that benefits estuarine and marine resources
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/

U. S. Geological Survey

Pacific Island Ecosystems Research Center (PIERC)

The USGS receives congressional based allocation for partnering on projects. The mission of PIERC is to provide scientific understanding and technology needed to support nad implement sound management and conservation of our Nation's biological resources occurring within cultural, sociological and political contex of the State of Hawai'i and other lands under U.S. jurisdiction in the Pacific Basin. Selection of projects is based of social and biological criteria. Projects which involve multiple USGS disciplines (e.g., biology and hydrology) receive higher priority.

U. S. Forest Service

Institute of Pacific Islands Forestry

The Institute of Pacific Islands Forestry provides research and technical assistance across 130 islands. Their research emphasis is divided among four teams:

1. Invasive species in Hawai`i
2. Tropical forested wetlands
3. Restoration of ecosystem processes
4. Forest management services

Most of their funding is provided by outside sources where they serve as a co-principle investigator. They provide research opportunities for students as well as forestry programs targeted toward reforestation and forest land enhancement on state and private lands.
http://www.fs.fed.us/psw/programs/ipif/

State of Hawai`i

Conservation Incentive Programs (Division of Forestry and Wildlife)

1. Forest Stewardship Program
2. Natural Areas Partnership
3. Watershed Partnership Program.—This program supports cooperative projects that benefit on-the-ground activities protecting land for watershed conservation.
4. Tree Farm Designation.—Provides a tax reduction for sustained production of forest products in quantities sufficient to establish a business
5. Forest Legacy.—This program is designed to preclude the conversion of forest land to non-forest uses.
6. Landowner Incentives Program (LIP)

Hawaii Invasive Species Council Research & Technology Grant Program

The primary purpose of this grant program is to initiate and support research that will result in improved management or control strategies for alien invasive species in Hawai`i.
http://www4.hawaii.gov/bidfiles/Research_Technology_HISC_Grants.pdf

Other Funding Resources

Watershed Assistance Grants are available to local watershed partnerships to support their organizational development and long-term effectiveness.
http://www.rivernetwork.org/howwecanhelp/index.cfm?doc_id=94

Funding Resources for Habitat Restoration Projects
http://www.estuaries.org/resources.php
http://www.estuaries.org/objects/FFGFY2003FullFinalv2.pdf

Hawai`i Eco-Tourism Authority

APPENDIX B

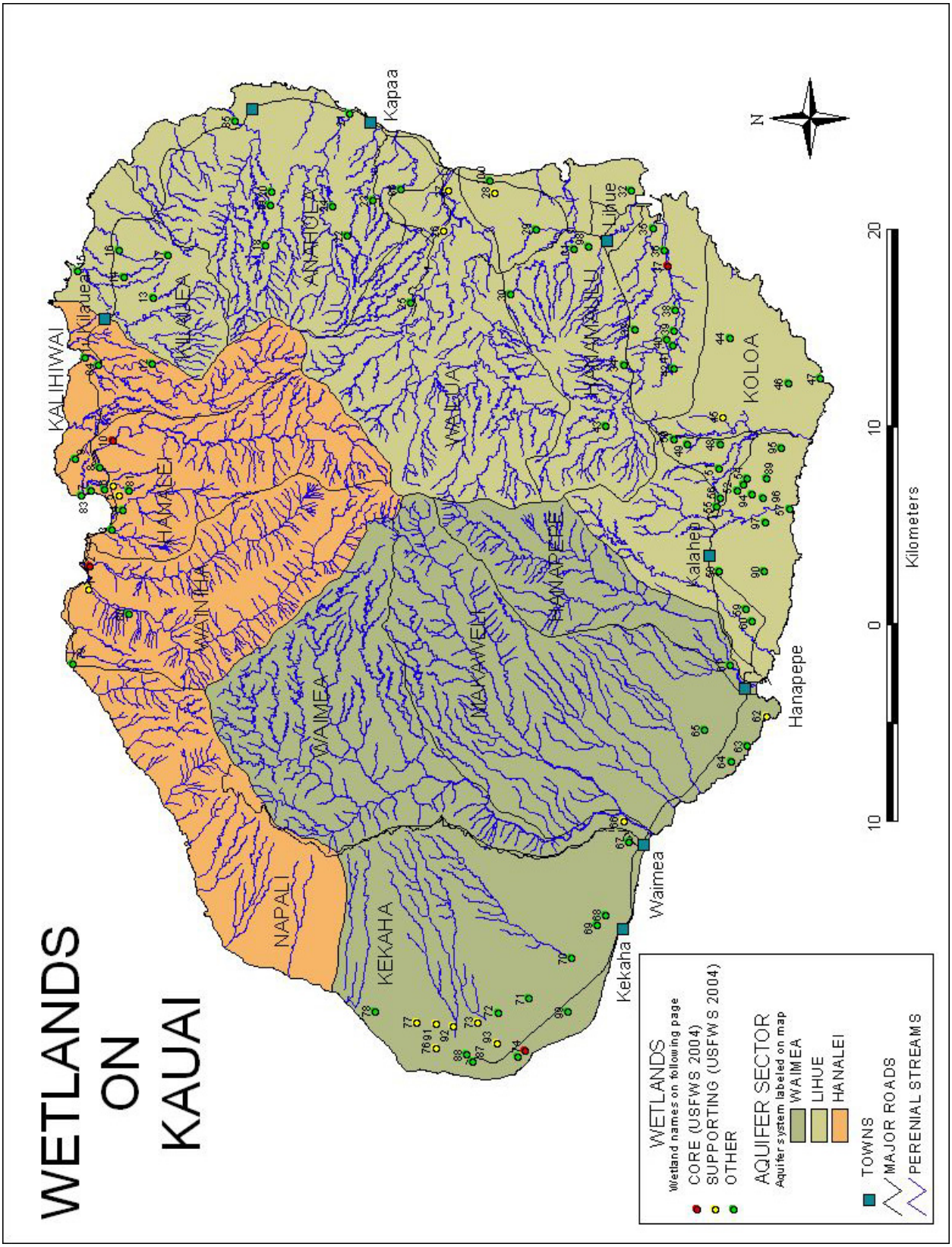
Table B - 1. Habitat objectives summarized by island for the recovery of Hawaiian coots, Hawaiian stilts, Hawaiian moorhen, and Hawaiian ducks in the Draft Revised Recovery Plan for Hawaiian Waterbirds (U.S. Fish and Wildlife Service 2004).

Island	Number of Wetland Sites		
	Core	Supporting	Total
Ni`ihau	1	0	12
Kaua`i	4	10	72
O`ahu	7	12	50
Moloka`i	1	4	11
Mani	2	2	51
Lana`i	0	1	1
Kaho`olawe	0	0	0
Hawai`i	3	8	16

Table B - 2. Threats and management goals for seven habitat types identified for shorebirds in the Hawaiian subregion of the U. S. Pacific Islands Regional Shorebird Conservation Plan (Engilis and Naughton 2005).

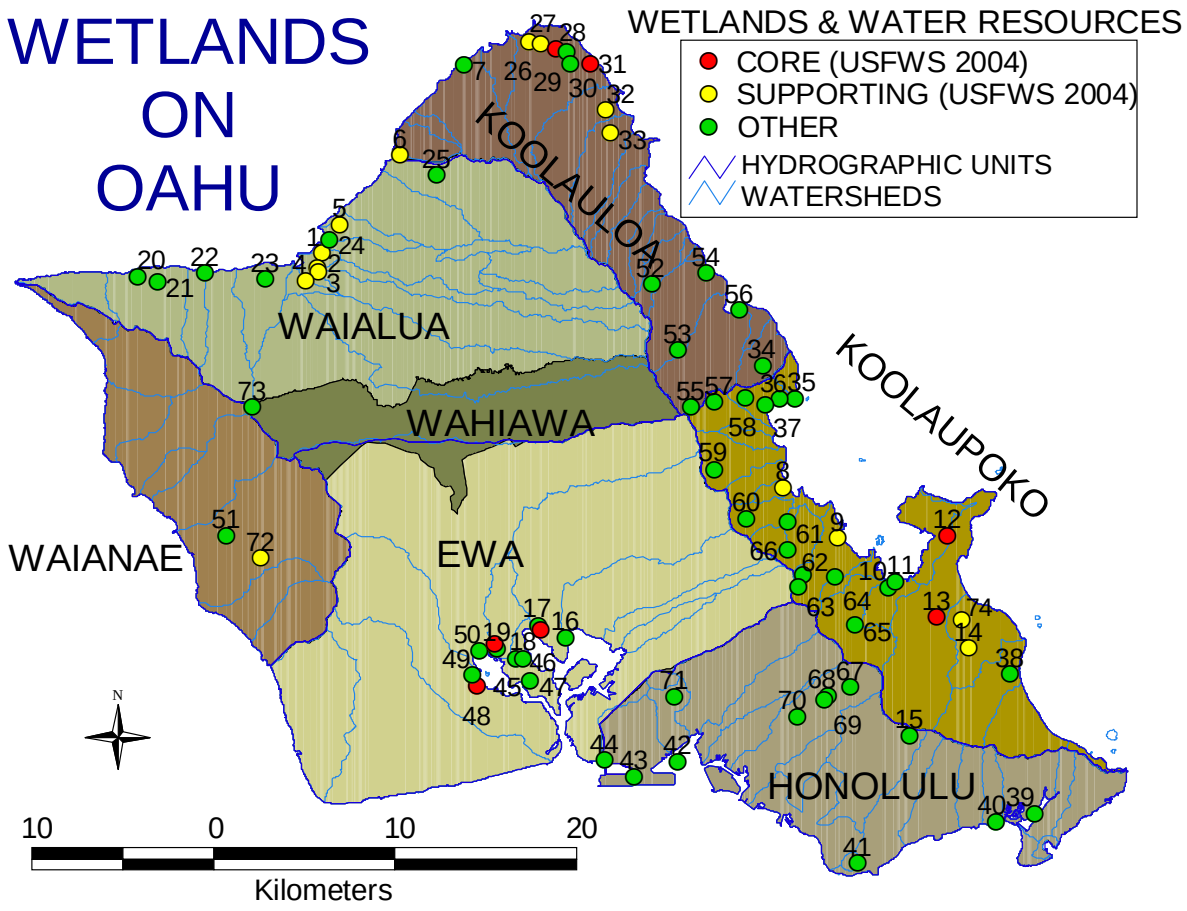
Habitat Type & Threats	Management Goals	Target Areas
Tidal flats and estuaries		
• Red mangroves • Contaminants • Non-point source pollution • Sedimentation • Most degraded habitat	Remove and control mangrove encroachment	Pearl Harbor Kaneohe Bay Kewalo Basin Moloka`i's S. Shore Nu`upia Ponds
	Protect remaining habitat from development and fill	Pearl Harbor Kaneohe Bay Kewalo Basin
	Monitor for contaminants	All
	Coordinate clean-up of hazardous spills with response teams	All
Permanent & semi-permanent wetlands	*See* Recovery Plan for Endangered Waterbirds	
Managed Water Projects		
• Transient in relation to long-term conservation efforts	Identify standards for implementation	All
	Seek safe harbor agreements or Habitat Conservation Plans to improve habitats	All
• Abandonment due to economic pressure impacts shorebirds	Minimize dependence on these habitats	All
Sand beach & dunes		
• Human-generated trash • Contaminants • Oil spills • Washed up tarballs • Human disturbance	Restore dunes, restrict ORV access	Oahu Moloka`i Maui
	Maintain secure beach and dune habitats	NW Islands Ka`ena Point, Oahu Mo`omomi Dunes, Moloka`i NPS lands, Maui NPS lands, Hawai`i
	Monitor and clean up trash accumulation	NW Islands
	Coordinate clean-up of contaminants with response teams	All
Grasslands		
• Development	Develop Safe Harbor Agreements	Private lands
	Coordinate with ongoing efforts to provide habitat for Hawaiian geese and ducks	All
	Develop Regional Habitat Conservation Plans	Upslope Maui Kohala Mtns. Upslope Mauna Kea
	Coordinate with reforestation efforts	All
	Control invasive species on protected lands	All
	Include appropriate grazing regimes	All
	Promote integrated pest management practices	Lawns & golf courses
Rocky shoreline/offshore islets		
• Introduced predators	Remove introduced predators (offshore islets)	All
• Human disturbance	Restrict human access to minimize disturbance	All

APPENDIX C: MAPS



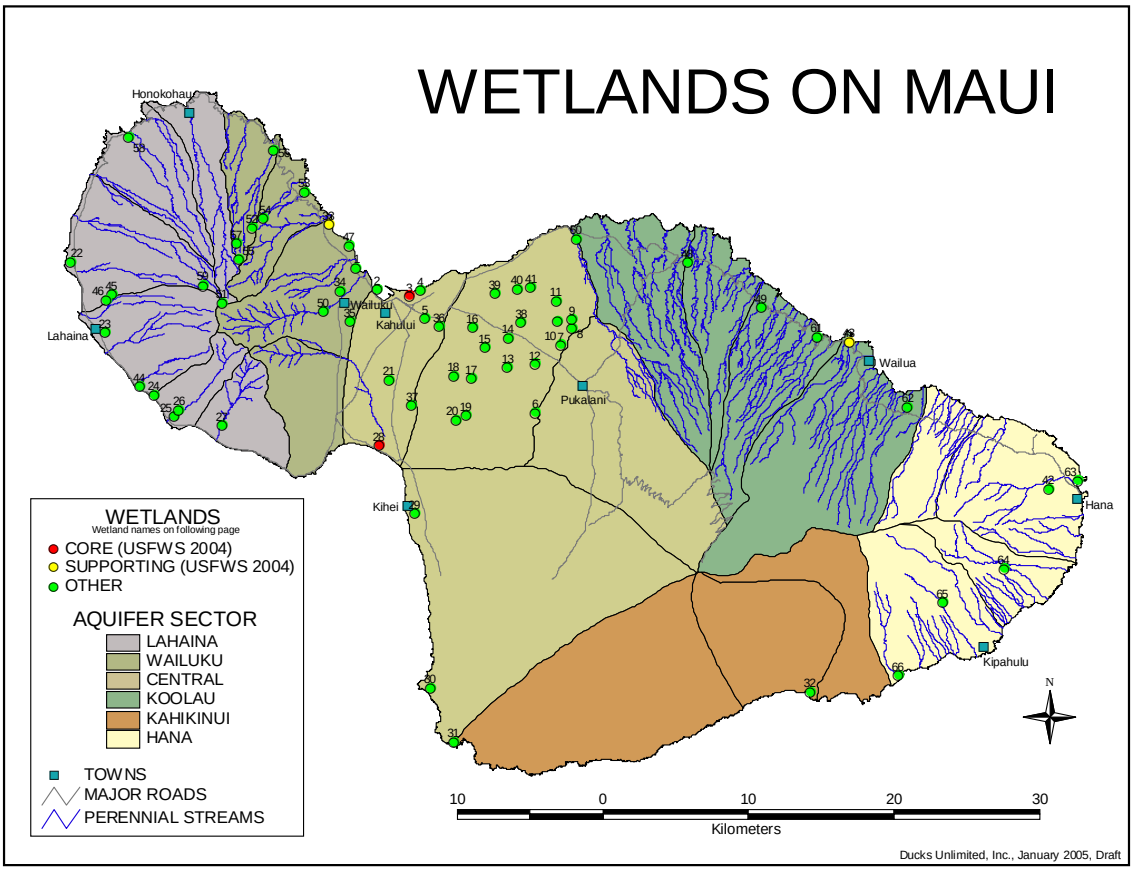
Numbered wetlands on Kaua`i

ID #	WETLAND NAME (KAUAI)	ID #	WETLAND NAME (KAUAI)
1	Wainiha Taro/River	51	Omao Reservoir
2	Lumahai River	52	Aepo Reservoir
3	Waipa Taro	53	Aepoalua Reservoir
4	Waioli Taro	54	Aepoekolu Reservoir
5	Halalei P.O. Taro	55	Hanini Reservoir
6	Hanalei Trader Taro	56	Huinawai Reservoir
7	Wilcox Ponds	57	Lawai Kai Estuary
8	Lower Hanalei River	58	Ipuolono Reservoir
9	Princeville Golf Course	59	Umi Reservoir
10	Hanalei NWR	60	Hukiwai Reservoir
11	Kalihiwai Estuary	61	Hanapepe Taro Fields
12	Kalihiwai Reservoir	62	Hanapepe Salt Ponds
13	Puu Ka Ele Reservoir	63	Kaumakani Gulch Ponds
14	Morita Reservoir	64	Olokele Settling Ponds
15	Kilauea Stream Estuary	65	Puu o Papai Reservoir
16	Waiakalua Reservoir	66	Waimea Taro
17	Ko Loko Reservoir	67	Waimea Heights Reservoir
18	Kaneha Reservoir	68	Kekaha Settling Ponds
19	Kanehu Reservoir 1	69	Kekaha Slaughter House Reservoir
20	Kanehu Reservoir 2	70	Waiawa Reservoir
21	Kapaa Stream Estuary	71	Wailau Siphon
22	Lono Res/Upper Kapahi Res	72	Nui Valley Reservoir
23	Twin Reservoirs	73	Mana House Reservoir
24	Lower Kapahi Reservoir	74	Kawaiele Sanctuary
25	Wailua Reservoir	75	Mana WRP
26	Opaekaa Marsh	76	Mana Base Pond
27	Paradise Pacifica (Smiths)	77	Saki Mana
28	Wailua Jail Swamp	78	Kolo Reservoir
29	Okinawa Res (Kailiilia Hinale)	79	Waikapalae Marsh
30	Kapaia Reservoir	80	Wainiha Marsh
31	De Mello Reservoir	81	Waioli Marsh
32	Westin Lagoons	82	Hanalei Fishpond Wetland
33	Kipu Road Reservoir	83	Puu Poa Marsh
34	Halenanahu Reservoir	84	Kalihiwai River
35	Niumalu Swamp	85	Anahola Valley
36	Menehune Fishpond	86	Kapaa Marsh
37	Huleia NWR	87	Mana South
38	Kipu Reservoir 1	88	Mana North
39	Kipu Reservoir 2	89	Aepoeka Reservoir
40	Kipu Reservoir 3	90	Ioleau Reservoir
41	Kipu Reservoir 4	91	Mana Reservoir
42	Kipu Reservoir 5	92	Kahelunui Reservoir
43	Papuaa Reservoir	93	Mana Ditches & Drains
44	Koloakapohu Res (Mahaulepu)	94	Kaupale Reservoir
45	Waita Reservoir	95	Koloa (Kukuiula) Sewage P
46	Puuhi Crater Reservoir	96	Kumanu Reservoir
47	Puu Ainako	97	Lauwai Reservoir
48	Pia Mill Reservoir	98	Lihue Settling Basin
49	Puu o Hewa Reservoir	99	US Navy Sewage Trt Pond
50	Mauka Reservoir	100	Wailua Golf Course

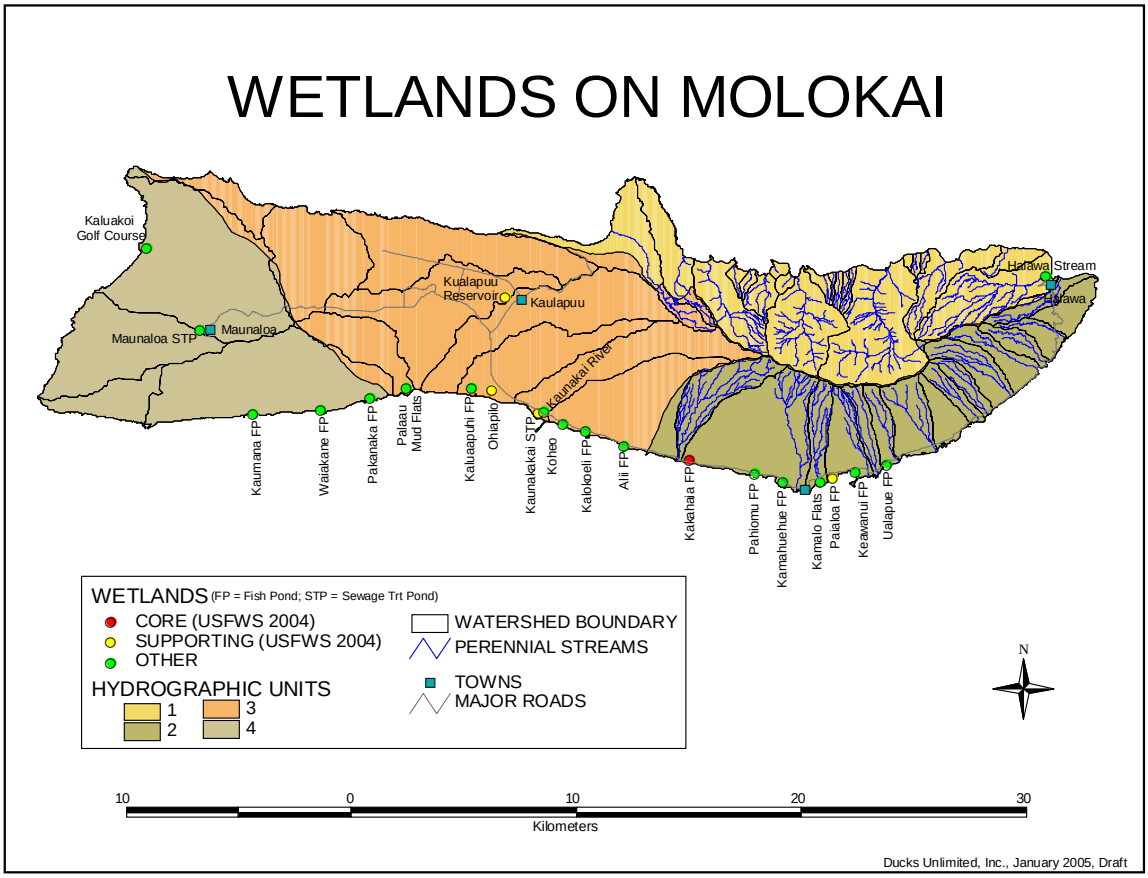

WETLANDS ON OAHU
WETLANDS & WATER RESOURCES
CORE (USFWS 2004)
SUPPORTING (USFWS 2004)
OTHER
HYDROGRAPHIC UNITS
WATERSHEDS
KOOLAULOA
KOOLAUPOKO
WAIALUA
WAHIAWA
WAIANAE
EWA
HONOLULU
N
10 0 10 20
Kilometers

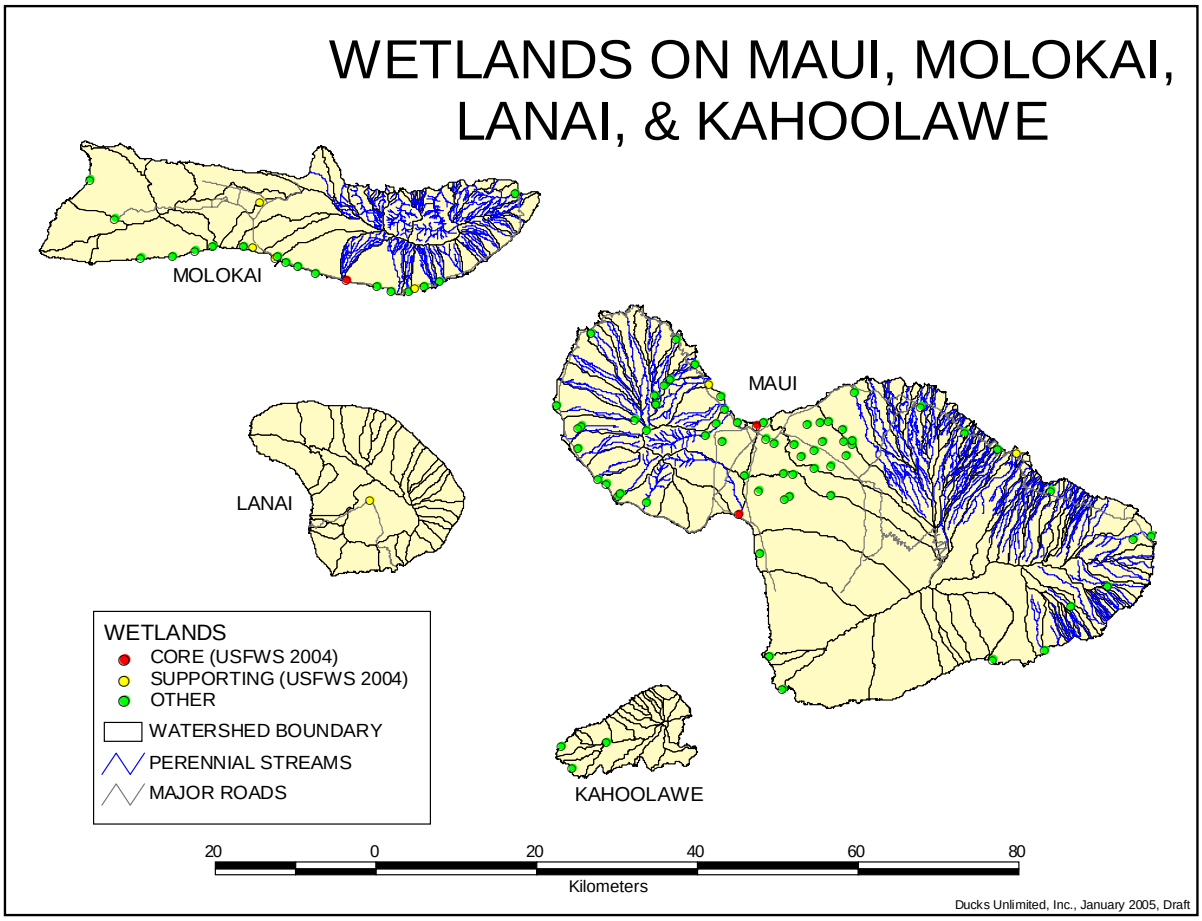
Numbered Wetlands on Oahu

ID	WETLAND (OAHU)
1	Haleiwa Marsh
2	Haleiwa Taro 1
3	Haleiwa Taro 2
4	Haleiwa Taro 3
5	Ukoa Pond
6	Waimea Estuary
7	Kalou Marsh
8	Waihee Marsh
9	Heeia Fishpond Marsh
10	Kawa Stream Marsh
11	Kawa Fishpond Wetland
12	Nuupia Fishponds Wetland
13	Kawainui Marsh
14	Kaelepulu Fishpond Wetland
15	Kaau Crater
16	Pearl Harbor East Loch
17	Pearl Harbor Middle Loch
18	Waiawa Unit PHNWR
19	Pearl Harbor West Loch
20	Mokuleia Quarry
21	Dillingham Field Pond
22	Crowbar Ranch Pond
23	Waiahole Stream
24	Loko ea Pond
25	Waimea Falls Arboretum
26	Kuilima Sewage Trt Pond
27	Punahoolapa Marsh
28	Punamano Unit JCNWR
29	Coconut Grove
30	Amorient
31	Kii Unit JCNWR
32	Kahuku Prawn Farm
33	Laie Prawn Farm
34	Kaaawa Stream
35	Apua Fishpond/Kualoa SP
36	Molii (Kualoa) Fishpond
37	UH Mariculture Research Ctr
38	Bellows Air Force Station
39	Kuapa Pond
40	Paiko Lagoon
41	Diamond Head Crater
42	Keehi Lagoon
43	Airport Reed Runway
44	Ft. Kamehameha Reef Flats
45	Waipahu Landfill
46	Waipio Basins
47	Walker's Bay
48	Honouliuli Unit PHNWR
49	Apokaa
50	Waikele
51	Lualualei Reservoir
52	Kaluanui Stream
53	Punaluu Stream
54	Punaluu Prawn Farm
55	Kahana Stream
56	Huilua Pond
57	Waikane Stream
58	Hakipuu Stream
59	Waiahole Stream
60	Waihee Stream
61	Ahuimanu Stream
62	Iolekaa Stream
63	Haiku Stream
64	Baskerville Spring
65	Hoomaluhia Botanical Garden
66	Kahaluu Stream/Wetlands
67	Nuuanu Reservoir 4
68	Nuuanu Reservoir 3
69	Nuuanu Reservoir 2
70	Nuuanu Reservoir 1
71	Salt Lake
72	Niulii Reservoir
73	Kaala Bog
74	Hamakua Marsh
75	Pouhala Marsh



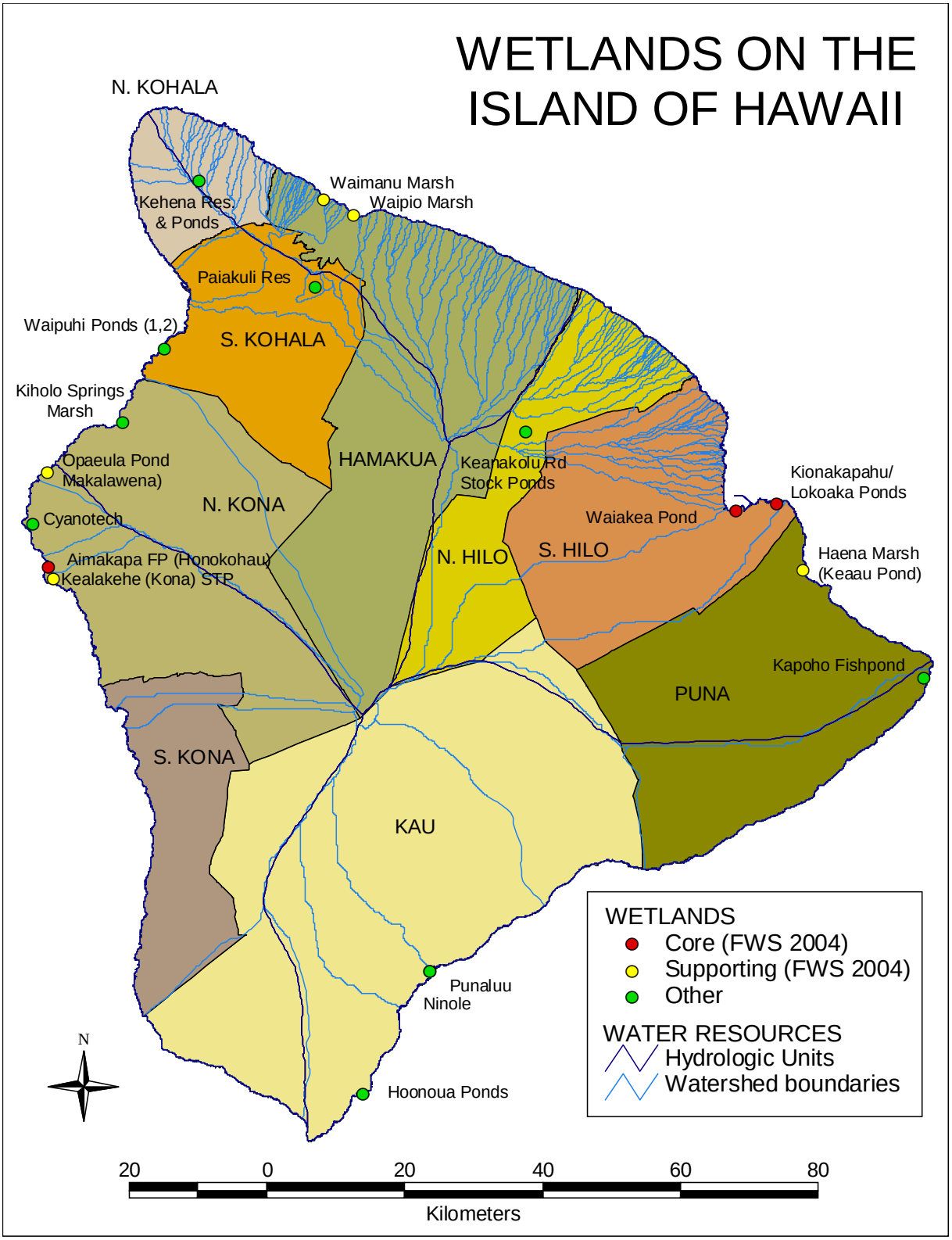
NOTE THAT WATER RESOURCE BASE MAPS DIFFER




WETLANDS ON MAUI, MOLOKAI, LANAI, & KAHOOLAWE
MOLOKAI
LANAI
MAUI
KAHOOLAWE
WETLANDS
CORE (USFWS 2004)
SUPPORTING (USFWS 2004)
OTHER
WATERSHED BOUNDARY
PERENNIAL STREAMS
MAJOR ROADS
20 0 20 40 60 80
Kilometers
Ducks Unlimited, Inc., January 2005, Draft

Numbered Wetlands on Maui

MAP ID#	WETLAND	MAP ID#	WETLAND
1	Paukukalo Marsh	34	Mill Pond
2	Kahului Settling Pond	35	Reservoir 73 (Waiale)
3	Kanaha Pond Wildlife Sanctuary	36	Kmart Settling Pond
4	Airport Drainage Ditch	37	Reservoir 90 (Airport Village)
5	Reservoir 72 (Omaopio)	38	Reservoir 50
6	Reservoir 40	39	Reservoir 60
7	Reservoir 32	40	Reservoir 29
8	Reservoir 20	41	Reservoir 26
9	Hailiimaile Treatment Pond	42	Hana Ranch WRP
10	Reservoir 22	43	Keanae
11	Reservoir 23	44	Launiupoko Pt Reservoir
12	Reservoir 33	45	Waihukuli Reservoir
13	Reservoir 35	46	Crater Reservoir
14	Reservoir 51	47	Waiehu Pt Marsh
15	Reservoir 52	48	Kapalaalaea Reservoir
16	Reservoir 61	49	Papaaea Reservoir
17	Reservoir 80	50	Iao Stream (Lower)
18	Reservoir 84	51	Puu Kukui
19	Reservoir 81	52	Keahikauo
20	Reservoir 82	53	Makamakaole Stream (Lower)
21	Reservoir 92	54	Makamakaole Stream (Upper)
22	Kaanapali Golf Course Ponds	55	Eke Crater
23	Lahina Aquatic Center	56	Kahakuloa Stream (Lower)
24	Cut Mountain	57	Kahakuloa Stream (Upper)
25	Olowalu Reservoir	58	Honokohau River (Lower)
26	Olowalu Reservoir 2	59	Violet Lake (approx location)
27	Ukumehame Res & Stream	60	Maliko Gulch
28	Kealia Pond & Wetlands	61	Honomanu Bay Wetland
29	Azeka Ponds 1 & 2	62	Nahiku Springs (Hanawai)
30	Paniaka Pond	63	Kawaipapa Stream/Nanualele Pt
31	Kauhi	64	Moulea, Wahio Valley
32	Nuu Pond	65	Kaukauai Marsh
33	Waihee Wetlands	66	Manawainui Stream (Lower)


WETLANDS ON THE ISLAND OF HAWAII
N. KOHALA
Waimanu Marsh
Waipio Marsh
Kehena Res & Ponds
Paiakuli Res
Waipuhi Ponds (1,2)
S. KOHALA
Kiholo Springs Marsh
HAMAKUA
Keanakolu Rd Stock Ponds
Kionakapahu/ Lokoaka Ponds
Opaeula Pond Makalawena)
N. KONA
Waiakea Pond
Cyanotech
N. HILO
S. HILO
Haena Marsh (Keaau Pond)
Aimakapa FP (Honokohau)
Kealakehe (Kona) STP
Kapoho Fishpond
PUNA
S. KONA
KAU
Punaluu Ninole
Hoonoua Ponds
N
WETLANDS
Core (FWS 2004)
Supporting (FWS 2004)
Other
WATER RESOURCES
Hydrologic Units
Watershed boundaries
20 0 20 40 60 80
Kilometers