Keālia Pond National Wildlife Refuge

Comprehensive Conservation Plan

Prepared by:

U.S. Fish and Wildlife Service
Maui National Wildlife Refuge Complex
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Kīhei, HI 96753

and

U.S. Fish and Wildlife Service
Pacific Islands Planning Team
300 Ala Moana Boulevard, Room 5-231
Honolulu, HI 96850

September 2011

Approved: ________________________ 9/28/11
Acting Regional Director, Region 1 Date
Portland, Oregon

U.S. Fish and Wildlife Service
Kealia Pond National Wildlife Refuge
Comprehensive Conservation Plan
Approval Submission

In accordance with the National Wildlife Refuge System Administration Act, as amended, the U.S. Fish and Wildlife Service completed a Comprehensive Conservation Plan (CCP) for Keālia Pond National Wildlife Refuge (Refuge). The purpose of this CCP is to specify a management direction for the Refuge for the next 15 years. The goals, objectives, and strategies for improving Refuge conditions – including the types of habitat we will provide, partnership opportunities, and management actions needed to achieve desired future conditions – are described in the CCP. The Service's preferred alternative for managing the Refuge is described in this CCP and the effects on the human environment were described in the Draft CCP and Environmental Assessment.

This CCP is submitted for the Regional Director's approval by:

Glynnis Nakai 09-20-11

Glynnis Nakai, Project Leader
Maui National Wildlife Refuge Complex

Date

Concur: Barry W. Stieglitz 9/22/11

Barry Stieglitz
Project Leader, Hawaiian and Pacific Islands NWRC

Date

Concur: Rob J. West 9/23/11

Robin West
Regional Chief, National Wildlife Refuge System

Date

Finding of No Significant Impact
for the
Keālia Pond National Wildlife Refuge Comprehensive Conservation Plan
Maui County, Hawaiʻi

The U.S. Fish and Wildlife Service (Service) has completed a Comprehensive Conservation Plan (CCP) and Environmental Assessment (EA) for Keālia Pond National Wildlife Refuge (Refuge). The CCP will guide management of the Refuge for 15 years. The CCP/EA describes our proposals for managing the Refuge and their effects on the human environment under three alternatives, including the no action alternative.

Decision

Based on our comprehensive review and analysis in the CCP/EA, we selected Alternative C for implementation, because it will guide management of the Refuge in a manner that:

- Achieves the mission of the National Wildlife Refuge System, and the purposes, vision, and goals of the Refuge.
- Maintains and restores the ecological integrity of the Refuge habitats and populations.
- Addresses the important issues identified during the CCP scoping process.
- Addresses the legal mandates of the Service and the Refuge.
- Is consistent with the scientific principles of sound wildlife management and endangered species recovery.
- Facilitates priority public uses appropriate and compatible with the Refuge purpose and the Refuge System mission.

Summary of the Actions to be Implemented

Implementing the selected alternative will have no significant impacts on the environmental resources identified in the CCP/EA. Refuge management under the selected alternative will protect, maintain, and enhance habitat for endangered species and resources of concern, and improve the Refuge's capability to provide food for migrating and wintering waterbirds, including shorebirds and waterfowl. Improving the Refuge's coastal and wetland habitats will increase the value of these lands and waters for a variety of native plants and wildlife.

The availability and quality of wildlife-dependent recreation on the Refuge will improve under the selected alternative, but within a regional context, the cumulative change would be small. A summary of the CCP actions we will implement follows.

Under Alternative C, restoration efforts and increased water management capabilities are intended to achieve the maximum potential for enhancing and maintaining biological requirements for endangered waterbirds, and indirectly benefit wintering migratory waterbirds. The Refuge will plan and implement the physical alterations needed to maximize our ability to control water in the Main Pond and adjacent vegetated mudflats, significantly remove the most aggressive pest plants, and control larger areas of pickleweed on the flats. Physical restoration includes: construction of a water control structure at the N. Kīhei Rd. culvert, additional groundwater sources (wells) to maintain water on the flats, and reconfiguration of topography to hold water longer.

Molokini, after establishment as an overlay refuge, will be managed as a seabird colony with periodic visits to monitor the population and continue the long-term banding. In addition, we will initiate a native plant restoration plan, particularly the rare ‘ihi (*Portulaca molokiniensis)* and a few other species found only on that islet, with a minimum of 2 additional visits per year. These visits will also be used to monitor tree tobacco for endangered ‘ōka‘i ‘aiea (Blackburn’s Sphinx Moth). The potential for their presence on Molokini is high given that they are found on Maui and Kaho‘olawe. Volunteers will assist with propagating plants in the Refuge’s greenhouse and outplanting will be conducted by Federal and State biologists under a cooperative agreement with DLNR.

Climate change analyses for Keālia Pond NWR will be evaluated for applicability to management strategies. Refuge staff will participate in development of climate change assessment protocols. Visitor services will be expanded with the Refuge open on weekends and additional efforts made to provide vegetated barriers and/or blinds to provide better viewing opportunities and increase areas for wildlife viewing. Visitor services staff will provide educational programs and materials.

Public Involvement and Changes Made to the Selected Alternative Based on Comments

We incorporated a variety of public involvement techniques in developing and reviewing the CCP/EA. This included three planning updates, several meetings with partners, and public review and comment on the Draft CCP/EA. The Service responses to public comments are provided in the CCP, in Appendix K.

Based on the public comments we received and considered, Alternative C as described in the Draft CCP/EA has been slightly modified to clarify our management strategies to retain the use of methoprene as a secondary tool to control spotted-wing midges, if needed.

Conclusions

Based on review and evaluation of the information contained in the supporting references, I have determined that implementing Alternative C as the CCP for Keālia Pond National Wildlife Refuge is not a major Federal action that would significantly affect the quality of the human environment within the meaning of section 102(2)(c) of the National Environmental Policy Act of 1969. Accordingly, we are not required to prepare an environmental impact statement.

Acting Regional Director

9/28/11
Date

Supporting References

U.S. Fish and Wildlife Service. August 2011. Keālia Pond National Wildlife Refuge, Draft Comprehensive Conservation Plan and Environmental Assessment.

U.S. Fish and Wildlife Service. September 2011. Keālia Pond National Wildlife Refuge Comprehensive Conservation Plan.

Note: This Finding of No Significant Impact and supporting references are available for public review at Maui National Wildlife Refuge Complex, Milepost 6 Mokulele Highway, Kīhei, HI, and U.S. Fish and Wildlife Service, Hawaiian and Pacific Islands National Wildlife Refuge Complex, 300 Ala Moana Boulevard, Room 5-231, Honolulu, Hawai'i 96850. These documents can also be found on the Internet at http://pacific.fws.gov/planning/. Interested and affected parties are being notified of our decision.

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Tables

Figures

Appendices

Note to Reviewers: Throughout the CCP document, all attempts have been made to use appropriate diacriticals related to the Hawaiian language (i.e., ‘okina and kahakō). However, places where diacriticals may not appear occur in the maps and literature cited. Due to limitations of the Geospatial Information System software used for the maps developed in the plan, some diacriticals may be missing where place names or legend text appear.

Readers' Guide

Native species discussed in this document are referred to by their Hawaiian names. Common English names and scientific nomenclature can also be found in the glossary in Appendix A. The U.S. Fish and Wildlife Service endeavors to be accurate in its use of the Hawaiian language and correctly spell Hawaiian words, including the diacritical marks that affect the meaning and aid in pronunciation. This guide is provided to simplify pronunciation for the reader.

When Captain Cook arrived in the Hawaiian Islands in 1778, the Hawaiians had a totally oral tradition. In 1820, western missionaries standardized a written version of the Hawaiian language that features eight consonants and five vowels.

Consonants

H - as in English
K - as in English
L - as in English
M - as in English
N - as in English
P - as in English
W - after i and e pronounced v
- after u and o pronounced like w
- at the start of a word or after a, pronounced like w or v
(ʻ) - ʻokina - a glottal stop

Vowels

A - pronounced like the a in far
E - pronounced like the e in bet
I - pronounced like the ee in beet
O - pronounced like the o in sole
U - pronounced like the oo in boot

Special Symbols

Two symbols appear frequently in Hawaiian words: the ʻokina and the kahakō. These two symbols change how words are pronounced. The ʻokina itself looks like an upside-down apostrophe and is a glottal stop – or a brief break in the word. An example of this in English is in the middle of the expression "uh-oh." The ʻokina is an official consonant – just as any of the other consonants.

The kahakō is a stress mark (macron) that can appear over vowels only and serve to make the vowel sound slightly longer. The vowels ā, ē, ī, ō, and ū sound just like their non-stress Hawaiian vowels with the exception that the sound is held slightly longer. Missing the ʻokina or kahakō can greatly change not only the how a word sounds, but also its basic meaning. A popular example of how an ʻokina and a kahakō can change the meaning of a word is "pau":

- pau = finished, ended, all done
- paʻu = soot, smudge, ink powder
- paʻū = moist, damp
- pāʻū = skirt

Refuge Place Names

Keālia	*(kay-AHH-LEE-ah)*	meaning: salt encrusted
Māʻalaea	*(MAHH ah-la-AY-ah)*	meaning: red colored earth
Molokini	(*Mo-lo-KEE-nee*)	meaning: many ties

Waterbirds

Ae‘o (EYE oh)

Hawaiian Stilt *Himantopus mexicanus knudseni*

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Indigenous

Laura Beauregard

‘Alae ke‘oke‘o (ah-lye KAY oh KAY oh)

Hawaiian Coot *Fulica alai*

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic

Laura Beauregard

Nēnē (NAY-NAY)

Hawaiian Goose *Branta sandvicensis*

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic

Laura Beauregard

‘Auku‘u (ow-KOO oo)

Black-crowned Night Heron *Nycticorax nycticorax hoactli*

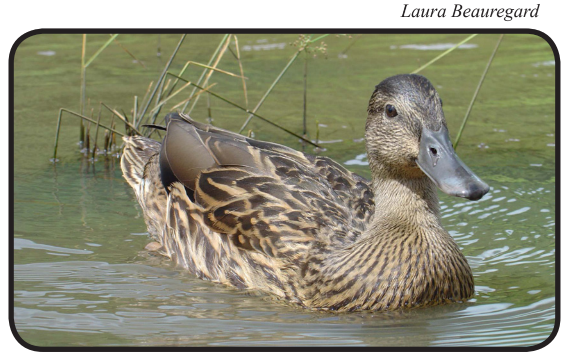
SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

Koloa maoli (ko-LOWah MAOW-lee)

Hawaiian Duck *Anas wyvilliana*

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic



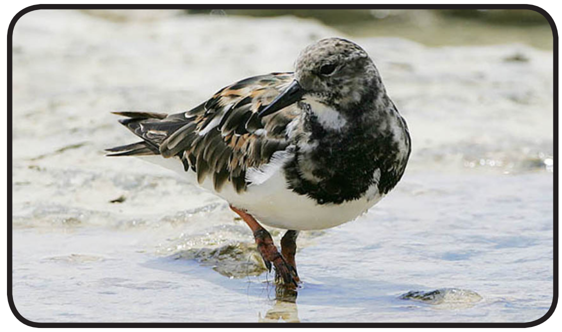
Brenda Zaun

Migrant Shorebirds

‘Akekeke (ah-kay-KAY-kay)

Ruddy Turnstone *Arenaria interpres*

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan - High Concern



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Hunakai (hoo-nah-KYE)

Sanderling *Calidris alba*

SPECIES STATUS:
State recognized as Indigenous

Hunakai means "sea foam." Their habit of running along the receding waves on the shore in search of small sand crabs apparently reminded early Hawaiians of the sea foam or hunakai left behind by the waves. It shares the name with a coastal plant.

©Michael Walther

Kioea (kee-oh-AY-ah)

Bristle-thighed Curlew *Numenius tahitiensis*

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

Laura Beauregard

Kōlea (KOHH-lay-ah)

Pacific Golden Plover *Pluvialis fulva*

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan - High Concern

©Michael Walther

‘Ūlili (OOO-lee-lee)

Wandering Tattler *Heteroscelus incanus*

SPECIES STATUS:
State recognized as Indigenous
U.S. Shorebird Conservation Plan - Moderate Concern

©Michael Walther

Seabirds

‘Ā (AHH)

Red-footed Bobby *Sula sula*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

Noio (NOY-oh)

Black Noddy *Anous minutus*

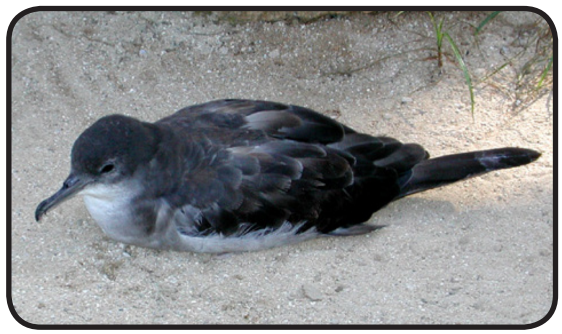
SPECIES STATUS:
State recognized as Indigenous
North American Waterbird Conservation Plan - Moderate concern

©Michael Walther

‘Ua‘u kani (OO-ah oo KAH-nee)

Wedge-tailed Shearwater *Puffinus pacificus*

SPECIES STATUS:
State recognized as Indigenous

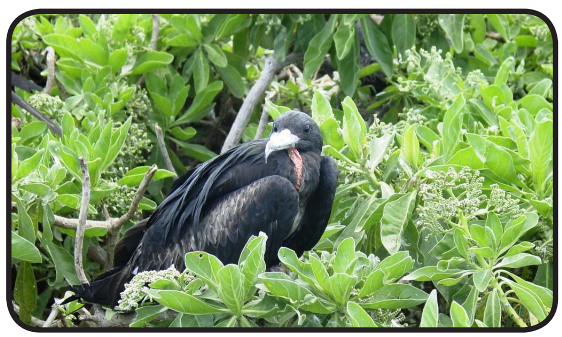


NPS

‘Iwa (EE-vah)

Great Frigatebird *Fregata minor palmerstoni*

SPECIES STATUS:
State recognized as Indigenous



USFWS

‘Ou (OH)

Bulwer’s Petrel *Bulweria bulwerii*

SPECIES STATUS:
State recognized as Indigenous

USFWS

Other Native Animals

ʻŌkaʻi ʻaiea (OHH-kah ee eye-AY-ah)

Blackburn's Sphinx Moth *Manduca blackburni*

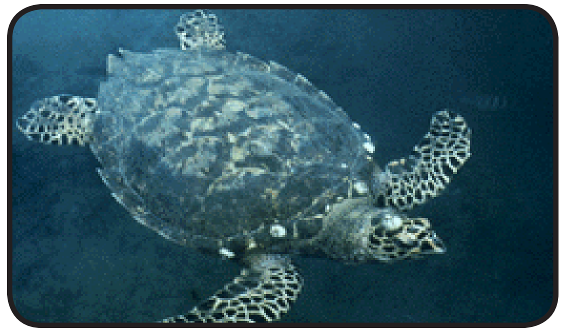
SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered
State recognized as Endemic

Ellen VanGelder

Honu ʻea (HO-noo AY-ah)

Hawksbill Turtle *Eretmochelys imbricata*

SPECIES STATUS:
Federally listed as Endangered
State listed as Endangered



George Balazs

Honu (HO-noo)

Hawaiian Green Turtle *Chelonia mydas*

SPECIES STATUS:
Federally listed as Threatened
State recognized as Indigenous
IUCN Red List Ranking - Endangered

Laura Beauregard

ʻĪlio-holo-i-ka-uaua (EEE-lee-oh HO-loh EE kah OO-ah OO-ah)

Hawaiian Monk Seal *Monachus schauinslandi*

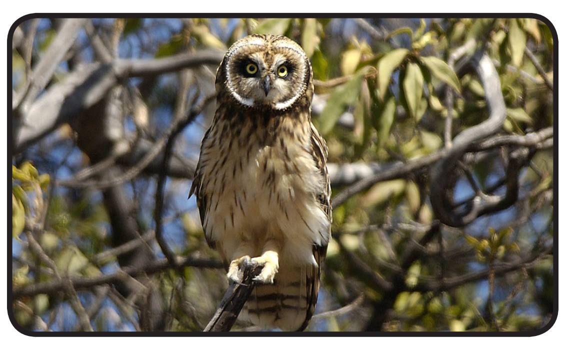
SPECIES STATUS:
Federally listed as Endangered

NOAA

Pueo (poo-AY-oh)

Hawaiian Short-eared Owl *Asio flammeus sandwichensis*

SPECIES STATUS:
State recognized as Endangered on Oʻahu
State recognized as Endemic



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Native Plants - Herbs

‘Ākulikuli (AAH-koo-lee-KOO-lee)

Sea Purslane *Sesuvium portulacastrum*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

‘Āki‘aki (AH-kee AH-kee)

Beach Dropseed *Sporobolus virginicus*

SPECIES STATUS:
State recognized as Endemic

Laura Beauregard

Pōhuehue (POHH-hoo-ay-HOO-ay)

Beach Morning Glory *Ipomoea pescaprae*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

Kaluhā (kah-loo-HAHH)

Alkali Bulrush *Scirpus maritimus*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

‘Ihi (EE-hee)

Ihi *Portulaca molokiniensis*

SPECIES STATUS:
Federally listed as Endangered

Forest & Kim Starr

Native Plants - Shrubs & Trees

Hala (HAH-lah)

Beach Vitex *Pandanus tectorius*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

'Ōhelo kai (OHH-heh-loh KYE)

Hawai'i Desert-thorn *Lycium sandwicense*

SPECIES STATUS:
State recognized as Indigenous

Forest & Kim Starr

Naio (NYE-oh)

False Sandalwood *Myoporum sandwicense*

SPECIES STATUS:
State recognized as Indigenous

Forest & Kim Starr

Naupaka Kahakai (now-PAH-kah kah-HAH-kye)

Beach Naupaka *Scaevola taccada*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

Pōhinahina (POHH-hee-nah HEE-nah)

Beach Vitex *Vitex rotundifolia*

SPECIES STATUS:
State recognized as Indigenous

Laura Beauregard

Ae‘o duo © Tony Temple

Chapter 1. Introduction

Keālia Pond National Wildlife Refuge (NWR or Refuge) was established in 1992 to preserve, restore, and manage essential habitat for two endangered Hawaiian waterbirds: the ae‘o (Hawaiian stilt) and ‘alae ke‘oke‘o (Hawaiian coot). The 704-acre Refuge is situated along the south-central shore of Maui in the isthmus separating the West Maui Mountains from the East Maui volcano, Haleakalā. Refuge habitats include open water (200 acres), vegetated flats (450 acres), and upland (54 acres). Keālia Pond is a significant foraging and nesting area for Hawai‘i's endangered wetland birds, and is host to hundreds of migratory shorebirds and waterfowl during winter months. In addition, the Refuge provides coastal beach strand habitat for native plant species, endangered ‘īlio-holo-i-ka-uaua (Hawaiian monk seal), threatened honu (Hawaiian green turtle), and endangered honu ‘ea (hawksbill turtle).

The proposed 19-acre Molokini Unit of the Refuge encompasses a crescent-shaped islet located between the Islands of Maui and Kaho‘olawe. It has a diameter of about 0.4 miles and hosts a colony of ‘ua‘u kani (wedge-tailed shearwaters) that nest from March-December. Other inhabitants include a smaller nesting population of ‘ou (Bulwer's petrel), ‘iwa (great frigate), noio (black noddy), and noio kōhā (brown noddy) that use the island for roosting. The ‘ihi plant (*Portulaca molokiniensis*) is a rare Hawaiian endemic known from only two locations, one on Molokini and one on Kaho‘olawe.

The Molokini Unit, Keālia Pond NWR, and Kakahai‘a NWR (located on the southeastern coast of Moloka‘i) make up the Maui National Wildlife Refuge Complex (Complex). This Comprehensive Conservation Plan (CCP) will focus on the Keālia Pond NWR and the Molokini Unit.

1.1 Purpose and Need for the CCP

The purpose of the CCP is to provide the Service, the National Wildlife Refuge System (Refuge System), partners, and citizens with a management plan for improving fish and wildlife habitat conditions and Refuge infrastructure, for wildlife and public use on Keālia Pond NWR over the next 15 years. An approved CCP will ensure that the Service manages to achieve the Refuge purpose, vision, goals, and objectives to help fulfill the mission of the Refuge System.

The CCP is needed for a variety of reasons. Primary among these is to establish improved habitat conditions on the Refuge's wetland habitats, which are degraded by invasive plants and animals. The plan also recognizes and identifies threats to the endangered ae‘o and ‘alae ke‘oke‘o, including predation by nonnative mammals, limited water supply, and human disturbance. There is a need to address public concern about the seasonal conditions within the wetland and the associated biological processes. Refuge public use programs have been analyzed for Refuge System wildlife-dependent priority public uses and to determine what improvements or alterations should be made in the pursuit of higher quality programs.

1.2 Planning and Management Guidance

The Service, an agency within the Department of the Interior, is the principal Federal agency responsible for conserving, protecting, and enhancing fish, wildlife, and plants and their habitats. Refuge management is guided by Federal laws, Executive orders, Service policies, and international treaties. Fundamental guidelines are found in the mission and goals of the Refuge System and the designated purpose of the Refuge as described in establishing legislation, Executive orders, or other documents establishing, authorizing, or expanding a refuge.

Key concepts and guidance of the Refuge System derive from the National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee) (Administration Act), the Refuge Recreation Act of 1962 (16 U.S.C. 460k-460k-4), as amended, Title 50 of the Code of Federal Regulations (CFR), and the Fish and Wildlife Service Manual (FW). The Administration Act is implemented through regulations covering the Refuge System, published in Title 50, subchapter C of the CFR. These regulations govern general administration of units of the Refuge System.

1.2.1 U.S. Fish and Wildlife Service Mission

The mission of the Service is "working with others, to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people." National natural resources entrusted to the Service for conservation and protection include migratory birds, endangered and threatened species, interjurisdictional fish, wetlands, and certain marine mammals. The Service also manages national fish hatcheries, enforces Federal wildlife laws and international treaties on importing and exporting wildlife, assists with State and Territorial fish and wildlife programs, and helps other countries develop wildlife conservation programs.

1.2.2 National Wildlife Refuge System

The Refuge System is the world's largest network of public lands and waters set aside specifically for conserving wildlife and protecting ecosystems. From its inception in 1903, the Refuge System has grown to encompass over 550 national wildlife refuges in all 50 States, and waterfowl production areas in 10 States, covering more than 150 million acres of public lands and waters. More than 40 million visitors annually fish, hunt, observe and photograph wildlife, or participate in environmental education (EE) and interpretive activities on national wildlife refuges.

1.2.3 National Wildlife Refuge System Mission and Goals

The mission of the Refuge System is "to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans." The goals of the Refuge System, as articulated in the Mission, Goals, and Purposes policy (601 FW1), follow:

- Conserve a diversity of fish, wildlife, and plants and their habitats, including species that are endangered or threatened with becoming endangered;
- Develop and maintain a network of habitats for migratory birds, anadromous and interjurisdictional fish, and marine mammal populations that is strategically distributed and carefully managed to meet important life history needs of these species across their ranges;
- Conserve those ecosystems, plant communities, wetlands of national or international significance, and landscapes and seascapes that are unique, rare, declining, or underrepresented in existing protection efforts;
- Provide and enhance opportunities to participate in compatible wildlife-dependent recreation (hunting, fishing, wildlife observation and photography, and EE and interpretation); and
- Foster understanding and instill appreciation of the diversity and interconnectedness of fish, wildlife, and plants and their habitats.

1.2.4 National Wildlife Refuge System Administration Act of 1966

The Administration Act, as amended by the National Wildlife Refuge System Improvement Act of 1997 (Improvement Act), requires us to develop a CCP for each national wildlife refuge in an open public process. The Administration Act states that the Secretary shall provide for the conservation of fish, wildlife, plants, and their habitats within the Refuge System, and ensure that the biological integrity, diversity, and environmental health of the Refuge System are maintained. House Report 105–106 accompanying the Improvement Act states ''…the fundamental mission of our System is wildlife conservation: wildlife and wildlife conservation must come first.'' As later made clear in the Biological Integrity, Diversity, and Environmental Health (BIDEH) policy (601 FW 3), "the highest measure of biological integrity, diversity, and environmental health is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions."

Each refuge must be managed to fulfill the Refuge System mission as well as the specific purpose(s) for which it was established. The Administration Act requires the Service to monitor the status and trends of fish, wildlife, and plants on every refuge. Additionally, six wildlife-dependent recreational uses are granted special consideration in the planning, management, establishment, and expansion of units of the Refuge System: hunting, fishing, wildlife observation and photography, and EE and interpretation. When determined compatible on a refuge-specific basis, these six uses assume priority status among all public uses of the refuge in question. The overarching goal is to enhance wildlife-dependent recreation opportunities and access to high-quality visitor experiences on refuges, while managing refuges to conserve fish, wildlife, plants, and their habitats. The Service is directed to make extra efforts to facilitate wildlife-dependent visitor opportunities.

When preparing a CCP, refuge managers must evaluate all general public, recreational, and economic uses proposed or occurring on a refuge for appropriateness and compatibility. No refuge use may be allowed or continued unless it is determined to be appropriate and compatible. Generally, an appropriate use is one that contributes to fulfilling the refuge purpose(s), the Refuge System mission, or goals and objectives described in an approved refuge management plan. A compatible use is defined as a use that, in the sound professional judgment of the refuge manager, will not materially interfere with or detract from the fulfillment of the mission of the Refuge System or the purpose(s) of the refuge. Current Appropriate Use Findings and Compatibility Determinations for existing and proposed uses for Keālia Pond NWR are in Appendix B.

The Administration Act also requires that, in addition to formally established guidance, the CCP must be developed with the participation of the public. Public comments play a role in identifying issues, guiding alternatives considered during development of the CCP, and selecting a preferred alternative. It is Service policy to develop CCPs in an open public process; the agency is committed to securing public input throughout the process.

1.3 Relationship to Previous and Future Refuge Plans

Planning has been a part of refuge operations since their beginning. Although not all were conducted in a comprehensive fashion, or with public participation considered adequate today, a considerable number of plans were completed over the years to guide managers. Additional smaller “step-down” plans and management agreements (plans addressing one program or resource) will be developed for the Refuge in conjunction with the CCP. Current management plans include:

- Fire Management Plan - 2004
- Integrated Pest Management Plan - 2008
- Station Safety Plan - 2010
- Highly Pathogenic Avian Influenza Disease Contingency Plan - 2009
- Avian Botulism Disease Contingency Plan - 2008
- Emergency Preparedness Response Plan - 2010
- Continuity of Operations Plan - 2010
- Station Hazardous Communications Plan - 2010

In progress Memorandum of Agreement (MOA)s include:

- U.S. Coast Guard - Molokini Islet Access
- Hawaiʻi Department of Land and Natural Resources (DLNR) - Molokini Islet Management

1.3.1 Future Planning

The CCP will be revised every 15 years or earlier if monitoring and evaluation determine that changes are needed to achieve the Refuge purpose(s), vision, goals, or objectives. The CCP provides guidance in the form of goals, objectives, and strategies for Refuge program areas but may lack some of the specifics needed for implementation. Step-down management plans will therefore be developed for individual program areas, as needed, following completion of the CCP. Step-down plans require appropriate NEPA compliance.

1.4 Refuge Establishment and Refuge Purpose

1.4.1 Refuge Establishment

Keālia Pond NWR was established administratively in 1992 under the authority of the Endangered Species Act of 1973 (ESA). The Service acquired a perpetual conservation easement from the property owner, Alexander & Baldwin Inc. (A&B), in order to manage the property as part of the Refuge System. A conservation easement is a transfer of usage rights from a property owner to the Service which creates a legally enforceable land preservation agreement for the purpose of conservation. The property owner retains partial ownership rights over the land but relinquishes rights to use the property for development. The Service holds interest in the property and is authorized, in accordance with the easement, to manage the property for Refuge purposes in perpetuity.

The Refuge was funded through the Land and Water Conservation Act of 1965. Prior to establishment as a national wildlife refuge, the Service and State of Hawaiʻi periodically conducted avian surveys at Keālia Pond and consistently observed high numbers of aeʻo and ʻalae keʻokeʻo, both of which were Federally listed as endangered species in 1970. Their endangered status and need for suitable habitat was the impetus for protecting this large wetland from future development. The total official acreage equals 703.884 acres.

Table 1.1 Refuge Acquisition History for Keālia Pond NWR

Date	Acquisition Authority	Comments
12/08/1992	ESA	Conservation Easement on 436.97 acres Tract 10C - Main Pond
12/08/1992	ESA	Facilitation Easement of 0.26 acres Tract 10R - Utility easement along entrance road
12/23/1992	ESA	Conservation Easement on 253.65 acres Tract 10C - Parcels B1 & B2 - vegetated flats Parcel B - Māʻalaea Flats (59.985 ac)
03/12/1997	ESA	Conservation Easement on 0.68 acres Tract 10C - Parcel B - Boardwalk parking area
04/06/2010	Fish and Wildlife Act of 1956	Conservation Easement on 12.324 acres Tract 10C-3- Headquarters and Visitor Center site

The Service is in the process of establishing Molokini islet as an "overlay refuge" attached to the Keālia Pond NWR. The designation will protect Molokini's large colony of nesting seabirds and help with restoring native plant species. The islet is currently under U.S. Coast Guard (USCG) ownership, but its transfer to the Service is under negotiation. A land-ownership transfer would create a permanent refuge in lieu of an overlay refuge.

Molokini USFWS

The overlay refuge would include only the land itself, and the State would continue to manage the surrounding Molokini shoals as a State Marine Life Conservation District.

1.4.2 Refuge Purpose

The purpose(s) for which a refuge was established or acquired is of key importance in refuge planning. Purposes are specified in or derived from the law, proclamation, Executive order, agreement, public land order, donation document, or administrative memorandum establishing, authorizing, or expanding a refuge, refuge unit, or refuge subunit. When an additional unit is acquired under an authority different from the authority used to establish the original unit, the addition takes on the purpose(s) of the original unit, but the original unit does not take on the purpose(s) of the newer addition.

By law, refuges are to be managed so as to achieve their purpose(s). When a conflict exists between the Refuge System mission and the purpose of an individual refuge, the refuge purpose supersedes the Refuge System mission. Refuge purpose(s) are also the driving force in the development of the refuge vision statements, goals, objectives, and strategies in the CCP and are critical to determining the appropriateness and compatibility of all existing and proposed refuge uses. Keālia Pond NWR was established with the purpose "… to conserve (A) fish or wildlife which are listed as endangered species or threatened species, or (B) plants …" (16 U.S.C. 1534, ESA).

1.5 Refuge Goals

Goals and objectives are the unifying elements of successful refuge management. They identify and focus management priorities, resolve issues, and link to refuge purpose(s), Service policy, and the Refuge System mission. A CCP describes management actions that help bring a refuge closer to its vision. A vision broadly reflects refuge purpose(s), Refuge System mission and goals, other statutory requirements, and larger-scale plans as appropriate. Wildlife, habitat, and visitor services management goals then define general targets in support of the vision, followed by objectives that direct efforts into incremental and measurable steps toward achieving those goals. Finally, strategies identify specific tools and actions to accomplish objectives. The Refuge vision statement is found on the inside front cover of this document. The following are our goals; their order does not imply any priority in this CCP.

Nā Pahuhopu Pu‘uhonua Holoholona

1. Kīa‘i a mālama i nā ‘āina pālialia a me ālialia wai maoli nohokau a me nā pālialia noho manawa no ka mālama ‘ana i ka mō‘aukala ola pono o nā manukai/wai Hawai‘i ‘ane make loa.

2. Ho‘onui aku i nā kaianoho o nā holoholona ‘ane make loa no ka ho‘omāhuahua hou ‘ana aku iā lākou iho.

3. Kīa‘i, ho‘ōla hou, a mālama i nā kaianoho lihikai no ka pono no ka ho‘opunana ‘ana o nā honu kai, manu kai, a me ka kūkahi o kēia mau kaiaola pio/pau wale.

4. Kīa‘i a mālama i ka ‘āina li‘ili‘i ma waho mai o Moloka‘i i kapa ‘ia o Molokini i kaianoho no nā manu kai ho‘opūnana.

5. ‘Ohi‘ohi i nā waiwai ‘epekema (nānā, noi‘i, a me ka ho‘ā‘o ‘ana) no ke kāko‘o ‘ana i nā makemake o ka mālama ‘ia ‘ana ma ka pahuhopu helu 1 a helu 4 no ka pu‘uhonua holoholona.

6. Ho‘omākaukau i kumu waiwai nui no nā kaianoho mākaukau no na holoholona ‘āhiu, a e kokua ho‘i i ka lehulehu ma ka ho‘onā‘auao a a‘o mai iā lākou e pili ana i nā i‘a, nā holoholona hihiu, a me nā waiwai nohona ‘ōiwi o kēia wahi nei i kapa ‘ia o Keālia Pond NWR.

7. Ho‘omākaukau ho‘i i polokalamu waiwai loa no ke a‘o ‘ana i nā haumāna e pili ana i nā kumuhana kūpono a me ka hana lima pu ma nā kaianoho holoholona hihiu.

Refuge Goals

1. Protect and maintain seasonal and semi-permanent wetland habitats to meet the life history needs of endangered Hawaiian waterbirds.

2. Expand protected species’ habitat to promote their recovery.

3. Protect, restore, and manage coastal habitat for the benefit of nesting sea turtles, seabirds, and the integrity of the fragile ecosystem.

4. Protect , restore, and maintain offshore Molokini islet habitat for seabird nesting.

5. Gather scientific information (survey, research, and assessments) in support of adaptive management decisions on the Refuge under Goals 1-4.

6. Through quality wildlife-dependent recreation and learning opportunities, visitors understand and appreciate the unique wildlife and habitats of Keālia Pond NWR.

7. Provide students and teachers high-quality hands-on environmental education programs that foster a connection with nature and the Refuge.

1.6 Relationship to Ecosystem Planning Efforts

When developing a CCP, the Service considers the goals and objectives of existing national, regional, and ecosystem plans; State/Territorial fish and wildlife conservation plans; and other landscape-scale plans developed for the same watershed or ecosystem in which the refuge is located. To the extent possible, the CCP is expected to be consistent with these existing plans and assist in meeting their conservation goals and objectives (602 FW 3.3). This section summarizes some of the key plans that were reviewed by members of the planning team during CCP development.

Beach Management Plan for Maui. The Beach Management Plan is specific to Maui County and is a guiding policy document to promote beach preservation and sustainable development of the coastal zone. The Plan includes issues on coastal erosion and beach loss, and recommendations for more efficient management of shoreline areas for resource conservation and erosion mitigation. Keālia Pond NWR's southern boundary does not include beachfront habitat at this time; however, protecting the integrity of the shoreline habitat also protects the Refuge's coastal flats habitat for endangered waterbirds. The Refuge's coastal habitat goal and strategies references this plan not only for the habitat but also to establish collaborative efforts with Federal, State, and County agencies, organizations, and landowners who have similar goals.

Hawai'i's Comprehensive Wildlife Conservation Strategy, 2005. With passage of the Commerce, Justice, and State Appropriations Act of 2001, Congress mandated each State and Territory to develop its own comprehensive wildlife conservation strategy. *Hawai'i's Comprehensive Wildlife Conservation Strategy* thoroughly reviews the status of the full range of the State's native terrestrial and aquatic species, over 10,000 of which are found nowhere else on Earth. Hawai'i's Species of Greatest Conservation Need include all native terrestrial animals, all endemic aquatic animals, additional indigenous aquatic animals identified as in need of conservation attention, a range of native plants identified as in need of conservation attention, and all identified endemic algae. This list includes: terrestrial mammal (1), birds (77), terrestrial invertebrates (~5,000), freshwater fishes (5), freshwater invertebrates (12), anchialine pond-associated fauna (20), marine mammals (26), marine reptiles (6), marine fishes (154), marine invertebrates (197), and flora (over 600). Details on all the listed wildlife taxa are provided in fact sheets that contain information for taxa, closely related groups of species, and species facing similar threats.

Hawai'i Nongame Management Program (Draft), 2000. The goal of the Hawai'i Nongame Management Program is to manage, preserve, and protect the native avifauna and their habitats for their intrinsic, recreational, scientific, and educational values and to provide opportunities for the residents and visitors to Hawai'i to use and enjoy these resources. A major focus of the program is on management and recovery of endangered species, including projects to monitor, manage habitat, and recover populations and control of predators affecting endangered species. Other nongame projects include increased surveillance of nonnative pests, construction of facilities and infrastructure to promote management or recreational opportunities to enjoy nongame resources, and maintenance of those facilities.

Draft Revised Recovery Plan for Hawaiian Waterbirds, (Second Draft of Second Revision), May 2005. The ultimate goal of the recovery program is to restore and maintain multiple self-sustaining populations of Hawaiian waterbirds within their historic ranges. The recovery of the endangered waterbirds focuses on the following objectives:

- Increasing population numbers to Statewide baseline levels (consistently stable or increasing with a minimum of 2,000 birds for each species);
- Establishing multiple, self-sustaining breeding populations throughout each species' historic range;
- Establishing and protecting a network of both core and supporting wetlands that are managed as habitat suitable for waterbirds, including the maintenance of appropriate hydrological conditions and control of invasive nonnative plants;
- For all four species, eliminating or controlling the threats posed by introduced predators, avian diseases, and contaminants; and
- For the koloa maoli (Hawaiian duck), removing the threat of hybridization with feral mallards.

U.S. Pacific Islands Regional Shorebird Conservation Plan, 2004. Conservation and restoration of shorebird habitats is essential for the protection of endangered and declining shorebird populations. Wetlands, beach strand, coastal forests, and mangrove habitats are particularly vulnerable on Pacific islands due to increasing development pressures and already limited acreage. Monitoring and research needs include assessment of population sizes and trends; assessment of the timing and abundance of birds at key wintering and migration stopover sites; assessment of habitat use and requirements at wintering and migration areas; exploration of the geographic linkages between wintering, stopover, and breeding areas; and evaluation of habitat restoration and management techniques to meet the needs of resident and migratory species. Education and public outreach are critical components of this plan. Resource management agencies of Federal, Territorial, Commonwealth, and State governments will need to work together with military agencies, nongovernmental organizations, and the scientific community. On a larger scale, coordination at the international level will be key to the conservation of vulnerable species, both migratory and resident.

Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*), 1997. The honu is listed as threatened throughout its Pacific Range, except for the endangered population nesting on the Pacific coast of Mexico, which is covered under the Recovery Plan for the East Pacific green turtle. By far, the most serious threat to these honu is from direct take of turtles and eggs, both within U.S. jurisdiction and on shared stocks that are killed when they migrate out of U.S. jurisdiction. In Hawai‘i, honu populations appear to have a somewhat less dire status, probably due to effective protection at the primary nesting areas of the Northwestern Hawaiian Islands (NWHI) and better enforcement of regulations prohibiting take of the species. However, an increase in the incidence of the tumorous disease, fibropapillomatosis, in the Hawaiian honu threatens to eliminate improvements in the status of the stock. Another serious threat to honu populations throughout the Pacific is associated with increasing human populations and development. In particular, human development is having an increasingly serious impact on nesting beaches.

Pacific Coast Joint Venture, Hawai‘i, 2006. This strategic plan for waterbirds and wetlands identifies management strategies for a diversity of resident and migratory species with varying life history requirements across multiple sites to fulfill archipelago-wide conservation goals 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" (Henry 2006). To accomplish this goal, six strategies are employed: protection, restoration, enhancement and management advocacy, outreach, and research. Habitat goals for the Pacific Coast Joint Venture (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.

Draft Recovery Plan for the Blackburn's Sphinx Moth (*Manduca blackburni*), 2003. The ‘ōka‘i ‘aiea (Blackburn's sphinx moth) is federally listed as endangered. This taxon is currently known to occur on three of the seven major Hawaiian Islands. No known ‘ōka‘i ‘aiea populations are entirely protected from the numerous factors threatening the species' recovery, and the moth is endangered throughout its range. Needed conservation and recovery activities include protection, management, and restoration of habitat; out-planting of native *Nothocestrum* spp. (‘aiea) host plants; and a captive breeding or translocation program.

Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle, 1998. The honu ‘ea (hawksbill turtle) is listed as endangered throughout its range. In the Pacific, this species is rapidly approaching extinction due to a number of factors, but the intentional harvest of the species for meat, eggs, and the tortoiseshell and stuffed curio trade is of greatest impact. Increasing human populations and the concurrent destruction of the habitat are also of major concern for honu ‘ea. The status of this species is clearly of highest concern for the Pacific and it is recommended that immediate actions be taken to prevent its extinction.

1.7 Planning and Issue Identification

In September 2009, approximately 250 copies of Planning Update #1 were mailed and hand-distributed to interested individuals, local conservation groups, research organizations; County, State, and Federal government agencies; and the Office of Hawaiian Affairs (OHA). Planning Update #1 described the planning process, Refuge purpose, and draft wildlife and habitat, and public use goals, and preliminary issues to be considered in the CCP.

1.7.1 Public Scoping Sessions

The public scoping period for this CCP was from October 21-November 20, 2009. A public meeting was held in Kīhei, Maui on November 5, 2009. At the meeting, the Refuge staff explained the CCP planning process; the Refuge purpose, vision, and management; and preliminary management issues, concerns, and opportunities. We received written comments and answered questions that addressed a number of issues and concerns from residents. Planning Update #2 (mailed February 2010) summarized the comments we received and listed preliminary management issues we used to draft alternatives and refine goals and objectives.

The core planning team evaluated the issues and the topics documented during scoping. Issues (defined as matters of controversy, dispute, or general concern over resource management activities, the environment, land uses, or public use activities) are important to the planning process to help identify topics to be addressed in the plan, pinpoint the types of information to gather, and help define alternatives for the plan. In Planning Update #3 (mailed March 2011), we described the three alternatives being considered with the preferred alternative identified. Concurrent with mailing, Planning Updates 1-3 were also posted on the Refuge Website.

Planning Update #4 and the Draft CCP and Environmental Assessment (EA) were published in August 2011 with a public comment period August 19-September 19, 2011. A public meeting on the Draft CCP/EA was held in Kīhei, Maui on September 8, 2011.

1.7.2 Issues Addressed in the CCP

The following issues were addressed in the planning process:

Wildlife and Habitat Resources: Endangered waterbirds are the primary management focus, but management also considers and includes endangered ‘ōka‘i ‘aiea and honu ‘ea, threatened honu, migratory shorebirds, waterfowl, seabirds, and native plant species. The Service is concerned with threats posed to native habitats and wildlife at Keālia Pond from invasive plants like California bulrush and pickleweed, and pest animals such as rats, mongooses, and cats.

Invasive aquatic insects and fish: Environmental conditions within the pond often times lead to increased emergence of native and nonnative midges (non-biting insects) and fish die-offs. The occurrence of these events is reported as a nuisance by local communities. The CCP identifies strategies to ameliorate midges and tilapia while adhering to the purpose of the Refuge.

Facilities and Facilities Maintenance: The maintenance of current facilities includes the 7,500 sq.ft. headquarters and visitor center (HQ/VC); vehicles and farm tractors; metal shipping containers that house shop maintenance and office storage; boundary fencing; ditches, dikes, and impoundments; water control structures; and wells and pumps. Due to the environmental conditions (e.g., constant wind containing salt spray and precipitation, warm temperatures, high humidity) associated with this coastal marine environment, degradation of equipment and facilities is accelerated and often exceeds normally acceptable mainland standards for maintenance costs and schedules.

Visitor Services Activities: Keālia Pond NWR provides opportunities for EE and interpretation, wildlife observation, and wildlife photography during much of the year. The Service must balance visitor use and wildlife protection and will ensure public use activities do not result in disturbance to wildlife and habitat. Compatibility Determinations (CD) for EE, interpretation, wildlife observation, and photography were approved in 2004, but have been re-evaluated during the CCP planning process.

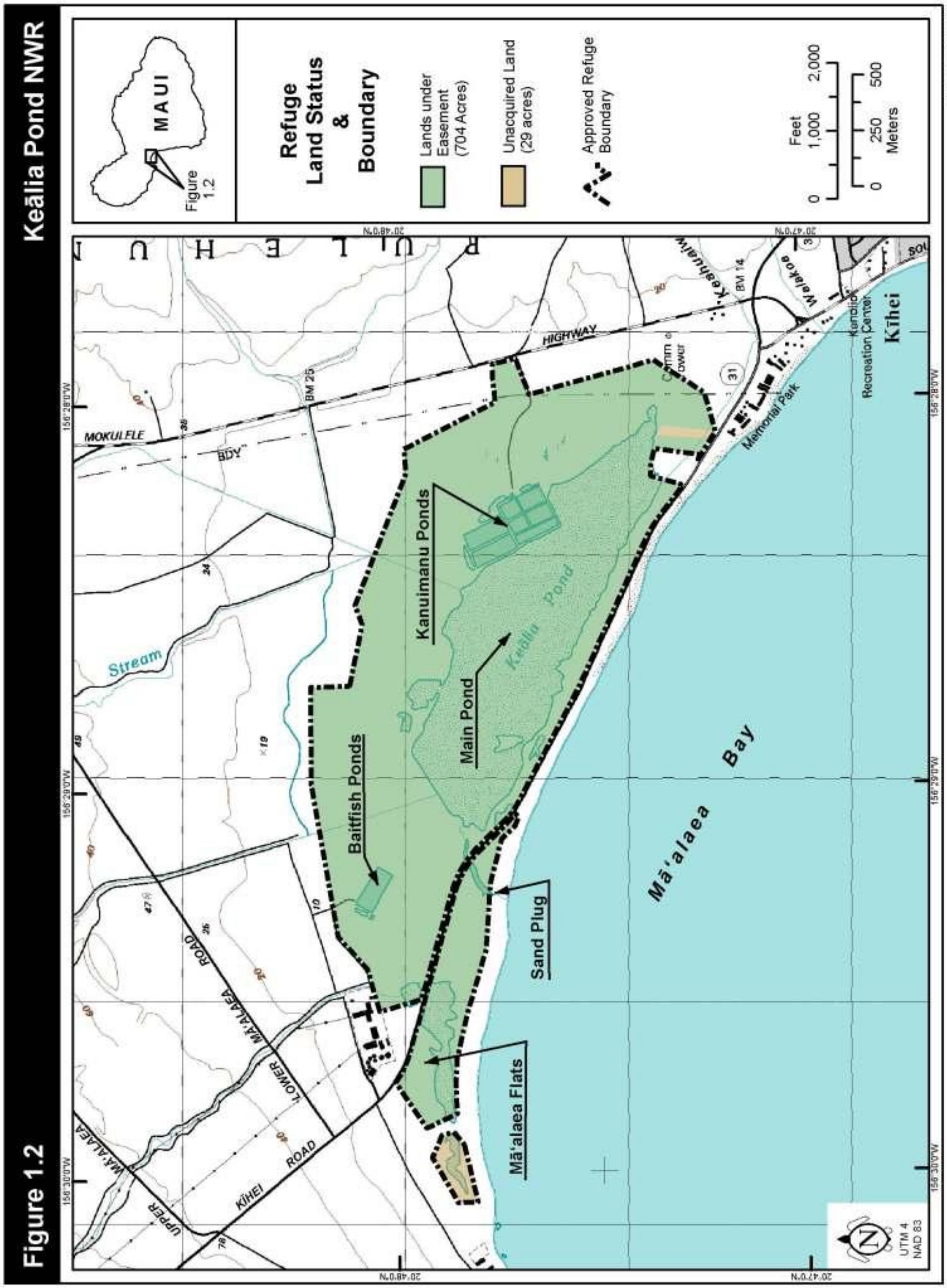
Law Enforcement: Refuge officers are responsible for upholding Federal laws and regulations that protect natural resources, the public, and employees. The sole Zone Officer is stationed in Honolulu and has responsibilities that extend to all of the Hawaiian and Pacific Islands refuges.

Adaptive Management: More data on impacts of pest species; seabird nesting on Molokini; and inter-island dispersal patterns of endangered waterbirds is needed. This lack of data hinders the Service’s ability to respond effectively to resource changes and to use adaptive management to evaluate the effectiveness of its management practices. The CCP identifies inventory, monitoring and research needs and the public’s role in determining and meeting these needs.

Figure 1.1 – Main Hawaiian Islands

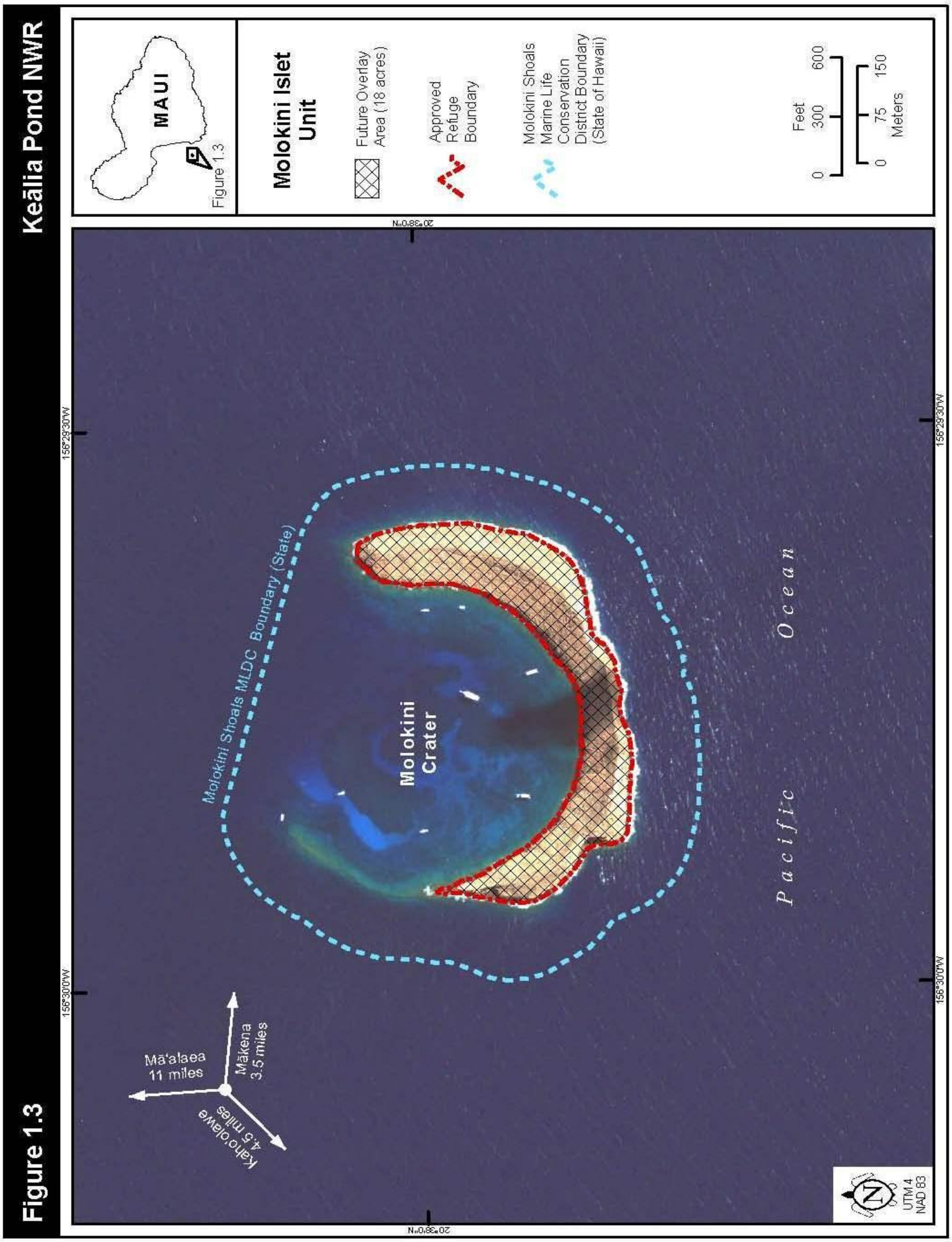
To preserve the quality of the map, this side was left blank intentionally.

Figure 1.2 – Refuge Land Status & Boundary



To preserve the quality of the map, this side was left blank intentionally.

Figure 1.3 – Molokini Islet Unit



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Chapter 2. Refuge Management Direction

2.1 Considerations in Design of the CCP

In thinking through appropriate actions for this long-term conservation plan, the planning team reviewed and considered a variety of resource, social, economic, and organizational aspects important for managing the Refuge. As is appropriate for a national wildlife refuge, resource considerations were fundamental in developing the CCP. House Report 105-106 accompanying the Improvement Act states "...the fundamental mission of our System is wildlife conservation: wildlife and wildlife conservation must come first."

Local, State, and Federal agencies and elected officials were contacted by the planning team to ascertain priorities and problems as perceived by others. The team also contacted Refuge users, nonprofit groups, and community organizations to ensure that their comments and ideas were considered during CCP development.

2.2 General Guidelines

To reduce the length and redundancy of the individual objective descriptions, common elements are presented below.

2.2.1 Implementation Subject to Funding Availability

Actions will be implemented over a period of 15 years as funding becomes available. Routine maintenance, repair, replacement, and improvement of existing facilities will continue, also dependent on funding. Annual priorities will follow CCP guidelines, although funding initiatives, unforeseen management issues, and budgets may vary from year to year. The CCP will be reviewed every year and updated as necessary throughout its life.

2.2.2 Interagency Coordination and Collaboration

Ecosystem planning efforts discussed in Chapter 1, Section 1.6 involve collaboration among Federal, State, and local agencies toward mutual goals. The Service will continue to maintain regular discussions and partnership with the DLNR. Topics for discussion continue to be the endangered waterbirds at Keālia Pond NWR and surrounding private and public lands, and wildlife monitoring. Upon establishment as an overlay refuge, the Service will seek a collaborative effort with DLNR for consultation and assistance in continuing the seabird monitoring program and development of a native plant restoration plan.

2.2.3 Threatened and Endangered Species Protection and Recovery

Protection of threatened and endangered (T&E) species is common across all alternatives. It is Service policy to give priority consideration to the protection, enhancement, and recovery of T&E species on national wildlife refuges. The protection of federally listed species is mandated through Section 7 of the ESA, called "Interagency Cooperation," is the mechanism by which Federal agencies ensure the actions they take, including those they fund or authorize, do not jeopardize the existence of any listed species. To ensure adequate protection, the Refuge is required to review all activities, programs, and projects occurring on lands and waters of the Refuge to determine if they may affect listed species. If the determination is that an action may affect an endangered species, then the Refuge conducts a formal review, known as a consultation, to identify those effects and means to mitigate those effects.

Endangered ʻalae keʻokeʻo USFWS

2.2.4 Historic and Cultural Resource Protection

Cultural resources on refuge lands receive protection and consideration in accordance with Federal cultural resources laws, Executive orders, and regulations, as well as policies and procedures established by the Department of the Interior (DOI) and the Service. Refuge management actions will support the State of Hawaiʻi's vision statement "to promote the use and conservation of historic and cultural resources for the education, inspiration, pleasure and enrichment of the public in a spirit of stewardship and trusteeship for future generations" (State Historic Preservation Plan 2010-2014).

The Native American Graves Protection and Repatriation Act (NAGPRA) is a Federal law passed in 1990 that provides a process for museums and Federal agencies to return certain Native American cultural items — human remains, funerary objects, sacred objects, or objects of cultural patrimony — to lineal descendants, and culturally affiliated Indian tribes and Native Hawaiian organizations. A Native Hawaiian organization includes any organization that: (a) serves and represents the interests of Native Hawaiians, (b) has as a primary and stated purpose of the provision of services to Native Hawaiians, and (c) has expertise in Native Hawaiian Affairs, and includes the Office of Hawaiian Affairs and Hui Malama i na Kupuna ʻo Hawaiʻi Nei. The DOI has interpreted this definition to also include the Hawaiian island burial councils and various ʻohana (extended families).

During early planning of any projects, the Refuge will provide the Service's Regional Historic Preservation Officer (RHPO) a description and location of all projects and activities that affect ground and structures, including project requests from third parties. Information will also include any alternatives being considered. The RHPO will analyze these undertakings for potential to affect historic properties and enter into consultation with the State Historic Preservation Officer (SHPO) and other parties as appropriate. The Refuge will also ask the public and local government officials to identify any cultural resource impact concerns. This notification is generally done in conjunction with the review required by NEPA or Service regulations on compatibility of uses.

2.2.5 Fire Management

The suppression of wildfires and the use of prescribed or controlled fire are a long-standing part of resource protection, public safety, and habitat management on national wildlife refuges. The Fire Management Plan (Appendix G) provides detailed guidance for the suppression and use of prescribed fire. The plan outlines wildfire response and prescribed fire objectives, strategies, responsibilities, equipment and staffing; burn units; implementation; monitoring; and evaluation.

2.2.6 Participation in Planning and Review of Regional Development Activities

The Service will actively participate in planning and studies for ongoing and future industrial and urban development, contamination, and other potential concerns that may affect the Refuge's wildlife resources and habitats. The Service will continue to cultivate working relationships with pertinent State and Federal agencies to stay abreast of current and potential developments and will utilize effective outreach tools and technologies and EE as needed to raise awareness of the Refuge's resources. The Refuge will participate in local community initiatives to protect, steward, and enhance natural landscapes and wildlife habitat. We will continue to identify and pursue new opportunities for land acquisition that will benefit the Refuge purpose.

2.2.7 Adaptive Management

Based upon 522 Departmental Manual (DM) 1 (Adaptive Management Implementation policy), Refuge staff shall utilize adaptive management for conserving, protecting, and, where appropriate, restoring lands and resources. Within 43 CFR 46.30, adaptive management is defined as a system of management practices based upon clearly identified outcomes, where monitoring evaluates whether management actions are achieving desired results (objectives). The recently published DOI Adaptive Management Technical Guide also defines adaptive management as a decision process that "promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood."

Adaptive management accounts for the fact that complete knowledge about fish, wildlife, plants, habitats, and the ecological processes supporting them may be lacking. The role of natural variability contributing to ecological resilience also is recognized as an important principle of adaptive management. It is not a "trial and error" process, but rather emphasizes learning while doing based upon available scientific information and best professional judgment considering site-specific biotic and abiotic factors on Refuge lands. Adaptive management results in effective monitoring and evaluation of the CCP.

Part of measuring the success of and adaptively managing the Refuge also includes the formal 15-year revision of the CCP. The revision will be initiated by the Service and will involve many of the same steps as this CCP including comprehensive review of management plans and research; working closely with partners; and engaging the public.

2.2.8 Integrated Pest Management

In accordance with DOI policy 517 DM 1 and Service policy 569 FW 1, an integrated pest management (IPM) approach will be utilized, where practicable, to eradicate, control, or contain pest and invasive species (herein collectively referred to as pests) on Refuge lands. The IPM will involve using methods based upon effectiveness, cost, and minimal ecological disruption, which considers minimum potential effects to nontarget species and the refuge environment. Pesticides may be used where physical, cultural, and biological methods or combinations thereof are impractical or incapable of providing adequate control, eradication, or containment. If a pesticide will be needed on Refuge lands, the most specific (selective) chemical available for the target species will be used unless considerations of persistence or other environmental and/or biotic hazards will preclude it. In accordance with 517 DM 1, pesticide usage will be further restricted because only pesticides registered with the EPA in full compliance with the Federal Insecticide, Fungicide, and Rodenticide Act and as provided in regulations, orders, or permits issued by EPA, that it is registered for use in the State of Hawai‘i, may be applied on lands and waters under Refuge jurisdiction.

Environmental harm by pest species refers to a biologically substantial decrease in environmental quality as indicated by a variety of potential factors, including declines in native species populations or communities, degraded habitat quality or long-term habitat loss, and/or altered ecological processes. Environmental harm may be a result of direct effects of pests on native species, including preying and feeding on them; causing or vectoring diseases; preventing them from reproducing; outcompeting them for food, nutrients, light, nest sites, or other vital resources; or hybridizing with them so frequently that within a few generations, few if any truly native individuals remain. Environmental harm also can be the result of an indirect effect of pest species. For example, decreased waterfowl use may result from pest plant infestations reducing the availability and/or abundance of native wetland plants that provide forage during the winter.

Throughout the life of the CCP, most proposed pesticide uses on Refuge lands will be evaluated for potential effects to Refuge biological resources and environmental quality. Pesticide uses with appropriate and practical best management practices (BMP) for habitat management as well as facilities maintenance will be approved for use on Refuge lands where there likely will be only minor, temporary, and localized effects to species and environmental quality based upon non-exceedance of threshold values in chemical profiles. However, pesticides may be used on Refuge lands where substantial effects to species and the environment are possible (exceed threshold values) in order to protect human health and safety (e.g., mosquito-borne disease).

Although human nuisance is not discussed at length in the IPM policy, the Service is committed to continue to address nuisance species of nonnative midges when not in conflict with the Refuge purpose and within available funding. For more information on strategies related to control of pests, see Appendix E.

2.2.9 National Environmental Policy Act Compliance

Since this CCP is programmatic in many issue areas, it may not contain the necessary detail on every future action outlined to adequately present and evaluate all physical, biological and socioeconomic impacts. For example, “step-down” plans required for various management actions such as visitor services and transportation will be developed after publication of the CCP. Thus, before certain objectives or actions are implemented, a decision will be made in coordination with the Regional NEPA Coordinator on whether separate step-down NEPA compliance (categorical exclusions, environmental assessments, or an environmental impact statement) are needed.

2.2.10 Law Enforcement

Officers’ Responsibilities

Fish and wildlife law enforcement issues on lands and waters of the Keālia Pond NWR are under the jurisdiction of the Service Zone Officer based in Honolulu. The role of the Zone Officer is to conduct patrols and document law enforcement incidents and coordinate and/or meet with all refuge project leaders, law enforcement supervisors, and refuge officers. The Hawaiian and Pacific Islands Zone Officer is highly mobile and is frequently deployed temporarily to various areas throughout the State of Hawaiʻi and across the Pacific Region. The need for a dedicated Refuge Officer for the Complex has been identified in the Implementation Plan (Appendix C).

Officers' Authority

The Zone and Refuge Officers are primarily responsible for enforcing refuge and wildlife laws, including but not limited to:

- Administration Act;
- The Lacey Act;
- Archaeological Resources Protection Act;
- Endangered Species Act;
- Migratory Bird Treaty Act; and
- Marine Mammal Protection Act.

Zone and Refuge Officers are also empowered to enforce all criminal laws, including traffic violations, drugs, and warrants for arrest as they relate to trespass, hunting, fishing, and the taking of wildlife on Federal lands, and in some instances boating safety related to refuge lands and waters. Service Officers work joint patrols and coordinate with the State Division of Conservation and Resources Enforcement (DOCARE), Maui Police Department, and the Sheriff Division of the State Department of Public Safety.

2.3 Summary of CCP Actions

Wildlife and Habitat Restoration efforts and increased water management capabilities are intended to achieve the maximum potential for enhancing and maintaining biological and ecological requirements for endangered waterbirds, and indirectly benefit wintering migratory waterbirds (Figure 2.1). The Refuge will plan and implement the physical alterations needed to maximize our ability to control water in the Main Pond and adjacent vegetated mudflats, significantly remove (or attain less than 10 percent cover) the most aggressive pest plants, and control larger areas of pickleweed on the flats. Physical restoration includes: construction of a water control structure at the N. Kīhei Rd. culvert, additional groundwater sources (wells) to maintain water on the flats, and reconfiguration of topography to hold water longer.

The increased capability to dewater and flood the Main Pond will enable the Refuge to use water level to control the three nuisance issues (spotted-winged midges, pest tilapia, and windblown sediment). Maintaining water coverage at 20-30 percent in the Main Pond December-February has resulted in a reduction of midges and lower abundance of tilapia. Flooding into the adjacent sedges and flats in March will provide habitat for breeding ʻalae keʻokeʻo and a shorter midge season with a lower intensity/density of nuisance midges. Water level will be maintained until natural recession occurs for aeʻo breeding activity.

Molokini, after establishment as an overlay refuge, will be managed as a seabird colony with periodic visits to monitor the population status and trends. The monitoring will include three to six visits during seabird nesting season (March-November). In addition to maintaining consistent data collection for ʻuaʻu kani, the extra visits will allow us to begin an ʻou monitoring program to determine the population parameters. After 3 years, the Refuge will evaluate the necessity to monitor annually and the potential to monitor every 2-3 years. In addition, we will initiate a native plant restoration plan, particularly ʻihi (*Portulaca molokiniensis)* and a few other species found only on that islet, with a minimum of two additional visits per year during the nonnesting season (December-February). These visits will also be used to monitor tree tobacco for ‘ōka‘i ‘aiea. The potential for their presence on Molokini is high given that they are found on Maui and Kaho‘olawe. Volunteers will assist with propagating plants in the Refuge’s greenhouse and outplanting will be conducted by Federal and State biologists under a cooperative agreement with DLNR.

Climate change analyses for Keālia Pond NWR will be evaluated for applicability to management strategies. Refuge staff will participate in development of climate change assessment protocols.

Visitor Services. Visitor services will be expanded with the Refuge open on weekends and additional efforts made to provide vegetated barriers and/or blinds to provide better viewing opportunities and increase areas for wildlife viewing. Visitor services staff will provide educational programs and materials. Recruitment and training of volunteers to provide additional programs will increase.

2.4 Goals, Objectives, and Strategies

Goals and objectives are the unifying elements for successful, adaptive refuge management. They identify and focus management priorities, resolve issues, and link to refuge purposes, Service policy, and the Refuge System mission. A CCP describes management actions that help bring a refuge closer to its vision. A vision broadly reflects the refuge purposes, Refuge System mission and goals, other statutory requirements, and larger-scale plans as appropriate. Goals then define general targets in support of the vision, followed by objectives that direct effort into incremental and measurable steps toward achieving those goals. Finally, strategies identify specific tools and actions to accomplish objectives. Unless specifically stated, all objectives are applicable throughout the life of this plan.

The goals for Keālia Pond NWR are presented on the following pages, followed by one or more objectives that pertain to it. The goal order does not imply any priority. Some objectives pertain to multiple goals and have simply been placed in the most reasonable spot. Similarly, some strategies pertain to multiple objectives and for clarity these strategies are listed under each relevant objective. Following the strategies, a brief rationale generally describes how management strategies will be implemented to achieve the intended objectives. The rationale may also, where necessary, discuss means to minimize potential impacts to non-target species and habitats. It also provides further background information pertaining to the importance of an objective relative to legal mandates for managing units of the Refuge System, including refuge purpose, trust resource responsibilities (federally listed T&E species and migratory birds), and maintaining/restoring BIDEH.

Table 2.1 - Keālia Pond NWR Management Summary

Key Themes		Objectives	Scope of Management
HABITATS	Seasonal & Semi-permanent Wetland Habitat	**1.1** Protect seasonal ponds	26 acres
		1.2 Protect vegetated flats	135 acres
		1.3 Protect open water	197 acres
		1.4 Protect coastal flats	60 acres
	Upland Habitat	**2.1** Enhance shrub land	5 acres
		2.2 Protect buffer zone	75 acres
	Coastal Habitat	**3.1** Protect and enhance coastal strand	3 acres
	Islet Habitat	**4.1** Protect seabird nesting	19 acres
Scientific Data		**5.1** Conduct inventory, monitoring, and research	Track nesting success; impacts of pest plants & animals; water quantity & quality; abundance of endangered waterbirds; monitor plants for ʻōkaʻi ʻaiea presence; monitor seabird nesting on Molokini; study most effective IPM strategies; and conduct research on ʻalae keʻokeʻo intra- & inter-island dispersal patterns
		5.2 Conduct scientific assessments	Assess watershed volume; assess water resources, assess bathymetric configurations; develop climate change assessment protocols; and evaluate SLAMM analyses
Visitor Services		**6.1** Provide opportunities for wildlife observation & photography	>12,000 visitors
		6.2 Evaluate fishing program	Complete fishing CD; develop brochures; analyze fish
		6.3 Expand interpretation and outreach	>10 programs annually
Volunteers		**6.4** Expand volunteer program	>75 volunteers
Environmental Education		**7.1** Expand EE partnerships	5-12 programs annually
		7.2 Expand internship program	4-5 interns

2.4.1 Goal 1.

Protect, maintain, and enhance seasonal wetland habitats to meet the life history needs of endangered Hawaiian waterbirds.

Objective 1.1: Protect, maintain, and enhance seasonal wetland habitat in constructed ponds.
Protect and maintain a mosaic of seasonal wetland habitat in Kanuimanu Ponds (20 acres) and Baitfish Ponds (6 acres) for the life history needs of aeʻo and ʻalae keʻokeʻo with the following attributes: • 75% of pond bottom composed of undulating, irregular topography that creates exposed, small, low islands with 4:1 slopes April-July for breeding aeʻo; • A mosaic of mudflat (dry and saturated) and open water (<12 in.) interspersed with 30-60% cover of native emergent vegetation; • Stable water level (1-2.5 ft. depth) in all ponds December-March for ʻalae keʻokeʻo nesting; • 1-4 in. open water depth, 6 in. maximum by September; • Predation of <1% of aeʻo or ʻalae keʻokeʻo occurring within this habitat per year; • No tilapia present; • <25% cover of pest plants (marsh fleabane, California bulrush, and California grass); • Levees and slopes covered with 10-50% native groundcover vegetation with <4 in. height; • Abundant nektonic and benthic invertebrates with densities of 480-720 invertebrates/yd^2; • ʻAlae keʻokeʻo brood-rearing within 55 yds. of nesting habitat; • Limited public access during ʻalae keʻokeʻo nesting December-March; and • Minimal human disturbance during aeʻo nesting season April-July.
Strategies for Achieving the Objective
Control pest plants using mowing, brush cutting, excavation, water level management, prescribed fire, and herbicides (see IPM, Appendix E)
Continue partial to complete closures to public access on levees to minimize disturbance to waterbirds, particularly during breeding season
Propagate and plant native species to establish natural vegetative cover on pond levees and slopes
Control tilapia with traps and nets, lowering water level, and/or drying the ponds August-September
Use IPM techniques to set back wetland succession and promote a mosaic of vegetation/open water to maximize territories for ʻalae keʻokeʻo
Pulse water from brackish wells to inundate emergent vegetation for ʻalae keʻokeʻo nesting (Nov.)
Maintain water cover at 70-80% to control pest plants November-December
Maintain stable water level of 1-2.5 ft. for ʻalae keʻokeʻo January-April
Pulse water during draw down to promote abundance and availability of invertebrates
Slow drawdown of water to eliminate pest fish and promote invertebrate/algal and plant response
Allow water to recede in mid-April to trigger aeʻo nesting by May
Maintain 60-70% water coverage for breeding aeʻo
Allow periodic dewatering from August-October to recycle nutrients and promote invertebrate abundance and diversity
Maintain stable water level and/or pulse water slightly during aeʻo nesting
Control predators with live-traps, snap-traps, bait stations, and water level management
Control cattle egret colonies by removing roosting trees, and/or direct removal of individual birds
Add fill and compact levees to maintain integrity, prevent flooding and erosion
Use heavy equipment to reconfigure pond topography to increase water coverage

Rationale

Aeʻo require different loafing and foraging habitats during the breeding (April-August) and nonbreeding seasons. Recently hatched aeʻo require shallow water of less than 2 inches to forage. During the remainder of the year, fledglings through adults can forage in water as deep as 6 inches. Seasonally regulating water depth stimulates germination of beneficial plant species, controls pest plants, and provides a variety of macro-invertebrates for young and adult aeʻo to feed upon, thereby creating and maintaining maximized production and carrying capacity of the wetlands. A mosaic of open water and vegetation serves as microhabitat for aeʻo thermoregulation. Dewatering the pond during nonbreeding season is beneficial for recycling nutrients, removing pest fish, and allowing staff to perform IPM (herbicide and mechanical) treatments before flooding. This drying cycle enhances soil aeration and invertebrate productivity.

Breeding aeʻo require dry to unsaturated mudflat habitat for building nests. Prebreeding water drawdowns help dry the mudflats for nesting. Saturated mudflats can be used as nest sites, but result in aeʻo expending additional energy to build nests robust enough to counter the excess moisture. The drawdown is timed to coincide with minimal or no ʻalae keʻokeʻo nesting or chick rearing, part of a cycle of wetting and drying of habitat to make it suitable to a greater number of birds throughout the year and increasing species diversity. Thus, aeʻo nesting habitat temporarily follows where ʻalae keʻokeʻo habitat existed previously.

The target distance between nest site to vegetation and water is approximately 5-20 feet. These slow breeding season drawdown rates also stimulate ample numbers and diversity of invertebrates throughout the brood-rearing period, allowing adults with broods to establish feeding territories and reduce inter-brood conflicts that can result in injury or death to young chicks.

ʻAlae keʻokeʻo prefer stable water levels (1-2.5 feet depth) for nest building and brooding. To prepare ponds for nesting, water levels are maintained at a constant level to provide adequate sites that are secure from predation. Fluctuating water levels would require nesting adults to continually expend energy to build the nest up or be isolated on dry ground and subject to greater predation.

Aeʻo and ʻalae keʻokeʻo are easily disturbed during their nesting seasons and will depart the nest when danger is perceived, leaving the nest, eggs, or young exposed to predators and the weather. Eggs can also be destroyed by prolonged exposure to high temperature, wind chill, and rain. Human disturbance must be minimized during the nesting period to reduce the risk of nest abandonment.

Nests, eggs, and young are vulnerable to a variety of predators including rats, mongooses, dogs, cats, cattle egrets, and ʻaukuʻu (black-crowned night-heron). Predator control success is defined, in part, by an increase in aeʻo nest success. Nesting islands with surrounding water help protect aeʻo eggs and chicks from cats, mongooses, and rats. Predator control and control of pest fish species (tilapia) also improve habitat condition and increase nest success. The target of removing all tilapia from the constructed ponds is attainable as no outside sources contribute directly to them. These ponds will be filled from a groundwater well, precipitation, and possibly some upwelling and/or seepage.

Low vegetation on levees creates important habitat for ʻalae keʻokeʻo as well as other species. Maintaining vegetation height of less than 4 inches provides foraging areas where ʻalae keʻokeʻo can graze on short grass and feed on associated invertebrates. Levees are also used as loafing habitat by shorebirds. Planting of native vegetation along slopes prevents erosion and also provides additional habitat.

Objective 1.2: Protect , maintain, and enhance seasonal vegetated flats for foraging, loafing, and breeding.
Protect and maintain up to 135 acres of vegetated flats for all life history (foraging, loafing, breeding) requirements of ae‘o and ‘alae ke‘oke‘o with the following characteristics: • A mosaic of flats and open water (<7 in., 1-4 in. optimal) interspersed with 30-60% cover of emergent vegetation and algae that provides seeds and green browse April-August; • No California bulrush, mangrove, or California grass; • Undulating, irregular bottom topography creating exposed non-saturated substrate (e.g., shoreline, islands) with gradual slopes; • <50 ft. width of emergent vegetation along shorelines for nesting ‘alae ke‘oke‘o December-March; • Predation of <3% of ae‘o or ‘alae ke‘oke‘o per year; • No human disturbance during breeding season, minimal disturbance remainder of year; and • Abundant epiphytic invertebrates (e.g., dragonflies) and aquatic benthic/nektonic macro invertebrates (density 480-720 invertebrates/yd^2), crayfish, and small forage fish.
Strategies Applied to Achieve Objectives
Mow and rototill to open pickleweed-dominated north shoreline of the Main Pond
Use IPM strategies including mowing, brush cutting, excavation, water level management, prescribed fire, and herbicides
Propagate and plant native species in place of pest plants to provide nesting structure for ae‘o and visual obscurity for ‘alae ke‘oke‘o territories
Control predators with live-traps, snap-traps, bait stations, and water level management
Manipulate water levels to expose islands and mudflats for foraging waterbirds
Flood Main Pond into vegetated flats in March to provide nesting habitat for ‘alae ke‘oke‘o
Mow and rototill wetland habitat on the north side of N. Kīhei Rd. culvert to increase mudflats
Minimize human disturbance by installing fences and signs, particularly along the south side of the Main Pond (N. Kīhei Rd.) by 2013
Construct a water source in vicinity of the Baitfish Ponds to flood the vegetated flats by 2016
Construct low berms to extend hydroperiod and promote plant response by 2019
Install predator-proof fence around the wetland perimeter to decrease mammalian predator immigration from sugarcane fields by 2020

Rationale

Vegetated flats extend beyond the Main Pond (open water) around its perimeter. The flats located on the north side of the Main Pond are over 900 feet-wide in contrast to the south side flats that are narrow and less than 260 feet wide. A mosaic of flats and open water (<7 in., 1-4 in. optimal) interspersed with 30-60 percent cover of emergent vegetation and algae provides seeds and green browse for ‘alae ke‘oke‘o, maximizes visual barriers for ae‘o nest territories, and provides concealment and thermal cover April-August. The south side is susceptible to wind-generated waves and human trespassing; therefore, the north flats provide higher-quality habitat for waterbirds. A majority of the management activities to control pest plants occurs on the north side during late summer and fall.

The hydrology of shallow water habitats benefits breeding, resting, and loafing requirements for ae‘o and ‘alae ke‘oke‘o as long as dry areas adjacent to water and vegetation are available. A mosaic of vegetative cover created by mowing and rototilling shoreline vegetation provides thermoregulation cover for protection from inclement weather and pair bonding and brood-rearing habitat. Based on experience in the Main Pond, a long-term transition to native wetland plants and nonnative waterbird forage plant species is anticipated. To keep birds from flying over the bridge to access the other side of the outlet, habitat enhancement on the north side of the N. Kīhei Rd. culvert will not be performed near the bridge, thus reducing the potential for road kill.

Predator control efforts increase prior to and during ae‘o breeding season around areas of high-density nesting. Due to their vulnerability in the vicinity of primary nesting area, partial to complete public access closures during ae‘o nesting/brood-rearing periods increases fledging success. With increased habitat restoration on the flats, management of water, and effective predator control, ae‘o nest success should increase.

Objective 1.3: Protect , maintain, and enhance open water habitat for waterbird life history requirements.
Protect and maintain up to 197 acres of open water habitat in Keālia Pond for all ae‘o and ‘alae ke‘oke‘o life history requirements year-round with the following characteristics: • <50 ft. width of emergent vegetation along shoreline of vegetated flats; • Open water with <12 in. depth over 30-40% of the pond during ae‘o breeding season (April-July) • >80% reduction of tilapia; • <720/yd^2 spotted-winged midge density; • Predation of <3% ae‘o and/or ‘alae ke‘oke‘o occurring in this habitat per year; • Abundant epiphytic invertebrates and benthic/nektonic macro invertebrates (density of 480-720 invertebrates/yd^2), crayfish, and small forage fish; and • No human disturbance.
Strategies Applied to Achieve Objectives
Continue partial to complete closure of Kanuimanu Ponds during breeding season, as needed
Control pest fish by deploying nets and traps to remove fish biomass when water recedes
Control windblown sediment by sheetflowing water through Well D water distribution line August-December
Control overabundance of spotted-winged midges with methoprene (no more than one treatment per year)
Use water control structures and well pump for water control for plant and invertebrate response and water manipulations
Control predators with live-traps, snap-traps, bait stations, and water level management
Control tilapia via chemical treatment to remnant water in the outlet in September
Construct a six-bay water control structure at N. Kīhei Rd. bridge to control water in the Main Pond by 2016
Control water in the Main Pond to maintain 30% cover December-February to control midges and tilapia
Flood Main Pond into vegetated flats in March to provide nesting habitat for ‘alae ke‘oke‘o

Rationale
Flooding and dewatering in the Main Pond is dependent on surface and groundwater; precipitation; and the natural recession April-July. Water management is performed August-December (or longer depending on the onset of winter rains) by direct pumping from brackish water wells.

The Main Pond is the primary source of nuisance issues (including spotted-winged midges, dead fish, and windblown sediment) for Refuge neighbors and yet this habitat is the most difficult to control. The abundance of spotted-winged midges varies from year to year but has occurred from mid-December to mid-April in most years. The highest abundance was approximately 96,000 larvae/yd^2. Based on monitoring and the level of complaints, we estimate 480-720 midge larvae/yd^2 is a level that is tolerable by neighbors yet provides sufficient forage for endangered and migratory waterbirds. The short-term control of spotted-winged midges has been an application of the insect growth regulator methoprene which has shown to decrease the adult nuisance. However, a natural long-term control is sought such as water manipulation to control midge density. When this control is established, methoprene will be used as a secondary option.

The presence of tilapia in the Main Pond is inevitable because the fish remain in the outlet where the deep channel retains water throughout the year. During rainstorms, tilapia from upstream irrigation reservoirs enter the Main Pond with stream flow. Long periods of flooded conditions result in the dispersal of fish from the outlet and the exponential increase in productivity, thus leading to overcrowded conditions resulting in a fish die-off when water level recedes to approximately 50 percent coverage. The Main Pond is allowed to dry September-December for regrowth of kaluhā (saltmarsh bulrush), breakdown of organic material, soil aeration, and dispersal of accumulated sediment.

When windblown sediment becomes a nuisance issue, water can be directed to the upper reaches of the Main Pond via the Well D water distribution line to sheet flow over extensively dry portions to hold down sediment. This will be performed after ae‘o breeding season September-December and after IPM treatments on pest plants along the vegetated edge has been completed.

In 2001, an in-depth study of the pond hydrology (quantity and quality) was initiated in addition to monitoring spotted-winged midges and tilapia abundance. Monitoring data from 2 years with low winter water level December-February resulted in midge numbers below nuisance level. Duplication of this water condition during key months (December-February) may be a long-term solution to controlling midges and tilapia. In most years, midge abundance was high when winter flooding was high (December-April). However, when water level was low and the salinity was high, the midge abundance was lower and not a nuisance to neighbors.

If water pumping capability is maximized and the water control structure at the N. Kīhei Rd. bridge is constructed, the ability to maintain low water conditions (20-30 percent coverage) from the time winter flooding occurs to end of February may be the solution to both controlling the abundance of midges and also the abundance of tilapia. The shallow, salty water conditions and disconnect from the pond outlet results in undesirable habitat for tilapia, thus their abundance will be controlled.

Objective 1.4: Protect , maintain, and enhance coastal flats for ae‘o life history needs.

Protect and maintain up to 60 acres of seasonal coastal flat habitat at Mā‘alaea Flats for all life history requirements of ae‘o throughout the year with the following characteristics:

- A mosaic of saturated and dry mudflats;
- Open water <7 in. depth;
- Documented predation level of <20% of ae‘o nests annually;
- No human disturbance within 109 yds. of breeding territories;
- Abundant invertebrates with densities of 480-720 invertebrates/yd^2;
- <30% cover of vegetation to provide cover and protection from wind;
- <30% cover of pickleweed;
- 50-100 ft. width of vegetation along N. Kīhei Rd.; and
- Physical barriers to prevent vehicular access onto the coastal flats.

Strategies Applied to Achieve Objectives
Maintain recycled-plastic fence along N. Kīhei Rd. to prevent vehicular access onto the flats
Construct water source (well, pump, water distribution line) at Mā‘alaea Flats to maintain shallow water by 2014
Implement complete or partial closure of Boardwalk, if necessary to prevent nest abandonment and egg/chick loss
Control predators with live-traps, snap-traps, bait stations, and water level management
Map topography of the mudflats to identify areas to construct low berms for water retention by 2013
Use IPM strategies including mowing, brush cutting, excavation, water level management, prescribed fire, and herbicides to control pest plants
Propagate and plant native species in place of pest plants
Create low islands within the flats to diversify topography by 2016
Restore Mā‘alaea Flats wetland community to provide additional habitat away from the Boardwalk by 2013
Alter bathymetry to retain water longer on Mā‘alaea Flats by 2013
Plant native shrub buffer along highway to reduce opportunities for waterbirds flying low over road by 2014

Rationale

Mā‘alaea Flats is connected to the Main Pond outlet on the east side and receives ocean water during higher high tides on the west end of the 60-acre flats. Natural flooding December-March appears to be from high water levels in the Main Pond via the outlet. If the Refuge had the ability to maintain water on the flats, there will be an increase in ae‘o use throughout the year. An additional source of water will enable the Refuge to maintain shallow water until completion of the breeding season. In addition, low berms on the east side, adjacent to the outlet will retain water on the flats instead of draining into the Main Pond outlet, particularly when the sand plug is breached (naturally or by hand). Monitoring human activities is a continuous need because of the connection to the beach front. Signage and fencing is necessary to control human access and law enforcement is essential to prevent disturbance to birds even during Boardwalk closures.

2.4.2 Goal 2.

Expand protected species' habitat to promote their recovery.

Objective 2.1: Enhance shrub land habitat for endangered ʻōkaʻi ʻaiea (Blackburn's sphinx moth).
Enhance plant community to provide habitat for the endangered ʻōkaʻi ʻaiea with the following characteristics: • 1-5 acres of dry to mesic shrub land and forest habitat; • 60-80% native host plants including ʻaiea, lama, hao, ʻohe, ʻālaʻa, ʻaʻaliʻi, wiliwili, maiapilo, and naio; • <40% pest groundcover plants and annual grasses; • 10-30% tree tobacco; and • Restrictions on public access to inhibit collection.
Strategies Applied to Achieve Objectives
Identify presence, location, and extent of plant species known to be used by ʻōkaʻi ʻaiea
Monitor plants for evidence of ʻōkaʻi ʻaiea activity (eggs, larvae, adults)
Use IPM techniques to remove pest plants (kiawe, marsh fleabane) around host species such as tree tobacco
Conserve native plants known to host ʻōkaʻi ʻaiea , including lama, hao, ʻohe, ʻālaʻa, ʻaʻaliʻi, wiliwili, maiapilo, and naio
Propagate and plant native host species

Rationale

The ʻōkaʻi ʻaiea moth is currently found in association with topographically diverse landscapes that contain low to moderate levels of nonnative vegetation. Vegetation types that support ʻōkaʻi ʻaiea include dry to mesic shrub land and forest from sea level to moderate elevations (USFWS 2003). Impacts to the moth's habitat from urban and agricultural development, invasion by nonnative plant species, habitat fragmentation and degradation, increased wildfire frequency, ungulates, and direct impacts to the moth from nonnative parasites and insect predators have reduced the species' range.

Most common native plants that the moth use are lama trees, hao, ʻohe, ʻālaʻa trees, ʻaʻaliʻi, wiliwili, and naio. The largest populations of ʻōkaʻi ʻaiea on Maui and Hawaiʻi are associated with trees in the genus *Nothocestrum* (i.e., tree tobacco). The necessary biological requirements of ʻōkaʻi ʻaiea larvae for foraging, sheltering, maturation, and dispersal are the two documented host plant species within the endemic *Nothocestrum* genus (*N. latifolium* and *N. breviflorum*) and the dry and mesic habitats between the elevations of sea level and 5,000 feet and receiving between 10-100 inches of annual precipitation which currently support or historically have supported these plants.
Although only a few ʻōkaʻi ʻaeia have been reported at Keālia Pond, the Refuge has the potential to meet these requirements for both adult and larvae. A closely associated State wetland management area, Kanaha Pond, is identified as such habitat.

Objective 2.2: Expand Refuge boundary to maintain a buffer from upper watershed impacts.
Maintain 75 acres of upland habitat along the Refuge boundary to serve as a buffer from future land use changes and protect wetland habitat from upper watershed impacts (filter pollutants, suspended sediment, pest plant species from streams entering into the wetlands). Expand the Refuge boundary to incorporate additional wetland habitat and upland habitat for the benefit of protected species (ae‘o, ‘alae ke‘oke‘o, honu, honu ‘ea, and seabirds) and wetland integrity.
Strategies Applied to Achieve Objectives
Maintain 75 acres of upland habitat along the Refuge's north boundary with forest, scrub-shrub, and grasses to minimize sedimentation from upper watershed
Acquire 9-34 acres of coastal wetlands at Mā‘alaea Flats from A&B to make the wetland a contiguous property
Acquire kūleana property (approximately 4 ac.) located along the Refuge's southeast boundary
Acquire 5-7 acres of coastal dune habitat as a conservation easement, from Keālia Resort in North Kīhei to the Refuge's western boundary at Mā‘alaea Flats
Evaluate the feasibility of expanding the Refuge's north boundary (5-8 ac.) to incorporate additional upland habitat as buffer around the wetlands
Evaluate the feasibility of acquiring Keālia coastal dunes at Mā‘alaea Flats

Rationale

The north side of the Refuge is comprised of upland vegetation and shrub habitat which provides a buffer and filter for sheet-flow runoff into Keālia Pond (e.g., slows water and allows groundwater seepage, filters sediments and pollutants before entering the vegetated mudflats and open water). This area is dominated by dense stands of pest plant species (e.g., kiawe, ironwood, and koa haole). While native plants are desirable, the existing vegetation provides an adequate buffer to shield endangered waterbird habitats from urban disturbances. The remaining upland forest habitat beyond the Refuge boundary is minimal but will be evaluated for an additional buffer zone for the wetland.

Suspended sediments contained in stream-flows from the upper watershed primarily derive from sugarcane production and urban development and settle in the Refuge wetlands. Acquisition of 9-34 acres beyond the current boundary at Mā‘alaea Flats will effectively encompass the remaining wetland and peripheral buffer of forest/shrub habitat on north side and coastal dunes on the south side. A portion of this area is within the previously-approved Refuge boundary. We have initiated discussions with the land owners for specific land parcels adjacent to Mā‘alaea Flats and the Refuge's southeast boundary and those will be the first priority for acquisition.

2.4.3 Goal 3.

Protect, restore, and manage coastal habitat for the benefit of nesting sea turtles, seabirds, and the integrity of the fragile ecosystem.

Objective 3.1: Restore and maintain coastal strand and dune habitat.
First restore and thereafter maintain 2-3 acres of the coastal strand and dune habitat for the benefit of nesting sea turtles (primarily honu ʻea) and nesting seabirds (ʻuaʻu kani), and also to provide a protective barrier to Māʻalaea Flats. The coastal dune and beach strand habitat will be restored and maintained for the following characteristics: • Patchy distribution of low-growing (2-8 ft.), native woody species (e.g., ʻilima, naupaka kahakai, pilo, wiliwili, naio, hala) as a mosaic; • 30-40% cover of native grasses (e.g., ʻākiʻaki) and herbaceous vegetation (e.g., ʻakulikuli and kīpūkai) on dunes; • <25% of woody pest plant species (e.g., marsh fleabane, kiawe, and koa haole) in coastal strand; • <25% cover of herbaceous pest plant species (e.g., saltbush) and grasses (buffel grass, swollen finger grass); • Manage public use to reduce human disturbance during turtle nesting season; and • Documented predation of no more than 1 seabird nest annually.
Strategies Applied to Achieve Objectives
Continue partnership with A&B with installation and maintenance of recycled-plastic fence along Keālia Beach to prevent erosion of sand dunes by vehicles
Resume Kokua Keālia project to restore native coastal plants to the dunes adjacent to the Boardwalk by 2012
Control predators with live-traps, snap-traps, bait stations, and water level management
Consult with State and/or County coastal engineers to identify climate change impacts and evaluate alternatives to enhancing coastal habitat
Coordinate with adjacent landowners for water source to irrigate plants during establishment phase, if necessary
Propagate native plants (ʻakulikuli, pauhoehoe, ʻākia, naupaka, nanea, ʻōhelo kai) in Refuge greenhouse for outplanting
Install temporary sand fencing to facilitate restoration of impacted dunes
Use appropriate IPM techniques (chemical, mechanical, manual) that will not result in additional erosion to control pest plant species

Rationale

Coastal dune communities are important to several rare and endangered plant and potentially animal species. Coastal dunes are also fragile and easily altered by human activity. Coastal dune and beach strand habitat also provides important foraging and loafing habitat for migratory bird species such as the ʻūlili (wandering tattler), kōlea (Pacific golden plover), hunakai (sanderling), and ʻakekeke (ruddy turnstone). Given the soil texture, relative position to the shoreline, and desirable plants species; the strand provides suitable subterranean burrow habitat for ʻuaʻu kani and ʻaʻo. This coastal habitat is also suitable for ʻīlio-holo-i-ka-uaua pupping and rearing and by honu ʻea and honu for laying eggs and basking.

Restoration of coastal dunes not only promotes habitat quality, it also enhances visitors' experience along the Keālia Coastal Boardwalk. Native species will be planted during the winter season to minimize the need to water during the establishment phase. Planting will not be performed when endangered birds are nesting. The dense vegetative growth of pest plants have provided an effective buffer between the ocean and Māʻalaea Flats therefore, careful planning and scheduling is needed to ensure the integrity and stability of the beach and dunes is not impacted during control and replanting efforts.

This section of the coastal strand and dune system is located at a greater distance from human activity with fewer human impacts. The area is ideal for nesting sea turtles (no headlights or condominium lights) and seabirds, in addition to aeʻo and migratory shorebirds on the mudflats.

2.4.4 Goal 4.

Protect, restore, and maintain Molokini islet habitat for seabird nesting.

Objective 4.1: Restore and manage Molokini for seabirds.
Restore up to 19 acres on Molokini for breeding seabirds, primarily ʻuaʻu kani (wedge-tailed shearwater), and ʻou (Bulwer's petrel) with the following characteristics: • >30% native vegetation; • 50-80% ʻuaʻu kani fledging success; • No nonnative predators; • No public access onto the islet; • Researchers access on islet from April-early November only.
Strategies Applied to Achieve Objectives
Maintain Memorandum of Understanding with DLNR and revise if needed
Finalize Memorandum of Understanding with the U.S. Coast Guard
Establish quarantine protocols for agency access
Continue long-term seabird banding
Propagate and plant native species during nonbreeding season (December-February)
Conduct ʻuaʻu kani breeding bird survey

Rationale

Molokini is in the process to be established as an overlay refuge unit of Keālia Pond NWR. Public access on the island has been limited since the early 1900s due to the sensitivity of burrowing seabird nest sites. Due to this, the seabird habitat is intact and very successful. The potential for native plant restoration is high, even with the access logistics (boat transportation, terrain), because the Refuge has volunteers to propagate plants in the greenhouse and references to historic (1913) and recent botanical surveys are available to replicate native species including: ʻihi, alena, nena, pili grass, paʻu o hiʻiaka, nehe, ʻōhelo kai, ʻakulikuli, ʻilima, and uhaloa.

A cooperative agreement with DLNR is essential to retain the consistency of management efforts, transfer of information, and expertise.

2.4.5 Goal 5.

Gather scientific information in support of adaptive management decisions on the Refuge under Goals 1-4.

Objective 5.1: Conduct inventory, monitoring, and research to document progress and evaluate management strategies to guide management decisions.
Conduct high-priority inventory and monitoring (survey) activities that evaluate resource management and public use activities to facilitate adaptive management. These surveys contribute to the enhancement, protection, use, preservation, and management of wildlife populations and their habitats on- and off-refuge lands. Specifically, they can be used to evaluate achievement of resource management objectives identified in this CCP. These surveys have the following attributes: • Data collection techniques will have zero to minimal animal mortality or disturbance and zero to minimal habitat destruction; • Collect minimum number of samples (i.e., water, soils, vegetative litter, plants, macroinvertebrates, vertebrates) to meet statistical analysis requirements for identification and/or experimentation in order to minimize long-term or cumulative impacts; • Studies will be designed to statistically detect early stages of habitat changes that would minimize long-term or cumulative impacts; • Use proper cleaning of investigator equipment and clothing as well as quarantine methods, where necessary, to minimize the potential spread or introduction of pest species; • Projects will adhere to scientifically defensible protocols for data collection, where available and applicable; and • Annual and cumulative reports will be completed for all inventory, monitoring, and research activities to document results and provide comprehensive analyses.
Inventory, monitoring, and research – **Keālia Pond**
Inventory and monitor bird abundance with monthly census
Monitor breeding ‘alae ke‘oke‘o from December-April for reproductive success
Monitor breeding ae‘o from April-July for reproductive success
Monitor macroinvertebrate densities
Monitor mongoose and rat abundance with tracking tunnel surveys at least every 90 days
Monitor and document predation of waterbirds
Monitor banded ae‘o and ‘alae ke‘oke‘o
Monitor midge larvae by core sampling during high water conditions (December-April)
Monitor water quantity (surface water and groundwater)
Monitor water quality (abiotic parameters: pH, temperature, salinity, conductivity, turbidity, dissolved oxygen)
Maintain and monitor weather station
Monitor fish abundance
Monitor vegetation response to IPM techniques
Monitor waterbird response to IPM strategies by sampling treated and untreated habitat
Conduct study to determine the most effective IPM strategies to control California bulrush and other pest species
Research to determine invertebrate composition and relative abundance in vegetated mudflats and open water habitats
Determine invertebrate composition and relative abundance at Mā‘alaea Flats

Inventory, monitoring, and research – **Keālia Pond** (continued)
Monitor human activities along the coastal mudflats and dunes for potential effects that jeopardize the integrity of the area
Periodically (once per 10 years) collect/analyze soil samples for contaminants, including streamflow entry areas
Identify presence, location, and extent of plant species known to be used by ‘ōka‘i ‘aiea
Monitor plants for evidence of ‘ōka‘i ‘aiea activity (eggs, larvae, adults)
Conduct research on ‘alae ke‘oke‘o intra- and inter-island dispersal patterns
Conduct study to identify alternative methods to control tilapia (reduce catch per unit effort)
Analyze fish to ensure they are safe for human consumption in potential fishing program (through Department of Health (DOH))
Implement a pilot program to evaluate the impacts of a fishing program at the Main Pond
Inventory, monitoring, and research – **Molokini**
Contract a complete archaeological and cultural investigation for Molokini when acquired as overlay refuge
Determine the breeding population of ‘ou on Molokini
Monitor active nesting attempts by ‘ua‘u kani and ‘ou (February-March)
Monitor ‘ou breeding (March)
Monitor ‘ua‘u kani nest success and band chicks (October)
Monitor and document seabird predation
Conduct a vegetation survey for composition and relative abundance

Rationale

The Administration Act requires us to ‘‘… monitor the status and trends of fish, wildlife, and plants in each Refuge.’’ Surveys are used primarily to evaluate resource response to assess progress toward achieving Refuge management objectives derived from the Refuge System mission, Refuge purpose, and maintenance of BIDEH. Determining resource status and evaluating progress toward achieving objectives is essential to implementing adaptive management on DOI lands as required by policy (522 DM 1). Surveys will provide the best available scientific information to promote transparent decisionmaking processes for resource management over time on Refuge lands.

Inventory, monitoring, and research studies are essential to high-quality habitat and population management. Conducting censuses for endangered waterbirds and compiling data is critical to evaluate population status and measure progress towards goals. Similarly, other populations, habitat conditions and habitat management practices, including restoration efforts must be monitored to evaluate their status and effectiveness. Population trends can be used to evaluate habitat effectiveness and guide management actions. When Molokini is acquired as an overlay refuge, a cultural and archeological investigation will be contracted to obtain information about the human history of the islet. It will seek to answer various questions about the pre-contact activities of Native Hawaiians and their interactions with the natural resources surrounding the Islet.

Refuges must collect site-specific information and conduct defensible research to provide information for devising, guiding, and adapting management practices. Applied research on the Refuge will help address management issues and questions, in theory, will result in improved management decisions on both the Refuge and on a regional basis. The Refuge has always maintained a close working relationship with State and local agencies, and universities to advance the knowledge base of a variety of habitats and plant and wildlife species. We have been monitoring environmental parameters (water, weather), vegetation, waterbirds, and invertebrates, to varying degrees, for the past 10 or more years and will continue to maintain consistent methodology in data collection. These data have provided baseline information for management planning to optimize habitat for endangered waterbirds, address nuisance issues, and evaluate adaptive management strategies.

The Refuge's location at the base of the watershed makes the wetlands vulnerable to impacts from upper land use activities. Periodic analyses of water and soils are a preventative measure to identify contaminants and trace elements, and changes in what is entering into the Refuge property. Some elements attach to soils but are not found in water, and vice versa; therefore, the need to sample both in order to gain a broader picture of upper watershed impacts. Although soils can retain contaminants over a period of time, water samples detect only one point in time but if collected during similar conditions (high water flow from streams), the data provides a sufficient index for long-term monitoring.

Opening the Refuge to a seasonal fishing program is in a discussion phase. A fishing program would primarily be a management activity but can be an opportunity to involve the public, with the stipulation that it does not negatively impact the endangered Hawaiian waterbirds. Time and additional staff would be needed to plan, complete policy requirements, and investigate logistics of operating a fishing program.

Objective 5.2: Conduct scientific assessments.
Conduct scientific assessments to provide baseline information to expand knowledge regarding the status of Refuge resources to better inform resource management decisions. These scientific assessments will contribute to the development of Refuge resource objectives and they will also be used to facilitate habitat restoration through selection of appropriate habitat management strategies based upon site-specific conditions. These assessments have the following attributes: • Utilize accepted standards, where available, for completion of assessments; and • Scale and accuracy of assessments are appropriate for development and implementation of Refuge habitat and wildlife management actions.
Strategies Applied to Achieve Objectives
Based on the topography of the Main Pond, evaluate the need to periodically excavate and reconfigure elevations to facilitate water management (flooding and dewatering capabilities)
Evaluate feasibility of using a pump at the pond outlet for water control (lowering water level)
Identify the quantity of water from the Pōhākea, Pale‘a‘ahu, and Waikapū streams that reach the Refuge
Conduct soil investigation to identify composition and profile and use data and hydrological processes information to reconfigure topography in order to retain water for foraging and nesting ae‘o
Evaluate the topography of Mā‘alaea Flats and identify methods to separate from outlet (berm and possible water control structure)
Collect and analyze soil (composition, profile) at Mā‘alaea Flats
Evaluate SLAMM Analyses for climate change planning
Conduct a biological assessment on Molokini (nonnative amphibians, invertebrates)

Rationale

Appropriate environmental assessments are necessary to determine resource status, promote learning, and evaluate progress toward achieving objectives whenever using adaptive management. These assessments will provide fundamental information about biotic (e.g., vegetation data layer) as well as abiotic processes and conditions (e.g., soils, topography) that are necessary to ensure that implementation of on-the-ground resource management achieve resource management objectives identified under Goals 1-4.

Three streams drain from 56 square miles of the West Maui Mountain watershed and 1 additional stream drains a portion of the Haleakalā watershed. These stream-flows are infrequent, unpredictable, and uncontrolled. Preliminary data exists on the amount of surface water these streams deliver, however, a comprehensive hydrological assessment is needed to determine the amount (acre-feet) of stream flow that is needed to maintain water level at a suitable depth to manage for aeʻo and ʻalae keʻokeʻo throughout the year.

Changes in the upper watershed can have potential impacts to the Refuge in terms of water quality and quantity; therefore, a more accurate assessment on these parameters is needed to ensure water is available for endangered and migratory bird species. Water and sediment samples from streams were analyzed in 2003 and provide a baseline for future monitoring of water quality. The function as a settling basin has created the endangered waterbird habitat for which the Refuge was established and thus, should be retained as much as possible. If streamflow subsides in the future, the Refuge will need to pump water from the brackish water wells throughout the year to replicate natural conditions. This would not only be costly, but also difficult to achieve for such a large wetland.

Māʻalaea Flats is partially flooded with water from the outlet when the Main Pond is full. This hydrological connection means that when the sandplug is breached (naturally or manually) water in the flats drains as well. This has a negative impact on waterbird foraging and nesting habitat on the flats. Planning, including evaluation of the elevational gradient and a new soil survey, is needed to identify methods to hold water on the flats and maintain the level for aeʻo foraging and nesting.

Molokini will be a new addition to the Refuge System and, although the islet is managed by DLNR, their activities are limited to monitoring ʻuaʻu kani nesting. A biological and vegetation assessment is needed prior to restoration planning initiation. There is a high potential to re-establish native plants and the capability of replicating the plant composition recorded in 1913. An inventory of invertebrates is needed to ensure nonnative species (e.g., big-headed ants and yellow crazy ants) will not negatively impact chick survival.

2.4.6 Goal 6.

Through quality wildlife-dependent recreation and learning opportunities, visitors understand and appreciate the unique wildlife and habitats of Keālia Pond NWR.

Objective 6.1: Provide opportunities for wildlife observation and photography.
Provide visitors with the opportunity for self-guided wildlife observation and photography to increase their knowledge and appreciation for wetland ecosystems and endangered species. • Focus on wetland ecology and the endangered waterbirds that rely upon these wetlands; • Provide viewing opportunities; and • Directly link opportunities to EE and interpretation programs.
Strategies Applied to Achieve Objectives
Maintain safe access on all trails and Keālia Coastal Boardwalk by performing periodic inspections and repairs
Install trail counter
Annually evaluate and implement a closure of the Keālia Coastal Boardwalk during ae‘o nesting season, if necessary
Monitor waterbird response to visitor use to minimize potential impacts to the species and adapt visitor use patterns
Complete the Complex brochure and bird species checklist
Coordinate with Hawai‘I Department of Transportation (HDOT) to establish a bus stop at the coastal Boardwalk between Mā‘alaea and Kīhei
Continue to accommodate recreational photographers visiting the Refuge and support existing agreements
Open Kanuimanu Ponds to the public on weekends
Develop and implement a Visitor Services Plan (VSP) by 2017
Evaluate the need, location, and logistics of photo blinds on/adjacent to Kanuimanu Pond levees
Evaluate the potential for fee program on the Refuge

Rationale

The Keālia Coastal Boardwalk is open year-round for visitors, but tours are only provided upon request. The parking area will only accommodate 12 vehicles, 2 disabled parking, and 2 buses; therefore, it may be advantageous to have the Boardwalk as one of the stops for public transportation when traveling from west (Lahaina) to east (Kīhei). As long as the period between stops is adequate, it may be a way to reach more people given the limited parking capacity.

Keālia Pond NWR has been more visible to the public since the opening of the Boardwalk. Visitor use will increase significantly when the new HQ/VC is opened to the public. The Refuge relies on static displays for self-guided visitation; however, additional opportunities for visitors and educational groups are expected in the future. The step-down VSP is intended to enhance visitors' knowledge of the value of wetlands, offshore islands and the wildlife that depend on their existence, and Native Hawaiian traditional uses.

Keālia Pond NWR hosts hundreds of migratory waterfowl and shorebirds during winter months and receives most of its visitors during that same period. With increased water control capabilities, the Refuge will have some flexibility with attracting wetland birds into accessible areas for wildlife observation. During the nesting seasons for endangered ‘alae ke‘oke’o (December-May) and ae‘o (April-August), continuous evaluation of waterbird use is conducted so Refuge staff can allow access to visitors where birds remain undisturbed. Accessibility onto Kanuimanu Pond levees gives photographers an opportunity to photograph wetland bird species. The size of the Main Pond and background with the West Maui Mountains makes a scenic shot, particularly in the morning when the sun’s glare is low and the trade-winds are light.

Recreational photographers have provided the Refuge with bird photographs for brochures by means of SUP and the photographer’s approval to use his/her photographs. This has worked well in the past and benefits the Refuge. Recreational photographers can access general public use areas and are usually not identified upon check-in at the visitor contact station (HQ). Increased visitation will require more law enforcement presence to protect wildlife and minimize vandalism. As an example, the Keālia Coastal Boardwalk is the target of graffiti, destruction of property, trash dumping, and camping. Illegal access to areas not open to the public can have detrimental impacts on waterbirds and vegetation (e.g., additional introduction of pest species).

Public access onto Molokini is prohibited due to the sensitivity and geology of the islet. There are, however, tour boat companies that provide snorkeling/diving opportunities in the surrounding waters outside our jurisdiction. Access will be given to Federal and State biologists performing Refuge duties. The Refuge brochure will mention Molokini as part of the Refuge System. Special Use Permits to access other areas are issued on a case-by-case basis if compatible.

Objective 6.2: Evaluate feasibility of a recreational fishing program.
Investigate, research, and evaluate the compatibility of a seasonal fishing program as a management tool for controlling pest species (tilapia) by 2016.
Strategies Applied to Achieve Objectives
As part of the VSP, determine the compatibility of fishing at Keālia Pond
Prepare materials related to fish ecology in Keālia Pond, (i.e., fish identification, biology, and impacts of pest species)
Evaluate whether or not a fishing program is an effective management tool for removing biomass
Analyze fish for contaminants and human consumption (DOH)
Define the Refuge’s role and participation in the State Fishing Education Program

Rationale

The Refuge hosted the State Fishing Education Program (an annual public education event) from 1997-2002 at Kanuimanu Ponds. The intent of this objective is to evaluate the need (compared with other management strategies to remove tilapia), compatibility, and feasibility of conducting a controlled public fishing program. Other aspects that need to be considered are law enforcement, safety, operating requirements (staffing), and outreach to the public. For the latter, the potential for illegal fishing during “off-season” is a greater concern. A fishing program would primarily be a management activity but can be an opportunity to involve the public, with the stipulation that it does not negatively impact the endangered Hawaiian waterbirds and migratory birds. Time and staff will be needed to plan, complete policy requirements, and coordinate logistics of operating a fishing program.

Objective 6.3: Provide interpretation and outreach programs.
Expand the Refuge's interpretation and outreach programs to foster appreciation and stewardship for wetland and cultural resources. Provide interpretive tours for visitors, birding groups, and other educational groups.
Strategies Applied to Achieve Objectives
Maintain high-quality, updated displays and signs for Keālia Coastal Boardwalk and trails to interpret the ecology, wildlife, and identification of wetland habitats and associated watersheds
Provide public presentations and interpretive tours on wetland ecology and wildlife, coastal habitats, and cultural history
Keep the Refuge Website updated on available opportunities and current projects
Provide public presentations and interpretive tours on wetland ecology and wildlife, coastal habitats, and cultural history
Prepare a pamphlet on Molokini for distribution to tour boat operators/companies
Incorporate Refuge opportunities and information into the Maui Visitors' Bureau products
Participate in off-site programs including Earth Day, beach cleanups, watershed events, etc.
Provide information on the Refuge System to the public

Rationale

Interpretation is intended to create emotional and intellectual connections between the audience and the resource as well as provide opportunities for visitors to make their own connections to the resource. Outreach is two-way communication between the Service and the public to promote involvement with the Refuge, and influence attitudes and actions, with the goal of improving joint stewardship of our natural resources. We rely heavily on self-guided opportunities for visitors. This is especially true for the Keālia Coastal Boardwalk which is approximately 2 miles from the HQ/VC.

Offering special talks at the Boardwalk by volunteers will enhance visitors' knowledge and understanding and encourage visitors to return. Volunteers may also assist with interpretation at Kanuimanu Ponds, particularly for school groups or to lead groups of birdwatchers. The new Keālia Pond HQ/VC is designed to prepare visitors for and enhance their experience on the Refuge.

Molokini is not accessible due to the sensitivity of the habitat and safety; however, informative materials and interpretation of the property will be given to Refuge visitors, tour boat operators, and others to develop awareness for seabird habitats.

We will increase outreach to direct more attention to the Refuge as an outdoor learning experience. Specialized tours could be developed to meet the needs of the public. This will increase the Refuge's visibility as part of the community where people can explore the natural resources and gain a sense of stewardship in becoming involved with Refuge programs.

Objective 6.4: Expand volunteer opportunities and partnerships.
Expand the Refuge's volunteer program to foster appreciation and stewardship for the wetland resources and assist with Refuge activities and facilities. Participate in partnerships and other collaborative efforts that provide ecosystem-based opportunities to facilitate Refuge objectives.
Strategies Applied to Achieve Objectives
Continue to support volunteerism through partnerships and community groups
Post available opportunities and current projects on Website
Continue partnerships with community organizations, County, State, and Federal agencies related to watersheds, wetland and coastal restoration, etc.
Establish a Friends group to promote and assist with the Refuge's purpose and mission
Incorporate Refuge volunteer opportunities into State and County volunteer programs and Maui Visitors' Bureau products
Recruit and train volunteers to assist with visitors and school groups, particularly during peak hours
Seek volunteers to offer special programs at the kiosks of the Keālia Coastal Boardwalk
Recruit and train volunteers to assist in the Refuge VC and provide introductory information to visitors

Rationale

Maui residents have a strong volunteer ethic and they are willing to help out if they know what is available to them. The Refuge's volunteer opportunities need to be advertised and the Refuge will continue to participate in community events. With additional staffing, we will put more effort into recruiting volunteers for all programs (biological, habitat, visitor services, EE, and interpretation).

The value of the coastal dunes to sea turtles and native plants is interpreted in Boardwalk panels. The coastal dune restoration project involves Refuge volunteers and the community and helps to instill a sense of stewardship of the natural resources. Volunteers will be recruited and trained to operate the Keālia Pond VC and provide a point of contact to visitors at the Keālia Coastal Boardwalk. Operation of the new VC is highly dependent on a robust volunteer program given the current lack of permanent resources with which to staff it.

Establishment of a Friends group is a high priority for operating the visitor center and assistance with other programs on- and off-Refuge (sea turtle monitoring program or Dawn Patrol). Volunteers assisting with propagation and planting native plants will also be working in the greenhouse to propagate plants specifically for restoring habitat on Molokini.

2.4.7 Goal 7.

Provide students and teachers high-quality hands-on EE programs that foster a connection with nature and the Refuge.

Objective 7.1: Provide a high-quality EE program.
Expand EE programs that connect children with nature and focus on the functions of wetlands and coastal ecosystems as part of watersheds. Quality curriculum includes: • Supports national and State Department of Education (DOE) standards; • Provides interdisciplinary opportunities that link natural resources through all subject areas; • Incorporates the Refuge System mission and Refuge purpose; • Involves the local community, volunteers, future Friends group, and partners; • Involves hands-on learning opportunities and stewardship components; • Incorporates current conservation issues and concerns; and • Located both on- and off-Refuge.
Strategies Applied to Achieve Objectives
Issue SUPs to EE organizations to conduct programs on the Refuge
Participate in teachers' workshops
Design/produce a pamphlet for Boardwalk interpretive panels
Develop site-specific curriculum materials for educators
Provide formal learning experiences on the Refuge that support teachers' curricula and DOE requirements
Establish and train volunteer docents to greet students and oversee EE programs at the Keālia Coastal Boardwalk

Rationale

Keālia Pond NWR is one of three wetlands on Maui that provides hands-on opportunities for school children. Our proximity to schools and year-round access provides teachers, students, and other local education organizations an opportunity to study natural resource management and conservation issues in an outdoor setting. Hands-on experiences and exposure to wildlife career opportunities can help direct students into natural resource disciplines. Teachers may not have the time and resources to compile pre- and post-visit materials; therefore, the Refuge can provide packets geared for different age groups for teachers to incorporate the visit into their curriculum.

We rely on partner organizations to provide formal EE opportunities to students by establishing SUPs each year. Organizations include Hawai‘i Nature Center (conducting the wetland curriculum at the Refuge for 14 years), Maui Digital Bus (for 8 years), and individual teachers on their own. The new visitor services manager will be responsible for the EE program.

Refuge-specific EE programs should be developed for school groups. Development of all programs will include pre- and post-visit materials for the teachers use. Teachers workshops will be held annually to ensure DOE requirements are met. Volunteers will be recruited and trained to assist with the program. All EE programs will have a stewardship component where students will participate in a wetland restoration project. Currently, this includes hand removal of pest plants and outplanting native plants. Cultural resources, which provide data and places to educate about changes in wildlife populations and the landscapes they inhabit, as well as cultural knowledge about the traditional uses of plants and animals, will be incorporated into EE curricula and programs.

Programs for high school students included Baldwin High School (built nest platforms), Kīhei Charter School (comparison of pest plant controls), Lahainaluna High School (GIS), and Maui High School (GIS). Hands-on opportunities give students a chance to experience a biologist vocation and also provide another tool for investigating alternative management methods for the Refuge. Other opportunities will likely become apparent as the Refuge implements programs and receives feedback from teachers and educators.

Objective 7.2: Provide high-quality internship opportunities.
Expand the Refuge internship program for Maui's students. Interns will be introduced to natural resource careers through hands-on work with, and training by, natural resource professionals to help develop a new generation of enthused and effective conservationists and ecologists.
Strategies Applied to Achieve Objectives
Collaborate with the University of Hawai'i campuses (Maui, Hilo) to host interns receiving credit hours (i.e., Pacific Internship Programs for Exploring Science)
Develop an internship program for Kamehameha Schools in their Natural Resources Academy
Host AmeriCorps and Youth Conservation Corps students
Develop an internship program for public schools on Maui
Host Mainland and international interns
Explore the potential for housing on- or off-site

Rationale

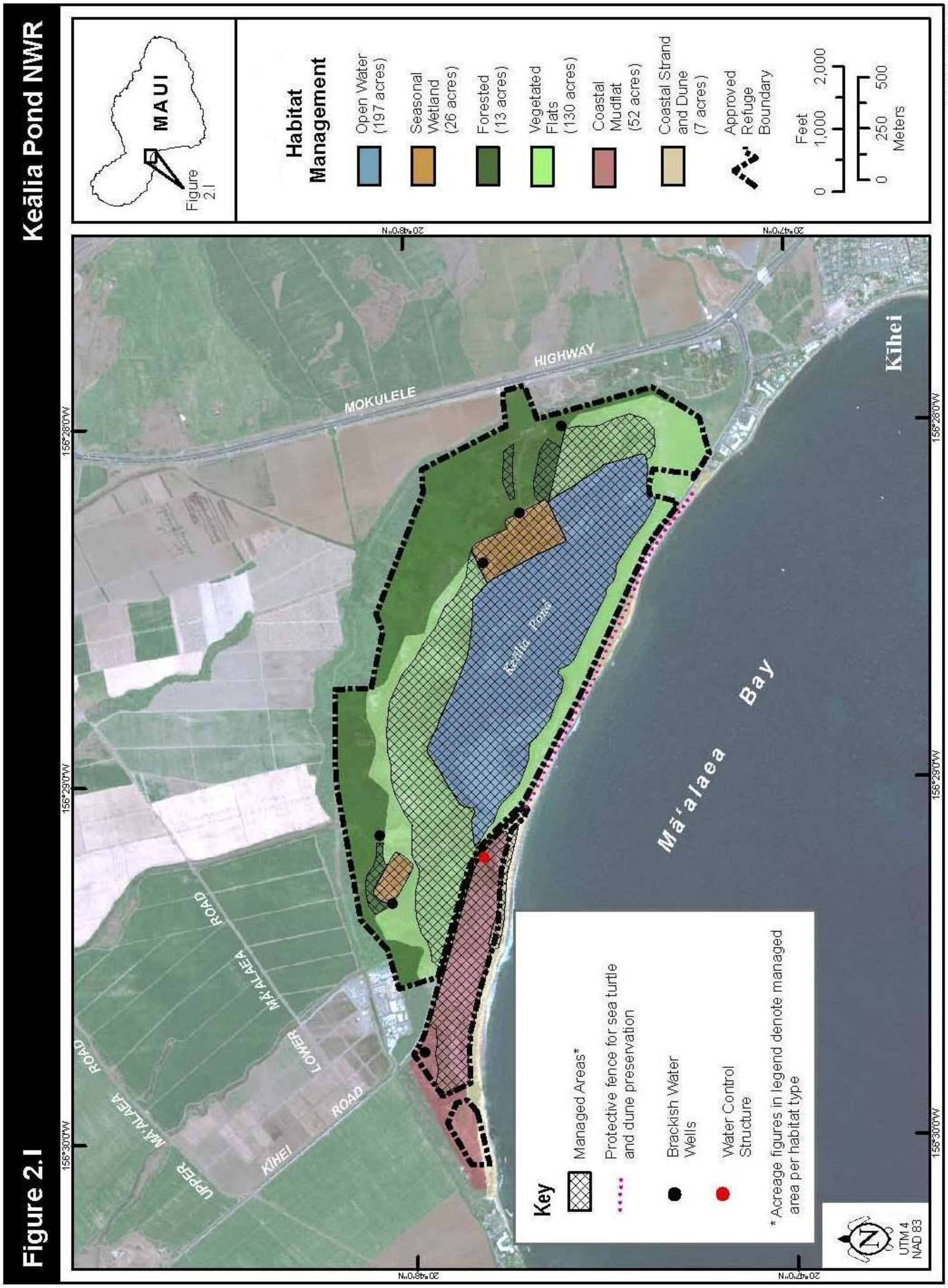
The Pacific Internship Programs for Exploring Science (PIPES) operates as an umbrella program for internship opportunities. Each summer all the PIPES student interns participate in a 4-day orientation and a 10-week internship program focusing on tropical ecology, evolution, natural resources management, and environmental education and outreach. Interns work on mentored research projects with mentors from university, Federal, State, and Counties agencies, as well as non-profit organizations.

The DOI is engaging young people across the country in conservation and energy efficiency projects on America's public lands, to inspire and provide career pathways in natural resource occupations and related sciences, and to become better educated about the Nation's ecosystems. Establishing an internship with Kamehameha Schools will benefit high school students but also recruit Native Hawaiians into environmental conservation fields. Interns play a vital role in helping the Refuge System in preserving a national network of lands and waters for the conservation and management of the fish, wildlife, and plants of the United States for the benefit of present and future generations. Most internships last between 12-20 weeks and offer opportunities to:

- Gain valuable hands-on natural resource management experience;
- Earn college credit; and
- Gain a working knowledge of the Service useful for future career decisions.

The Youth Conservation Corps (YCC) is a program for young adults who are between the ages of 15-18; where projects are conducted for 8-10 weeks during the summer. Environmental awareness is an integral aspect of the YCC program, with projects embracing both work and environmental learning goals. The participants spend most of their time in the outdoors. All participants are expected to gain an understanding and appreciation of the Nation's environment and heritage equal to 1 full academic year of study.

Figure 2.1 –Habitat Management



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Keālia Pond and West Maui Mountains © Tony Temple

Chapter 3. Physical Environment

3.1 Refuge Introduction

Keālia Pond is adjacent to Māʻalaea Bay along the south-central part of the Island of Maui, Hawaiʻi. The Refuge is separated from the Bay on the south side by a narrow band of coastal dunes. Located within the isthmus bounded between the West Maui Mountains and Haleakalā, the Refuge is exposed to the regularly occurring trade-winds (trades) that come from the northeast and subject to the less frequent Kona (southerly) winds. Although the isthmus is less than 12 miles in length (north-south), the Refuge lies within a dry area compared to the wetter north shore.

The Refuge wetlands were formed by the combined natural action of the wind, waves, and erosion and act as a sump within the floodplain for the Waikapū watershed that drains approximately 56 square miles. This results in unique climatological and hydrological conditions that direct management capabilities.

Molokini is an eroded remnant of a tuff cone, arising from Haleakalā's southwest rift in the Alalākeiki Channel about 3 miles west of Puʻu Olaʻi on Maui's south shore. The islet reaches a maximum elevation of 165 feet. The outer sea cliffs are pockmarked with weathered holes and shelves, and an average slope of about 73 degrees. The inner walls are not as steep with a 32-degree slope. The inner walls terminate in vertical sea cliffs above a wave cut terrace at the water's edge. The ridgeline distance between the islet's 2 northern points is nearly 3,200 linear feet and the total area is about 19 acres. Submerged remnants of the cone extend seaward in an arc from the northwest point.

3.2 Climate

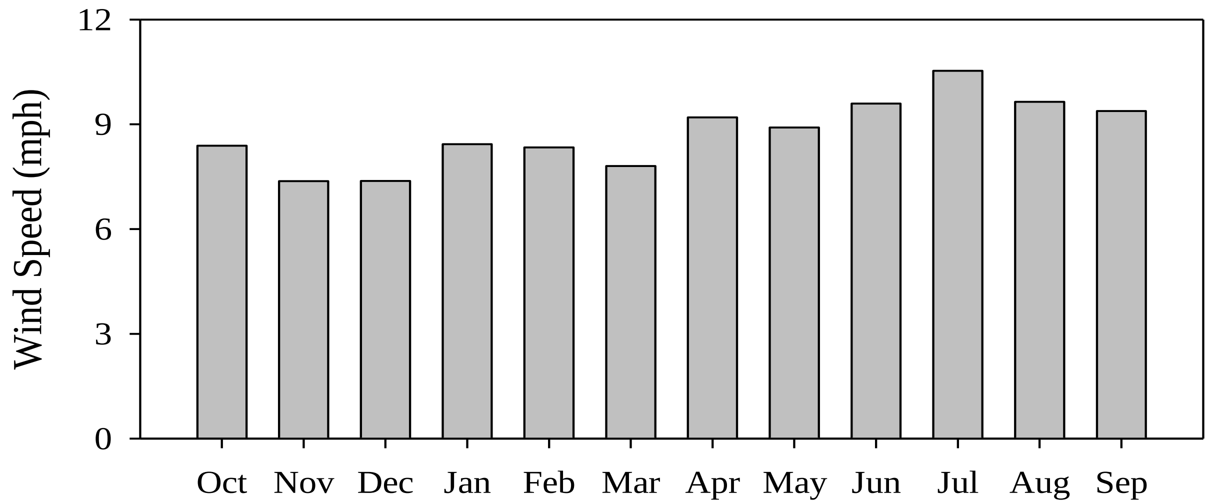
Located 2,400 miles southwest of the nearest continental landmass, the Hawaiian Islands are the most isolated archipelago in the world. The climate of Hawai‘i is generally constant throughout the year, with only minor periods of diurnal and seasonal variability. During the summer season, temperatures are slightly warmer, conditions are drier, and trades originate from the northeast. The winter season is characterized by cooler temperatures, higher precipitation, and gustier winds. Native Hawaiians recognized only 2 seasons of 6-months each: a warm season with drier weather and more reliable trades and a cooler wetter season with more storms and fewer trades.

Modern analysis of climate records indicates the soundness of the Hawaiian system of seasons. The wet season is now considered to extend 7 months October-April and the dry season May-September. During the wet season, there may be two or as many as seven major storm events a year. Such storms typically bring heavy rains and large stream runoff into the Pond and are often accompanied by strong Kona winds that blow from the south. Rainfall and stream runoff are rare during the May-September dry season.

One of the most noticeable features in Hawai‘i's climate is the persistent trades. The north Pacific anticyclone (high pressure area) moves south to north seasonally with the sun, and reaches its northernmost position at summer half-year. This position brings the center of the trades across Hawai‘i during May-September. Trades are prevalent 80-95 percent of the time during this period. During October-April, the Pacific High moves south of the islands. Trades still blow across the island much of this period, but with less frequency (50-80 percent of the time in terms of monthly averages).

Maui's topography has a profound effect on wind. The funneling effect of Haleakalā and the West Maui Mountains tends to accelerate the normal trades through the isthmus of the island. Keālia Pond, being located at the south end of the isthmus, is exceptionally windy, even for Hawai‘i, because of this effect. Data on wind speed and direction at Keālia Pond have been collected regularly since 2002, shown in Figure 3.1. Wind speeds are greatest in the summer months with July being the windiest. Wind is generally less consistent during the winter months, although there are some very windy days associated with Kona winds that blow from the south instead of the north. The timing and seasonality of winds at Keālia Pond have some important physical and biological implications that will be discussed later.

Figure 3.1. Average monthly wind speeds at Keālia Pond NWR, 2002-2006.

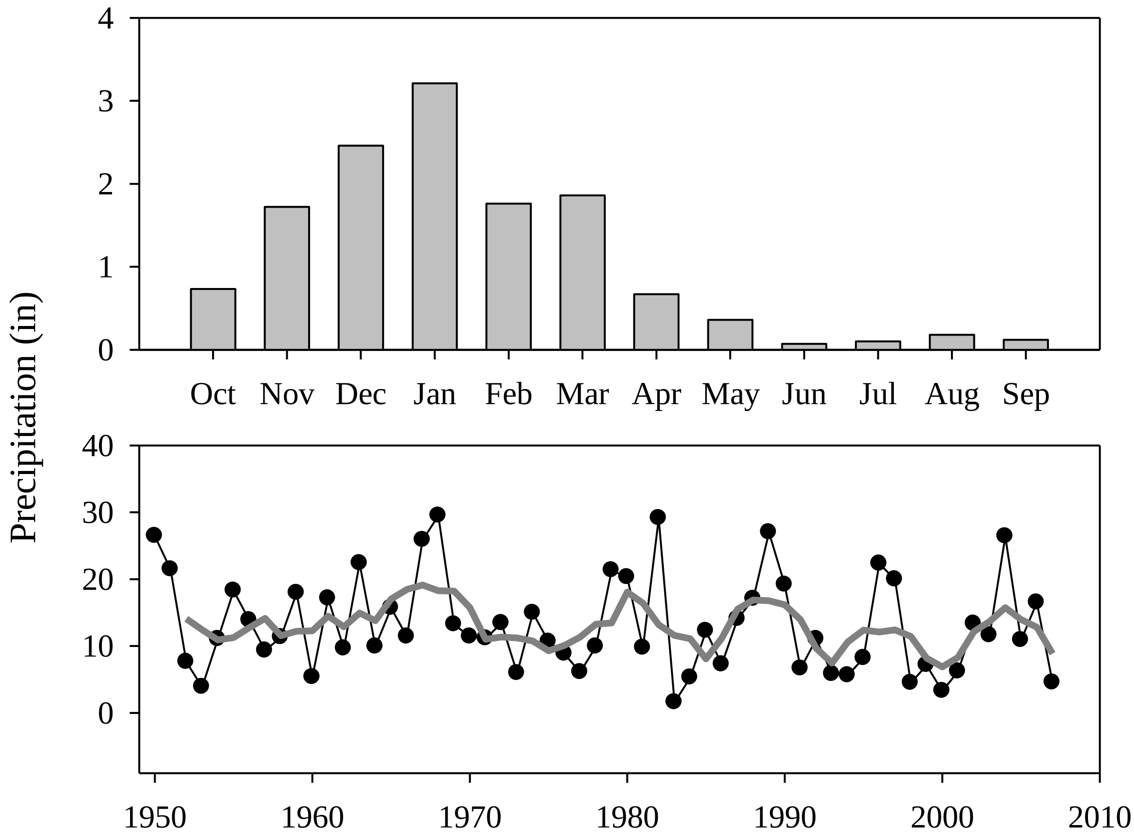


The Hawaiian Islands are broadly separated into two physiographic zones: windward and leeward, depending on the exposure to trades and associated precipitation. Keālia Pond is located in the leeward zone of the island. As a result of this and the rainshadow effect from Haleakalā, the area around Keālia Pond is arid. Tributary streams to Keālia Pond drain 56 square miles of the West Maui Mountains. Rainfall data at the Refuge has only been collected since 2000. However, there are four National Weather Service cooperative weather stations near the Refuge with rainfall data from 1950 to the present. Of the four stations, monthly rainfall at Kīhei (Station 514489) appears most similar to that measured at the Refuge, based on the period of overlapping records.

Approximately 92 percent of the total annual rainfall at the Kīhei station falls October-April. The period May-September is typically quite dry and windy in the area. Annual precipitation at the Kīhei station for the period 1950-2010 has averaged about 13 inches per year but has varied greatly from a minimum of 3 in/yr to a maximum of 30 in/yr. There has been slightly less precipitation and greater variability during the last half of the 57-year record. Figure 3.2 shows the average monthly precipitation at Kīhei from 1950-2010.

The climate is usually warm and pleasant year-round with average January daytime temperatures around 81° F and July/August averaging about 88° F. Evening lows in January average about 63° F with the summer evening lows averaging 69° F. While there is very little variation in annual temperature there appears to be an increase in the late 1970s which may correspond to the widely-recognized shift in the Pacific Decadal Oscillation (PDO) from negative to positive phase in 1977.

Figure 3.2. Annual cycle of average monthly precipitation (top) and total annual precipitation with 5-year moving average (bottom) at Kīhei, HI, 1950-2008.



3.2.1 Global Climate Changes and Projections

Global climate change is supported by a continuously growing body of unequivocal scientific evidence. The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body organized by the World Meteorological Organization and the United Nations Environment Programme in order to assess the causes, impacts, and response strategies to changes in climatic conditions. According to the Fourth Assessment Report by the IPCC, global temperatures on the Earth's surface have increased by 1.33° F over the last 100 years. This warming trend has accelerated within the last 50 years, increasing by 0.23° F each decade. Global ocean temperatures to a depth of almost 2,300-feet have also increased, rising by 0.18° F 1961-2003 (Solomon et al. 2007).

Global forecasting models offer a variety of predictions based on different emission scenarios. The U.S. Government agency Overseas Private Investment Corporation (OPIC) suggests that a further increase in greenhouse gas (GHG) emissions could double atmospheric concentrations of CO_2 by 2060 and subsequently increase temperatures by as much as 2-6.5° F over the next century. Recent model experiments by the IPCC show that if GHG and other emissions remain at 2000 levels, a further global average temperature warming of about 0.18° F per decade is expected. Sea level rise (SLR) is expected to accelerate by two to five times the current rates due to both ocean thermal expansion and the melting of glaciers and polar ice caps. Recent modeling projects sea level to rise 0.59-1.93 feet by the end of the 21st century. These changes may lead to more severe weather, shifts in ocean circulation (currents, upwelling), as well as adverse impacts to economies and human health. The extent and ultimate impact these changes will have on Earth's environment remains under considerable debate (OPIC 2000, Buddemeier et al. 2004, Solomon et al. 2007, IPCC 2007).

3.2.2 Climate Change in Hawaiʻi

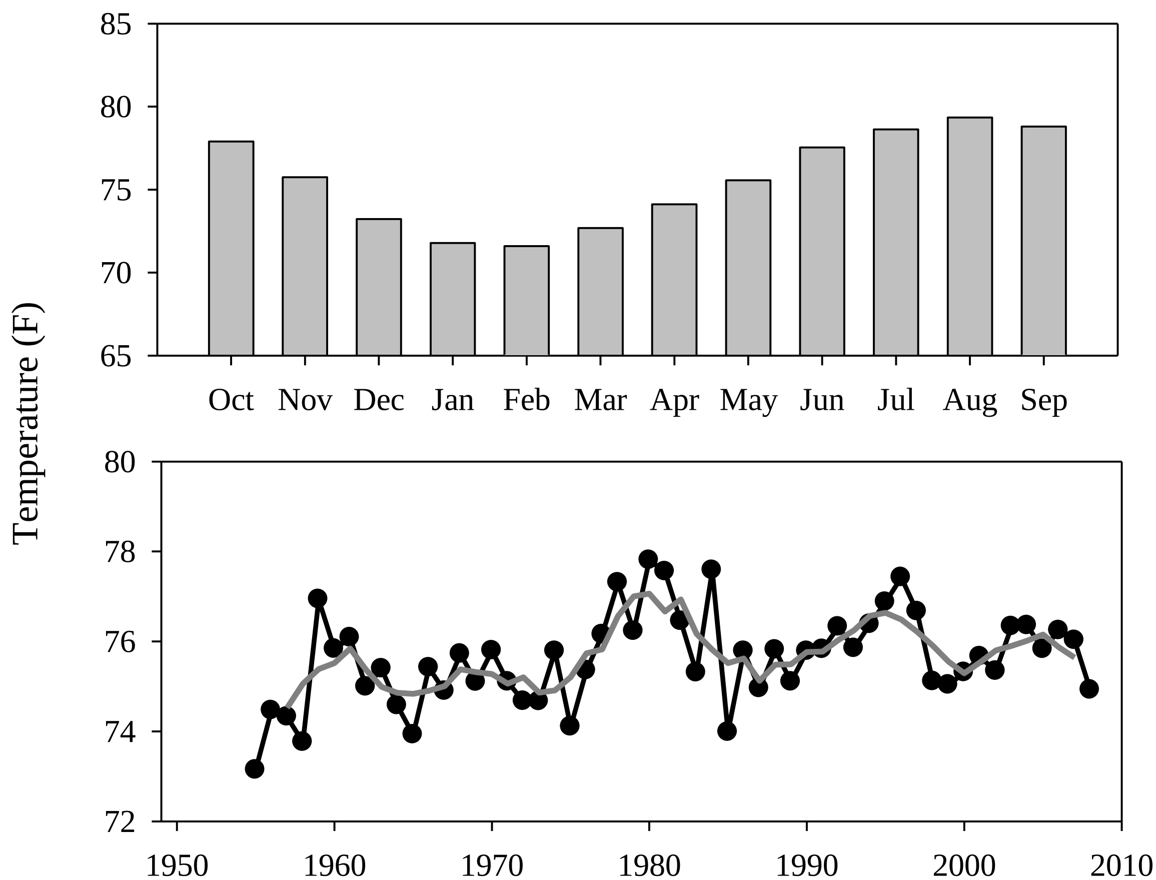
Climate change impacts expected for Hawaiʻi are warmer temperatures (air and ocean), more severe droughts and floods, and a rise in sea levels. Giambelluca et al. (2008) reported that air temperatures in Hawaiʻi have increased at a rate of 0.3° F/decade since 1975, which is comparable to the rate of increase in global temperatures. Temperature observations at the Mauna Loa Observatory 1977-2006 indicate a warming trend of 0.4° F/decade. Rainfall intensity has increased 12 percent in Hawaiʻi between 1958-2006 but total rainfall has decreased about 15 percent over the last 20 years. These changes have and will continue to affect biologic and water resources on Maui and the other islands (Mimura et al. 2007, Oki 2004, Chu and Chen 2005, Turcotte and Malamud 2009, Fletcher 2010).

The Service is supporting the development of regional Landscape Conservation Cooperatives that will integrate local climate models with models of climate-change responses by species, habitats, and ecosystems. The local version of these Landscape Conservation Cooperatives is the Pacific Islands Climate Change Cooperative (PICCC), headquartered in Honolulu, but working across the Pacific. The PICCC was established in 2010 to assist those who manage native species, island ecosystems, and key cultural resources in adapting their management to climate change for the continuing benefit of the people of the Pacific Islands. The PICCC steering committee consists of more than 25 Federal, State, private, indigenous, and nongovernmental conservation organizations and academic institutions, forming a cooperative partnership that determines the overall organizational vision, mission, and goals.

Similar to the rest of the world, temperatures in Hawaiʻi are rising. The EPA has estimated that the average surface temperature in Honolulu has increased by 4.4° F over the last century. In particular, nighttime temperatures are notably warmer, increasing by about 0.5° F per decade over the past 30 years. Recent studies have shown that this rising average night temperature is greater at high elevation sites than lower areas. Sea surface temperature near the islands has been increasing recently, showing a 0.72° F rise from 1957-1987. Sea level around the Hawaiian Islands is rising by 6-14 inches per century. Over the last 90 years, precipitation has also decreased approximately 20 percent (EPA 1998, Arakawa 2008, Giambelluca 2008).

Global and regional predictive climate simulations may not capture unique and important features of the Hawaiian climate. Existing large-scale models show large variability and uncertainty for the Hawaiian Islands; thus, applying these models to predict local conditions must be done with caution until more fine-scaled models are developed. Models from the IPCC and United Kingdom Hadley Centre's climate model suggested that by 2100 annual temperatures in Hawaiʻi could increase by 3° F, with a slightly higher increase in fall. Other estimates predict a 5-9° F rise by the end of the 21st century. Future changes in precipitation are uncertain, dependent largely on shifts in El Niño/La Niña events. Some predictions forecast an additional rise of 17-25 inches by 2100, while others suggested decreased precipitation. The trend in precipitation at the Refuge, shown in Figure 3.3, has been decreasing since 1950. The temperatures, as shown in Figure 3.3, have been on a slight rise since 1950 (TenBruggencate 2007, Timm 2008).

Figure 3.3. Annual cycle of average monthly temperature (top) and mean annual temperature with 5-year moving average (bottom) at Kahului airport, 1955 -2008.



Long-term climate change may be increasing temperature and reducing precipitation, groundwater recharge, and streamflow in Hawai‘i for extended periods. Oki (2004) looked at long-term trends in streamflow from 1913-2004 for seven streams in Hawai‘i, including three on Maui, that 1) had data available, 2) were free of upstream regulation or diversion, and 3) represented a variety of physical and climatological characteristics. He reported statistically significant declines in baseflow in all seven streams but a statistically significant decline in total annual flow in only one of the streams. These baseflow declines are consistent with a long-term downward trend in rainfall observed over much of the State during that same period and may reflect a decrease in groundwater storage and recharge. However, the author states that detection of the trends was dependent on the period of record considered. He says that the downward trends may just reflect higher than average baseflows from 1913 to the 1940s, followed by a period with little or no trend in baseflows.

3.2.3 Sea Level Rise

According to the IPCC, the oceans are now absorbing more than 80 percent of the heat added to the Earth's climate system. Since 1961, this absorption has caused average global ocean temperatures to increase and seawater to expand. Thermal expansion of the sea is the primary cause of global sea level changes. Melting ice-sheets, ice caps, and alpine glaciers also influence ocean levels. Worldwide, sea level changes have historically occurred on a small scale; however, scientific evidence suggests that the current, accelerated rate of global change began between the mid-1800s and 1900s. Similarly, sea levels in the Pacific have regularly changed over the centuries due to variations in solar radiation. Since 1800, sea levels in the Pacific region have been rising. During the last century, these levels have risen about 6 inches and this is likely to rapidly increase in the next century (Noye and Grzechnik 2001, GAO 2007).

Due to localized geographic and oceanographic variations, it is not possible to discuss SLR on a global scale. Near Pacific Island ecosystems, SLR is influenced by the rate and extent of global sea level rise, as well as changes in episodic events, such as the El Niño Southern Oscillation (ENSO) and storm-related conditions. Topography and exposure to normal and storm swell produce localized differences. Furthermore, it is important to note that shoreline sea levels are historically and currently influenced by isostatic tectonic changes as the islands move with the Pacific Plate, which are not due to global changes in sea level. Thus, sea level change in the Pacific is highly variable due to geologic uplift (Michener et al. 1997, Carter et al 2001).

Sea level rise is expected to exacerbate inundation, storm surge, erosion, and other coastal hazards. Currently, ocean waters only occasionally reach Main Pond during high tides with large waves. The frequency of these events will likely increase due to SLR. It is also likely that Mā‘alaea Beach may be more prone to erosion which may threaten habitat and infrastructure in the area.

In an effort to address the potential effects of sea level changes on national wildlife refuges, the Service contracted the application of the Sea Level Affects Marshes Model (SLAMM) 6 for several Pacific Region Refuges. This analysis is designed to assist in development of long-term management plans. The SLAMM model predictions for Keālia Pond NWR suggest that inland inundation within this Refuge will occur given SLR scenarios below 3 feet (eustatic). It is in the 3-feet scenario that rising waters begin to have an impact on the main part of the Refuge. The dry land (and beaches) between the Main Pond and the ocean, which acts as a natural impoundment against inundation, becomes heavily eroded in higher scenarios.

There is little or no tidal influence within the Refuge, however, after 3 feet of SLR salt water is predicted to move beyond the road barrier. Within this SLAMM application, a connectivity algorithm was used to determine when floodwaters are predicted to penetrate beyond the road resulting in more frequent flooding and salinity changes within the Refuge. Under the highest SLR scenarios, N. Kīhei Rd. is predicted to be regularly flooded and convert to ocean beach or open water if left as is without human intervention.

There is always uncertainty about how regularly flooded wetlands will respond to SLR. The most important effects of SLR at Main Pond and Mā‘alaea Flats are the gradual inundation and flooding of historic wetlands and dryland areas, as well as increases in the salinity of wetlands. Salinity alterations have the potential to shift aquatic plants and animal communities that do not tolerate high salinity. Higher sea levels may inundate these low-lying land areas, potentially helping Refuge personnel to reclaim/restore former wetland areas for endangered waterbirds.

3.2.4 Ecological Responses to Climate Change

Evidence suggests that recent climatic changes have affected a broad range of individual species and populations in both the marine and terrestrial environment. Organisms have responded by changes in phenology (timing of seasonal activities) and physiology; range and distribution; community composition and interaction; and ecosystem structure and dynamics. The reproductive physiology and population dynamics of amphibians and reptiles are highly influenced by environmental conditions such as temperature and humidity. For example, sea turtle sex is determined by the temperature of the nest environment; thus, higher temperatures could result in a higher female to male ratio. In addition, increases in atmospheric temperatures during seabird nesting seasons will also have an effect on seabirds and waterbirds (Duffy 1993, Walther et al. 2002, Baker et al. 2006).

Changes in ocean temperature, circulation, and storm surge due to climate change will impact seabird breeding and foraging. The ENSO has been shown to cause seabirds to abandon habitats, nest sites, and foraging areas for colder/warmer waters. Studies have found that nesting success is reduced for some species during this climatic event. Oceanographic changes associated with ENSO may also increase or decrease food supply for seabirds and subsequently impact populations that forage offshore. Shifts in marine temperature, salinity, turbidity, currents, depth, and nutrients will have an impact on seabird and waterbird prey composition and availability. Although these potential changes may impact seabirds throughout the Hawaiian Islands, contrary evidence suggests that seabirds may have coped with and evolved around climatic changes in the past (Duffy 1993).

Warming has also caused species to shift toward the poles or higher altitudes and changes in climatic conditions can alter community composition. For example, increases in nitrogen (N) availability can favor those plant species that respond to N rises. Similarly, increases in CO_2 levels can impact plant photosynthetic rates, decrease nutrient levels, and lower herbivore weights. Although there is uncertainty regarding these trajectories, it is probable that there will be ecological consequences (Vitousek 1994, Walther et al. 2002, Ehleringer et al. 2002).

Climate change has the potential to influence two important ecological issues in the State of Hawai‘i: endangered species and pest species. The majority of U.S. endangered species are found in the State of Hawai‘i. Species declines have resulted from habitat loss, introduced diseases, and impacts from pest species. Changes in climate will add an additional threat to the survival of these species. For example, warmer night temperatures can increase the rate of respiration for native vegetation, resulting in greater competition from pest plants. Furthermore, climate change may enhance existing pest species issues because alterations in the environment may increase the dispersal ability of flora or fauna. Species response to climate change will depend on the life history, distribution, dispersal ability, and reproduction requirements of the species (DBEDT and DOH 1998, Middleton 2006, Giambelluca 2008).

3.2.5 Climate Change at at Keālia Pond NWR

Most of the anticipated climate change impacts at Keālia Pond NWR involve water supply and water quality. Tributary streams that flow into Main Pond originate in the West Maui Mountains, which is one of the wettest places in the world. Hydrologic conditions at Main Pond are largely dependent on streamflow inputs, which can be highly variable from year to year and are affected by climatic conditions and upstream regulation. Both short-term interannual climate variability and long-term decadal variability affect streamflows on Maui and the other islands. Many of the droughts in Hawaiʻi are related to El Niño events, which are associated with drier than normal winters. The PDO also influences Hawaiian climate. The pattern of ocean-atmosphere variability associated with ENSO phenomenon occurs on a relatively short time scale of 1 to several years while the PDO is a longer term phenomenon occurring over 1 to several decades. Rainfall and streamflow tends to be low in winter during El Niño periods and high during La Niňa periods, especially during positive (warm) phases of the PDO. Temperature may be affected by PDO phases too. A number of studies suggest that climate change could be a major factor in accentuating the current climate regimes and the changes from normal that come with ENSO events (Mimura et al. 2007, Oki 2004).

It is difficult to assess the relative threat of long-term changes in rainfall and runoff to the Main Pond. Certainly declines in rainfall and runoff, including baseflow, would affect the water supply for the Pond. Warmer air temperatures may mean warmer water temperatures, decreased dissolved oxygen (DO), and greater evaporation. Nuisance issues of blowing dust and fish kills may also be expected to be more common. Presently, the water level record at Main Pond is not long enough to assess whether or not the frequency of dry conditions has already increased in response to warmer temperatures, increasing evaporation, and decreasing precipitation. However, any gradual, long-term changes in rainfall and stream inflow may be overshadowed by more immediate and direct changes in upstream regulation and diversion and land management practices. As will be discussed below, such changes have the potential to greatly modify Pond hydrology and ecology.

More severe flooding would also affect the Main Pond in a number of ways. They may increase the frequency or severity of disturbance in the Pond and may also increase sediment loads reaching the Pond, which could affect water quality and Pond bathymetry. More severe flooding would also underscore the hydrologic function of the Main Pond with respect to ameliorating flooding and runoff to the ocean. The Main Pond is valuable for retaining storm water and reducing the velocity of flood waters. This wetland minimizes flooding of N. Kihei Rd., protecting the road as well as allowing through-traffic during most rain storms.

The Pond and surrounding area act as a buffer, capturing flood waters and holding them before they move into the ocean (either as surface flow or subsurface seepage). The wetland also protects the adjacent beach and offshore coral reef ecosystem from deleterious effects of erosion, sedimentation, and eutrophication associated with flood waters.

Most of the islands of the northwestern end of the Hawaiian archipelago are low sand and coral islands. A foot of SLR could inundate much of the dry land of the NWHI and high islets such as Molokini will have high value for seabirds in search of new protected nesting areas above water.

3.3 Geology and Soils

The Hawaiian Islands were formed by a series of volcanic eruptions that occurred at hotspots beneath the Earth's crust. As the tectonic plate slowly drifted, magma welled up from fixed spots creating a linear chain of islands. Iron-rich, quartz-poor rock flowed out of thousands of vents as highly fluid lava.

3.3.1 Keālia Pond

The Island of Maui formed from two shield volcanoes that were close enough that their lava flows overlapped, forming an isthmus between them. The oldest volcano, now forming the West Maui Mountains, is about 5,000 feet high. The younger volcano, Haleakalā, on the east side of the island is over 10,000 feet high. The isthmus that separates the two volcanic masses is formed from sandy erosional deposits and is the prominent topographic feature for which the island is known: "the Valley Isle."

A general soil survey for Maui County, including Keālia Pond, was completed by the Natural Resources Conservation Service (NRCS) in 1972. Soils at Keālia are all classified as Keālia silt loam. This soil series is found along coastal flats throughout the island and is associated with nearly level, poorly drained soils with high salt content. Ponding occurs in low areas after heavy rains, and salts accumulate on the surface with drying and evaporation. A representative soil profile consists of a dark reddish-brown silt loam about 3 inches thick with stratified layers of silt loam, loam, and fine sandy loam below this. A brackish water table occurs at a depth of 12-40 inches. The soil has a high concentration of salts and is moderately alkaline. It is highly erosive when dry and the surface becomes loose and fluffy.

Soils profiles described at several cores collected at Keālia Pond were generally silt loams and silty clays intermixed with layers of coarser sandy loams and fine sands at depth. The water table in the cores was consistently encountered at the depth of the sand layer or in the soil horizon just above it. This suggests that coarser textured sand layers may be acting as conduits or permeable horizons for groundwater movement into, out of, or underneath and around the Pond. Reportedly there is a hardpan underlying much of the bottom of the Pond itself, which probably acts to seal the Pond bottom and minimize groundwater/surface water exchange (Smith and Medeiros 1952, Nakai and Mayer 2001).

At two sites near the historic mouth of Waikapū Stream, the presence of the sands and rounded basalts indicated that at one time the stream channel flowed with enough energy to carry and deposit such material near the Pond. Presently, the stream lacks a defined channel near the Pond and does not appear to transport and deposit such material anymore. In cores located away from the Waikapū Stream channel, the sand layer still exists at depth but the sands are finer textured and there are no rounded basalts. The more permeable soils near the mouth of Waikapū Stream result in water levels that are much flashier and more variable than elsewhere, based on water level data from piezometers installed near the Pond. There is a much larger range of water levels here as compared to elsewhere around the Pond.

The presence of permeable sand layers and/or a hardpan has implications for management proposals to excavate the Pond or construct additional impoundments. If dredging or excavation is deep enough to intersect the sand layers, this may facilitate the flow of subsurface water into or out of the Pond or impoundment, depending on local head gradients. Groundwater in some of the shallow wells around the Refuge, especially on the north shore and to the southeast, is very saline (as much as 70 parts per thousand (ppt) or more). Intersecting a deeper, permeable layer with high salinity groundwater during dredging may cause saline groundwater to flow into the Pond and may alter Pond ecology. Additionally, the presence of a hardpan layer underlying the Pond would be important to consider as well. It is not known how thick this layer is or what is below this layer but removing this impediment to drainage and groundwater movement would undoubtedly affect Pond hydrology and water quality as well.

Chemical analysis of sediments in 2001 in the Pond found high salinity. The average conductivity of 1:1 soils to distilled water mix was approximately 4 ppt salinity. The high salinity of the sediments was apparently the reason Hawaiian Commercial & Sugar Company (HC&S) abandoned plans to drain the Pond and grow sugarcane in the early part of the 20th century. The high salinity of the sediments may also be part of the reason for a lack of rooted vegetation in the Pond. The only substantial area of emergent aquatic vegetation in the Pond is the area receiving freshwater from the wells. Sediments upgradient in the stream channels are not saline, suggesting that salts are accumulating in the Pond and not being transported to it (Smith and Medeiros 1952).

All the soils and sediments are very high in phosphorus (P) (total, extractable, and water soluble) and ammonia-N but fairly low in nitrate-N. Phosphorus is commonly the nutrient limiting primary productivity in aquatic systems but Keālia seems to be naturally rich.

3.3.2 Molokini

The tiny, crescent-shaped islet of Molokini lies 3 miles offshore of Maui. Molokini is a volcanic cone that rises about 500 feet from the submarine flank of Haleakalā to a summit only 162 feet above sea level. The cone is capped by a crater 1,770 feet in diameter, although the northern rim is below sea level and the crater is flooded by the sea. It was active about 230,000 years according to an age measured from lava fragments contained in the cone. Molokini is completely exposed to trades through the Maui isthmus on its north side and easterly winds wrapping around Maui to hit its south side. Wave action is continuously eroding the islet as evident by the undercutting along the sides (USGS 2008).

Hundreds of ancient cinder cones can be found all around Maui, but Molokini is unique because it is one of the few that rose all the way from the deep ocean floor and erupted above the water. When the islands were forming, molten lava flowed beneath the surface of the ocean through porous tubes. These tubes also trapped water within their rocky structure. When magma erupts explosively in shallow water, the liquid water heats, expands rapidly, and changes to steam, adding to the eruptive force. Rock and cinder were spewed into the sky and formed a crescent shape as they fell (USGS 2008).

Shallow marine eruptions have two consequences for the appearance of the resulting cone. The first is grain size, because the ripping power of these marine eruptions leads to finer-grained deposits than in cinder cones onshore. The second is the abundance of volcanic glass, because the lava fragments are quickly cooled by water before crystals can form. Glass is a geologically unstable material. It alters rapidly to brownish-yellow clays, giving Molokini its earthy yellow color. In contrast, cinders erupted on land are reddish and black. The Molokini deposits are basanite, a type of basalt with fairly low amounts of silicon (Si) and high concentrations of sodium and potassium (USGS 2008).

3.4 Hydrology

The hydrologic processes that occur in the Hawaiian Islands are unique compared to continental landmasses or temperate zones. Drainage basins are typically small and streams are characterized by steep longitudinal profiles and numerous waterfalls. Due to its location, Keālia Pond has historically served as a settling/deflation basin for a 56-square mile watershed extending to the West Maui Mountains. There are three major streams that are tributary to the wetland: Pōhākea Stream, Pale‘a‘ahu Stream, and Waikapū Stream. All three streams are unpredictable and intermittent, some of which is due to diversions for agriculture. Wilcox (1996) reports that most of Hawai‘i’s streams are flashy, with flow rates that rise and fall rapidly in response to precipitation. Several other streams occasionally flow into the wetland from the west side of Haleakalā during very high rainfall events. Historically, these streams may have flowed into the wetland more frequently.

Hydrologic conditions vary considerably seasonally and annually. During the wet season, the Main Pond usually maintains moderate to high water levels due to increased precipitation and streamflow with a maximum Pond depth of 3-4 feet. As summer progresses, precipitation decreases, less stream water flows into the Pond, and the water levels recede. Some years, inflows are sufficiently high to maintain water levels throughout the summer. Most years, the water level begins to recede by April or May, resulting in very low water or even dry conditions in the Pond by late summer or early fall.

3.4.1 Annual Hydrologic Cycle

The information presented next is based on Pond water level data collected at Keālia’s Main Pond from 1996-2006. Since June 2000, Pond levels have been recorded hourly with a datalogger. Figures 3.4, 3.5, and 3.6 show the Pond levels and monthly precipitation for water years 1996-2007. The relationship between precipitation and water levels can be observed in the figures, with wetter years and wetter times of the year resulting in higher water levels.

In most years, the Main Pond fills quite abruptly (within days) due to a combination of rainfall and runoff following the first major storm in the fall or winter. Usually, this occurs in October or November, although it has happened later, as in 2000 and 2006. Rainfall directly on the Pond is a fairly minor component of the total inflow into the Pond. The majority of inflow is from runoff and streamflow. Inflow reaches the Pond in three forms: as direct streamflow from any of three major tributaries to the Pond; as runoff and diffuse surface flow from the surrounding lands; and as subsurface flow (groundwater seepage).

Of the three main streams flowing to the Pond, Waikapū Stream is the major contributor of inflow during the wet season. Although this stream is dry much of the time, the volume of water is considerable when it is flowing. Peak flow measurements were collected annually from 1963-1997 at USGS Station 16650500 Waikapū Stream, located just upstream of the Refuge at Lower Mā‘alaea

Rd. The peak flows averaged 620 cubic feet per second (cfs) and ranged from 104-1,130 cfs. Flows greater than 1,000 cfs are not uncommon in the record. Weekly estimates of flow were collected at this same site by Refuge staff 2001-2006. The maximum estimated flow recorded was 450 cfs and the site was dry about 80 percent of the weekly visits. Historically, Waikapū Stream was believed to be perennial through its entire reach but the stream was fully diverted of all but peak flows many years ago for the purpose of sugarcane irrigation (Maciolek 1971). There is presently a reservoir upstream of the Refuge on Waikapū Stream that may affect inflows to the Pond. Within the past 5 years, water rights issues have come to the forefront between environmental groups, agricultural companies, and user groups that include the Waikapū Stream. However, to date, the State's decision to return water to some of the West Maui streams has not included the Waikapū Stream.

The other two streams, Pōhākea and Pale‘a‘ahu, make up a smaller fraction of the streamflow to the Pond. Weekly flow estimates of these two streams were collected by Refuge staff 2001-2006 as well. These two streams are still intermittent but flow more consistently than Waikapū Stream. Pōhākea Stream was dry an average of 50 percent and Pale‘a‘ahu Stream was dry an average of 20 percent of the weekly visits. The maximum estimated flow was 94 cfs in Pōhākea Stream and 25 cfs in Pale‘a‘ahu Stream. Flows in Pōhākea Stream have been greatly reduced since 2004, based on Refuge staff observations. From 2001-2004, Pōhākea Stream was observed to be dry 23 percent of the weekly visits to the stream. In 2005 and 2006, the stream was dry 92 percent of the weekly visits. The decrease is likely due to some upstream change in water or land management. Pōhākea Stream is not a major contributor of inflow to the Pond. The major effect of this change is that the area around the outlet channel of this tributary has become slightly drier.

Groundwater levels are quite dynamic and generally follow the same seasonal patterns as surface water levels in the Pond. There is large temporal and spatial variability in water table levels and groundwater salinity. However, the groundwater system appears to be only weakly connected to the surfacewater system and groundwater seepage to the Pond is a minor component of total inflow. Groundwater does not seem to influence the Pond in terms of quantity or quality, although groundwater storage adjacent to the Pond may buffer the Pond water levels to some extent.

During the wet season, inflows from rainfall and streamflow usually exceed outflows, maintaining high Pond water levels through this season. As precipitation and runoff decrease in the late spring and summer, Pond levels begin a slow, steady decline. This decline usually begins in April or May and continues unabated throughout the dry season until the fall rains begin. Water is lost from the Pond through three processes: 1) surface flows to the ocean; 2) groundwater seepage losses; and 3) evapotranspiration losses. Based on the physical constraints to surface outflow discussed below and the consistency of salinity measurements as the Pond recedes (discussed later), the primary water loss from the Pond appears to be through evaporation.

Figure 3.4. Water level depths and monthly precipitation at Keālia Pond NWR, water years (WY) 1996-1999.

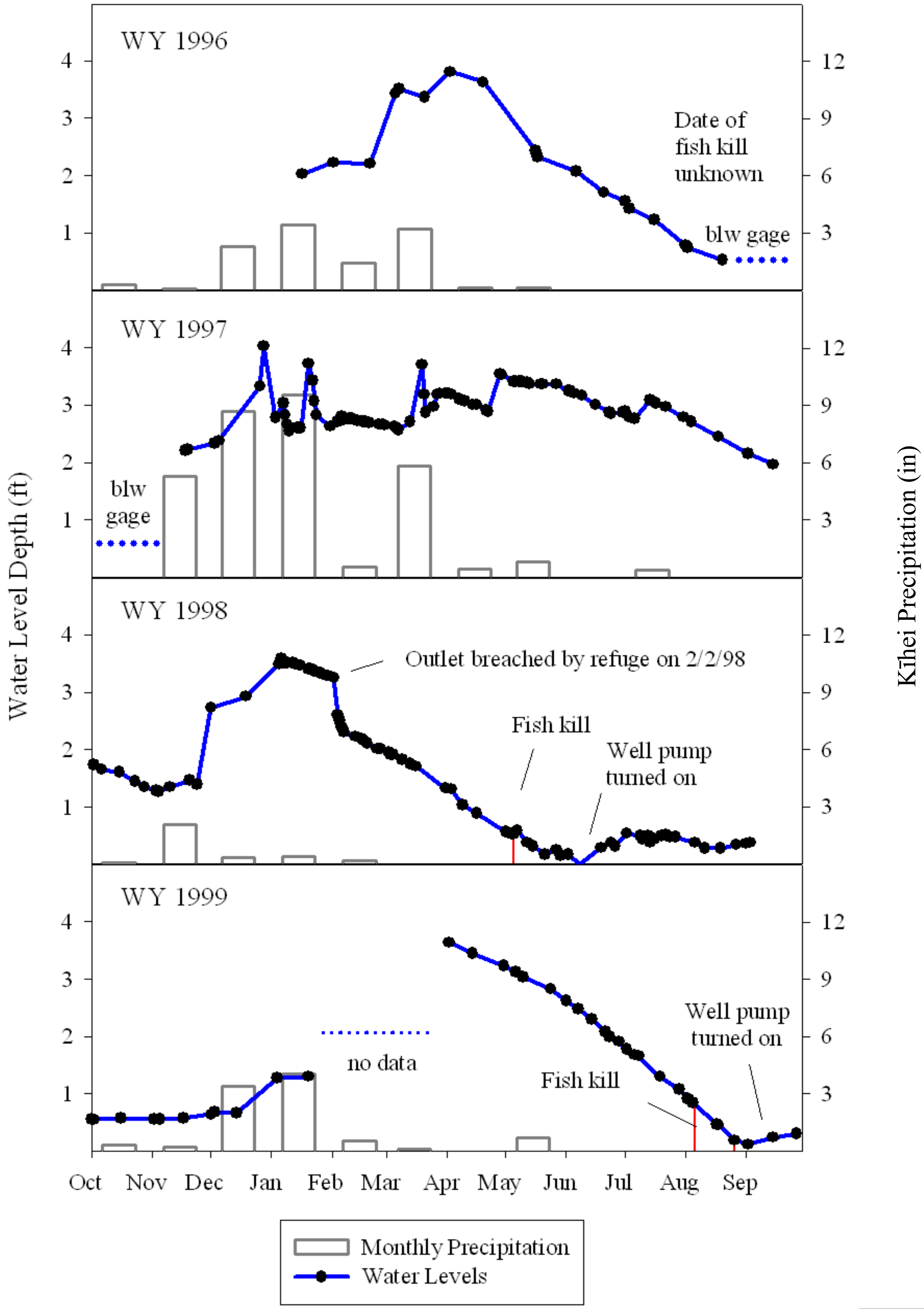


Figure 3.5. Water level depths and monthly precipitation at Keālia Pond NWR, 2000-2003.

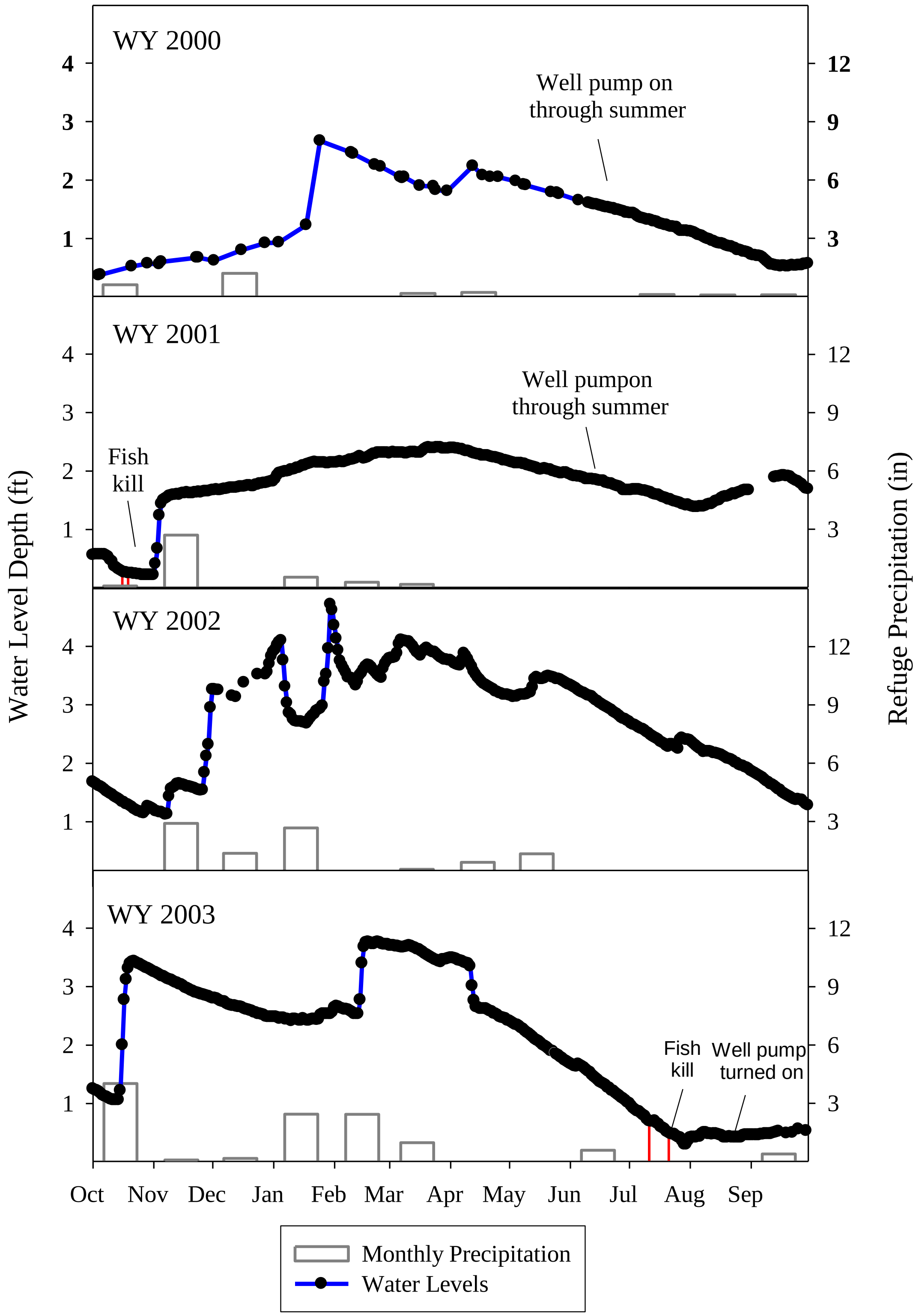
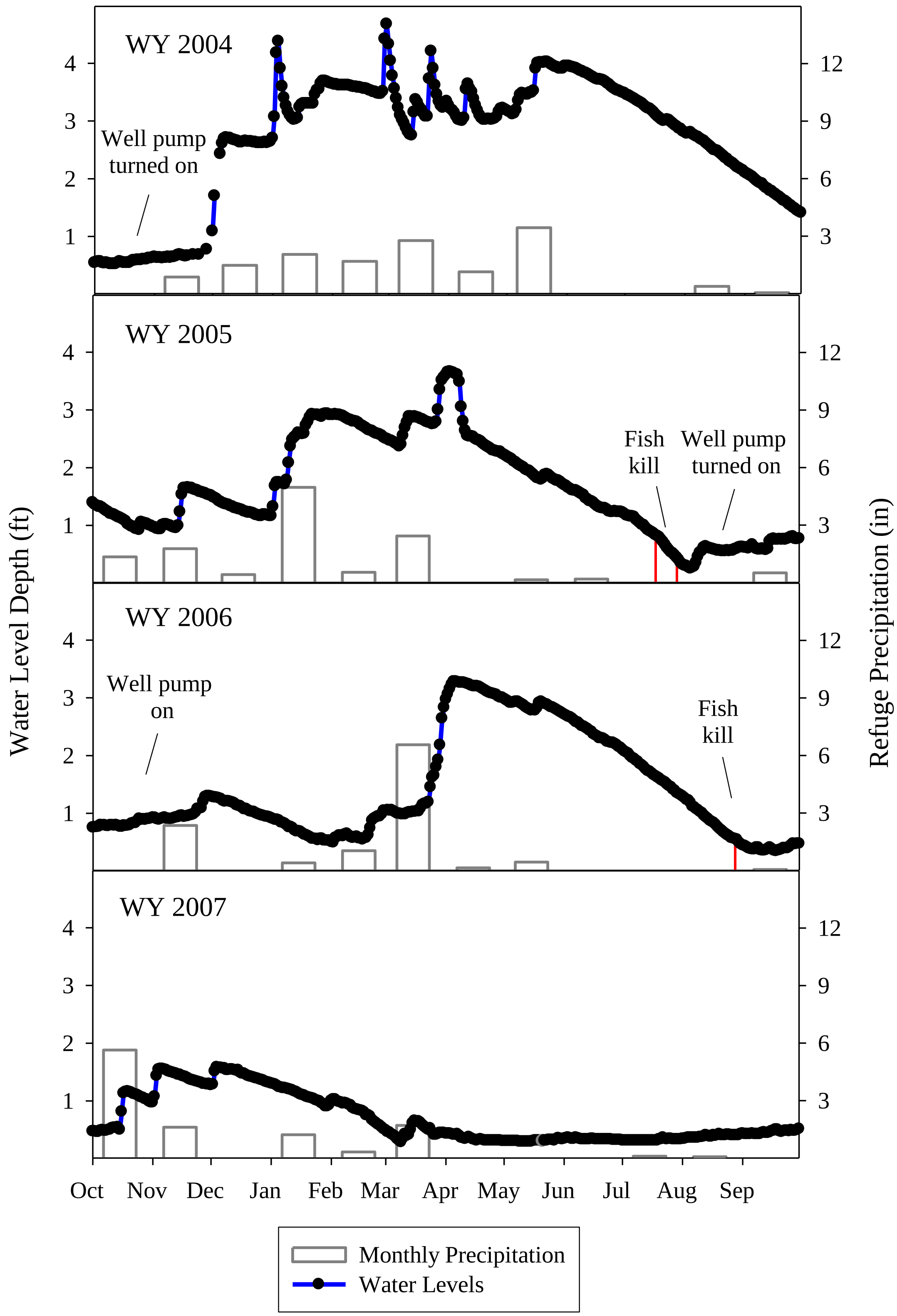


Figure 3.6. Water level depths and monthly precipitation at Keālia Pond NWR, 2004-2007.



Surface outflows to the ocean occur only occasionally in the winter at high Pond levels which are greater than 4 feet mean lower low water (MLLW). The outlet channel from the bridge to the ocean is usually blocked by a sandplug formed naturally by ocean currents and tidal action. This sandplug and the berm separating the Pond from the ocean cause water to Pond. Large rain events will raise the Pond level enough to breach the sandplug temporarily, allowing surface outflow to the ocean and resulting in a rapid drop in Pond levels. The sandplug typically rebuilds within several days. Although the water that outflows to the ocean contains some suspended sediment and organic matter, Maciolek (1971) believed that, at the time of the report, this turbidity was not severe enough to harm the Mā‘alaea coral reef community living at or to the west of the discharge point.

There appears to be a small amount of subsurface seepage through the sand beach berm and plug from the Pond to the ocean. Water can be observed to be flowing out under the bridge on N. Kīhei Rd. even when the sandplug is in place and there is no surface outflow to the ocean. This indicates the existence of subsurface seepage through the beach berm separating the Pond and the ocean. The sand substrate of the beach berm is probably more permeable than the silts and clays underlying the remainder of the Pond. The subsurface seepage outflow is estimated to be as high as 2 cfs or 4 acre-feet/day, depending on the Pond elevation. Subsurface seepage losses will be head-dependent, meaning the higher the Pond level, the greater the subsurface seepage outflow.

The elevation of the bottom of the box culvert under the bridge is 2.54 feet MLLW. As the water level recedes below this elevation, the box culvert blocks any outflow under the bridge, isolating the Pond from the area of seepage outflow. Seepage losses in other areas of the Pond are very small and, it appears that Pond outflows at water surface elevations less than about 2.5 feet MLLW are solely through evaporation. The Pond essentially acts as a closed basin as water levels recede below the elevation of the box culvert at the bridge. This has important chemical and biological implications since evaporation concentrates salts, nutrients, and other solutes, as will be discussed later.

One of the characteristics of evaporative losses at Pond levels less than 2.5 MLLW is that they are quite predictable. The rate of evaporation varies seasonally but is consistent from year to year in the absence of any significant inflows. The dry season rate of decline, without any pumping of well water into the Pond, has averaged 0.023 feet/day (0.65 feet/month), with a range from 0.020 feet/day, in 2002, to 0.026 feet/day, in 1999 and 2008 (Table 3.1). Variability in the rate of decline during the dry season appears to be related mainly to fluctuations in evaporation rates and to occasional stream inflows during the period of decline. Pumping groundwater into the Pond slows the rate of decline considerably. In 2000, the rate was 0.01 feet/day and in 2001, it was 0.008 feet/day. In both years, pumps were running fairly consistently throughout the spring and summer during the period of declining water levels. The rate of water level decline is slightly slower in the cooler wet season. In the absence of any groundwater pumping or inflows, it averages about 0.013 feet/day during the winter months and about 0.18 feet/day during spring/fall months, based on data from 2007-2008.

At the previous well capacity of approximately 700 gallons per minute (gpm), groundwater pumping slowed the rate of decline and stabilized the Pond elevation at about 1.00-1.30 feet MLLW (about 0.4-0.5 feet average Pond depth) in the summer. This elevation range represents about 50-60 percent water coverage. Above this elevation, the evaporative losses are too great and the existing well capacity cannot meet the demand.

Table 3.1. Rates of Water Level Decline for Periods with No Significant Inflow to Pond.

Water Year	Period with No Significant Inflow	Season	Rate of Pond Level Decline (ft./day)
1998	2/24-5/21/98	Winter/Spring	0.021
1999	6/23-8/26/99	Summer	0.026
2000	4/17-9/5/00	Spring/Summer	0.010*
2001	4/1-8/1/01	Spring/Summer	0.008*
2002	8/24-10/11/02	Summer/Fall	0.020
2003	5/17-7/24/03	Spring/Summer	0.023
2004	9/5-24/04	Summer/Fall	0.022
2005	5/26-8/1/05	Summer	0.022
2006	7/4-9/5/06	Summer	0.026
2007	2/3-3/12/07	Winter	0.017
2008	2/22-4/30/08	Winter/Spring	0.018
Summer Average			0.023

* Wells were pumping continuously during the summer period during 2000 and 2001. These years were not included in the summer average rate of decline calculation.

There is about 2 feet of difference between winter maximum water levels and summer minimum water levels. Maximum water levels typically occur in winter months of February -April, with mean depths of about 3 feet. Even during the dry winter in 2006, the Pond was full by April. June, July, and August levels have been quite variable, but are usually quite low in dry years. October and November have consistently been the months of minimum water elevations. Early fall storms are responsible for the higher elevations observed during October and November in some years.

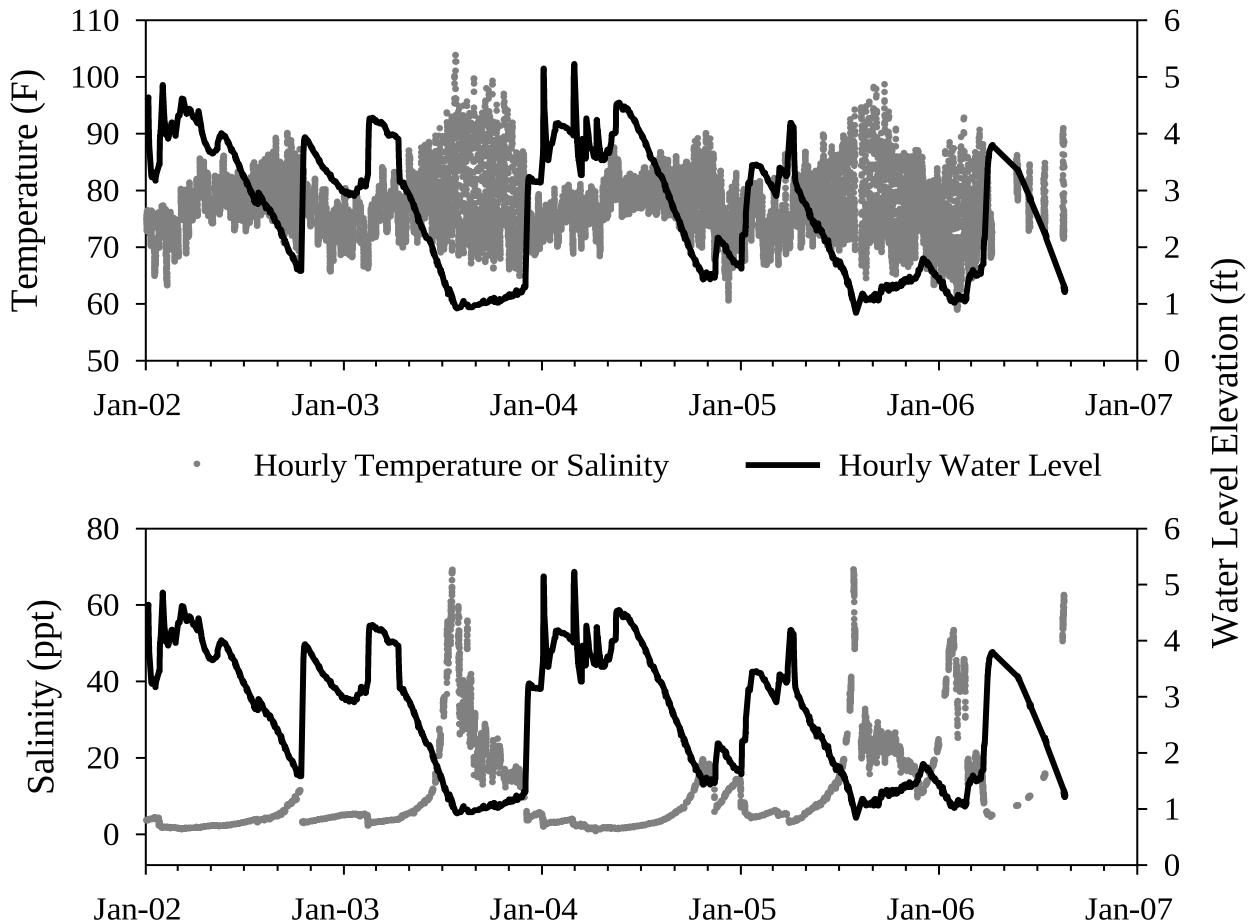
3.4.2 Water Quality of the Main Pond

The water quality and algae information presented here is based on 5 years of monitoring at the Main Pond from 2001-2006. In general, the Pond is extremely productive and hypereutrophic, meaning chlorophyll-a concentrations greater than 100 parts per billion (ppb) as classified by the Organization for Economic Cooperation and Development. Chlorophyll-a had a median concentration of 125 ppb for the period but concentrations were greater than 1000 ppb on several occasions. Water temperatures, salinity, turbidity, macronutrient concentrations, chlorophyll- a concentrations, and algal biomass were usually greater in summer and fall at lower water levels. The Pond has a very low relative depth (ratio of depth to surface area) and flat bathymetry, and is polymictic (mixed continuously) due to the shallow depth and strong local winds. There is little spatial variability in water quality conditions in the Pond because it is so well-mixed. Water quality is strongly related to Pond water levels; this is the single most important factor affecting water quality. Pond depths and water quality are strong controls of its biota as well (OECD 1982).

Temperature

Mean annual water temperature at Keālia is 76.6° F and ranges from an average of about 73° F in winter (December-March) to 79° F in summer (June-September). This is very close to the annual average of 75.2° F predicted for water bodies at this latitude. A time series plot of hourly water temperature and water level elevation is shown in Figure 3.7. Water temperature is strongly dependent on time of day, season, and water level depth.

Figure 3.7. Water Temperature and Salinity, 2002-2007.



Temperatures are higher and fluctuate more with shallow water depths. Daily maximums were as high as 102 °F in July 2003 and 95 °F in September 2005, when water levels were around 1.0 MLLW or less. The diurnal difference in daily minimum and maximum temperatures often exceeds the seasonal variation between winter and summer temperatures and can be as great 50 °F or more at very low water levels (Lewis 1987).

Salinity

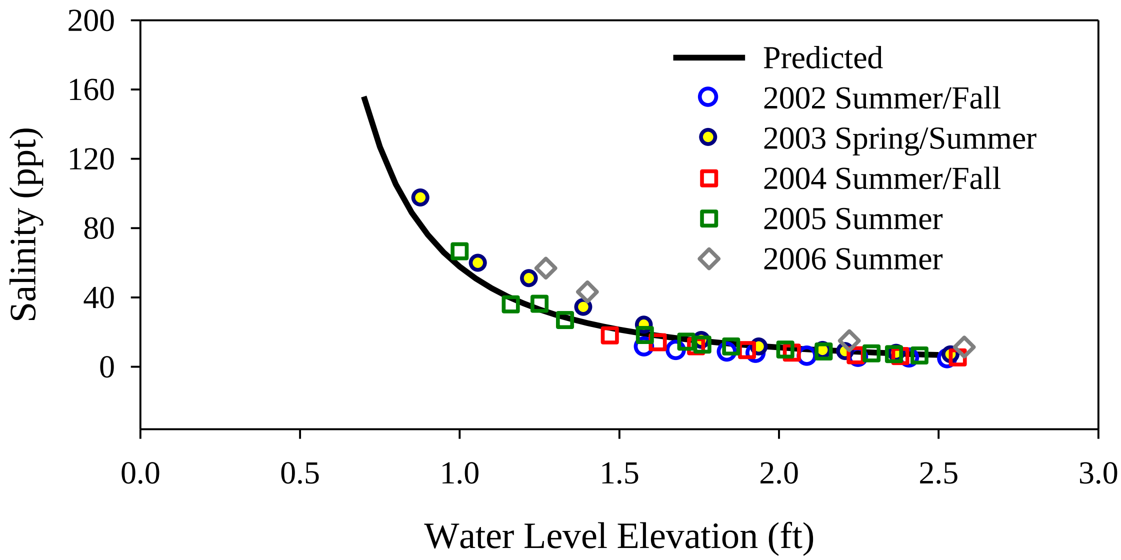
Salinity varies seasonally and interannually in the Pond, from fresh to brackish levels in winter to hypersaline levels in summer and fall. A time series plot of hourly salinity and water level elevation is shown in Figure 3.8. The range in salinity over a single season is large, from values less than 1 ppt to values of 70 ppt or more. The maximum salinities observed represent values twice as saline as sea water. This must be an extreme physiological stress on organisms living in the Pond. Given the seasonal fluctuations in salinity, it is almost certainly a strong environmental control of biota in the Pond.

The strong seasonal changes in salinity are driven by evaporation and surface inflows. Streams flowing into the Pond are characterized by very low salinity waters (about 1 ppt). With the initial fall flooding of the Pond, low salinity stream waters are mixed with residual Pond waters, usually of high salinity, to produce an initial salinity of 1-6 ppt. Salinity usually remains below 6 ppt throughout winter and spring until water levels drop to about 2.5 feet MLLW. Below this elevation, there are no longer any surface or subsurface outflows, only evaporative losses. As water levels drop below this elevation, salinity starts to increase rapidly and predictably, due to evaporative concentration of salts.

The predicted and observed salinity as a function of elevation below 2.5 feet MLLW is shown in Figure 3.7. The observed salinities were measured during the periods of no significant inflows. Most of the measured points fall close to the line of predicted values, indicating good agreement. Well water from the 2 production wells at Keālia is fresh (less than 1 ppt) so pumping groundwater into the Pond can reduce the salinity, depending on the ratio of Pond water to well water.

There is a very strong and consistent relationship between water levels and salinity in the Pond. The fact that the observations closely align with the predicted salinity assuming evaporative concentration of salts points to evaporation as being the single major outflow from the Pond at levels below 2.5 feet MLLW. Since evaporative losses from the Pond are predictable, it is possible to predict salinity in the short term as well, in the absence of any significant inflows.

Figure 3.8. Predicted and observed salinity concentration as a function of water level elevation.



Dissolved Oxygen

Like other field water quality parameters, DO varies diurnally and seasonally in relation to a number of factors. The DO concentration in the Pond results from a combination of photosynthesis, decomposition, algae biomass or organic matter concentration, temperature, water level, and mixing in the Pond. Photosynthesis of algae produces DO while respiration of algae and decomposition of organic matter consumes it. The higher the algal biomass, the greater the amount of photosynthesis, generally speaking, leading to more DO production, at least during the day. On the other hand, higher concentrations of organic matter will lead to more decomposition and consumption of DO. The diurnal cycle of DO is largely a result of the balance between photosynthesis and respiration.

A time series plots of hourly DO concentrations and water level elevation is shown in Figure 3.8. Conditions in Keālia Pond are very productive, causing very large swings in DO on a daily basis, with supersaturated DO concentrations during the day (meaning DO concentrations are much greater than equilibrium concentrations with atmospheric O) and undersaturated conditions at night (meaning DO concentrations are much lower than equilibrium concentrations with atmospheric O). Dissolved O, expressed as percent saturation, commonly exceeds 300 percent during the day and drops to near 0 at night, particularly at low water levels. The DO concentrations reached 20 ppm, the maximum measurable with our instrumentation, on numerous occasions. As with salinity, the large fluctuations in DO means that it is almost certainly a strong environmental control of biota in the Pond.

The solubility of DO is also strongly temperature-dependent, with declining equilibrium DO concentrations at warmer temperatures. Photosynthesis and decomposition are temperature-dependent, too. This means diurnal and seasonal temperature variability contributes to DO variability. At greater water depths (3 feet or more) and cooler temperatures, the range of DO is more moderate and less likely to become extremely supersaturated or undersaturated. Lower water levels have warmer temperatures, increased photosynthesis and decomposition, and greater chlorophyll- a and algal biomass, which produce a wider range of DO conditions.

Potential of Hydrogen (pH)

Like DO, pH shows diurnal and seasonal variability in response to many of the same factors. Dissolved CO_2 is the principal constituent controlling pH in the water column. The CO_2 acts as an acid in water and lowers the pH. Photosynthesis consumes CO_2 and causes pH to increase during the day, because of the removal of an acid. Respiration and decomposition produces CO_2 and causes pH to decline at night, because of the addition of an acid. Seasonal effects on temperatures and water levels will affect pH in the same way as DO, through the effects on photosynthesis and decomposition. Buffering in the Pond may moderate some of the pH swings.

The range of pH in the Pond is generally 8.0-9.5, with greater diurnal fluctuation and lower minimums (closer to 7.5) at lower water levels (about 2.0 feet or less) (Figure 3.9). The maximum daily pH is usually between about 9.0-9.5 but at lower water levels, pH exceeded 9.5 on several occasions. At very high water levels, the range of diurnal pH becomes smaller.

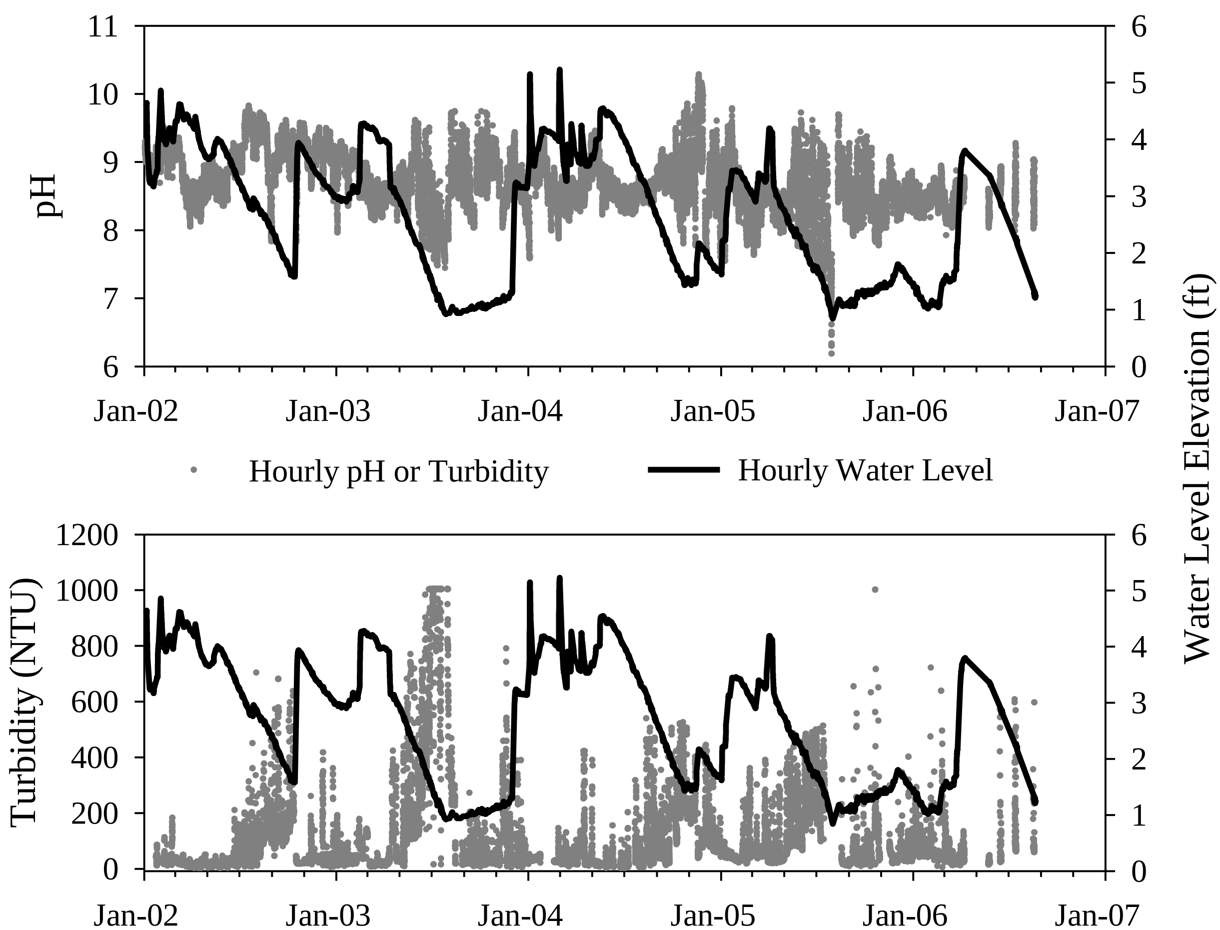
Turbidity

Turbidity is a measure of the amount of light scattered by suspended solids in the water column. Suspended solids have a tremendous effect on the light environment of the Pond, thereby affecting photosynthesis and primary productivity. The higher the turbidity or the concentration of suspended solids, the less light will penetrate into the water column. There is an inverse relationship between turbidity and Secchi depth (a measure of water clarity as determined by lowering a black and white disk into the water).

Turbidity in the Pond is quite variable and ranges from 0 to greater than 1000 nephelometric turbidity units (NTU), which is the maximum reading on the hydro-measuring device (Figure 3.9). Turbidity is very strongly related to water depth and wind speed. At shallow depths, algal productivity is great, increasing the biomass and solids concentrations in the Pond. Mixing depths likely extend all the way to the sediment in shallow water, which means that any particle or material that has settled can be resuspended by wind mixing. Algal biomass and total organic carbon are also important to turbidity since these are primary sources of suspended material. As pointed out above, algal biomass increases with decreasing water levels. All of these factors mean that turbidity increases with decreasing water levels. Daily fluctuations in turbidity are correlated with the daily fluctuations in wind speed. Seasonally, mixing of settled material is more likely to occur during the dry season because of more consistent trades and lower water levels.

There are questions as to the origin and cause of turbidity and suspended solids in the Pond. Initially, we believed that suspended material was being brought into the Pond from upland areas through tributary streams. While this probably occurred in the past, it does not appear to be now. Even substantial surface storm runoff to the Main Pond rarely causes any measureable increase in turbidity or total suspended solids (TSS). There is rarely any turbidity increase associated with major inflow or abrupt water level increase in the Main Pond. This may be because the large expanse of flat, vegetated area upstream slows stream-flow and traps sediment. Conversion from flood irrigation to drip irrigation in the agricultural lands upstream in the 1970s probably reduced runoff and erosion from these areas as well. Most of the suspended material in the Main Pond now is autochthonous organic matter, meaning it is synthesized in the Pond rather than brought to it from the surrounding drainage.

Figure 3.9. Hourly pH, turbidity, and water level data at Keālia Pond, 2002-2006.



Secchi Depths
The Secchi is a small circular disk used to measure water transparency. The disk is mounted on a line and lowered into the water until it is no longer visible. The depth at which this occurs is the Secchi depth. Secchi depth measurements were made weekly or bi-weekly at the Pond from January 2004-April 2006. Secchi depths ranged from 0.05-1.4 feet and averaged 0.57 feet. Secchi depth is negatively correlated with turbidity, TSS, volatile suspended sediments, total organic carbon, and chlorophyll-a and positively correlated with water level depth, with increasing transparency and Secchi depths at higher water levels. As such, it varies with water depths , wind speeds, and algal biomass as a result of the same factors responsible for decreasing turbidity, TSS, organic carbon, and chlorophyll-a .

Macronutrients
The macronutrients P and N are both essential for algal growth and both will often control algal productivity in the aquatic environment. Total P (TP) and total N (TN) concentrations are high in the Pond (median concentrations 0.502 ppb and 4.91 ppb, respectively) but bioavailable forms (soluble reactive P, dissolved inorganic N) are very low. The median soluble reactive P (SRP) concentration in the Pond is 0.007 ppb. The median dissolved inorganic N concentration (DIN) is 0.028 ppb. Almost all of the nutrients are in particulate form, most likely associated with algae and organic matter. This is not unusual in highly productive systems where the demand for bioavailable nutrient forms is great. Concentrations of SRP and DIN do spike periodically and these spikes are almost always associated with inflow to the Pond, suggesting the surface and/or subsurface inflows are sources for bioavailable nutrient forms. The stream and piezometer sampling indicates that median concentrations of SRP and DIN are higher than the Main Pond, although median concentrations of total P and total N are lower. Surface and subsurface inflows may be important sources of bioavailable nutrients for algae.

Concentrations of TP and TN are significantly greater in the summer than in the winter. The median July-October summer concentration is 0.79 TP ppb and 7.1 TN ppb and the median January-April winter concentration is 0.37 TP ppb and 3.1 TN ppb, respectively. The higher concentrations in the summer are likely due to several factors including evaporative concentration (the same process that concentrates salts in the summer). They may also indicate a source of internal nutrient loading from the sediments or a nutrient contribution from groundwater seepage inflow. Most of the algae in the Pond are not cyanobacteria so they are not obtaining N through the atmosphere. At low water levels, total nutrient concentrations can become extremely high. Total P concentrations reached peaks of 11.2 ppb in July 2003 and 9.5 ppb in August 2005. Total N concentrations reached 45.0 ppb and 60.8 ppb during the same months. These high concentrations corresponded to the minimum water levels for the respective years.

Chlorophyll-a
Chlorophyll-a is the green pigment found in plants that allows them to convert sunlight to energy. Chlorophyll-a measurements indicate the biomass (weight) of phytoplankton in the Main Pond and its primary productivity. Keālia Pond is quite productive, with chlorophyll-a concentrations greater than 8,000 ppb observed in July 2003 and greater than 3,000 ppb in July 2005. These are extremely high concentrations and they coincide with the timing of nutrient peaks described above. Chlorophyll-a and algal biomass affect many other things in the Pond: turbidity, DO levels, pH, organic carbon, nutrient cycling, light attenuation, and possibly food resources for invertebrates and higher biota such as fish and waterbirds.

Chlorophyll-a is inversely related to Pond elevation. Lower water elevations generally correspond to periods of higher algal biomass. Light may be a limiting factor for algal growth, especially at higher water levels. While turbidity, TSS, algal biomass, and total O content (TOC) decrease at high water levels, allowing more light penetration, there is still a significant amount of the water column that is without light. Under these conditions, winds could mix algae in and out of the photic zone and thereby limit the time they spend in the photic zone.

Chlorophyll-a concentrations appear to build during quiescent periods with little water level change, especially at the lower water surface elevations (less than about 2.0 feet). Chlorophyll-a concentrations typically reach their annual peak at minimum water elevations. The high concentrations observed in July 2003 corresponded to the minimum water elevation (0.82 feet) for the year. Annual maximums in fall 2001 and fall 2002 corresponded to about 1.6 feet MLLW in both years.

Dissolved Silicon

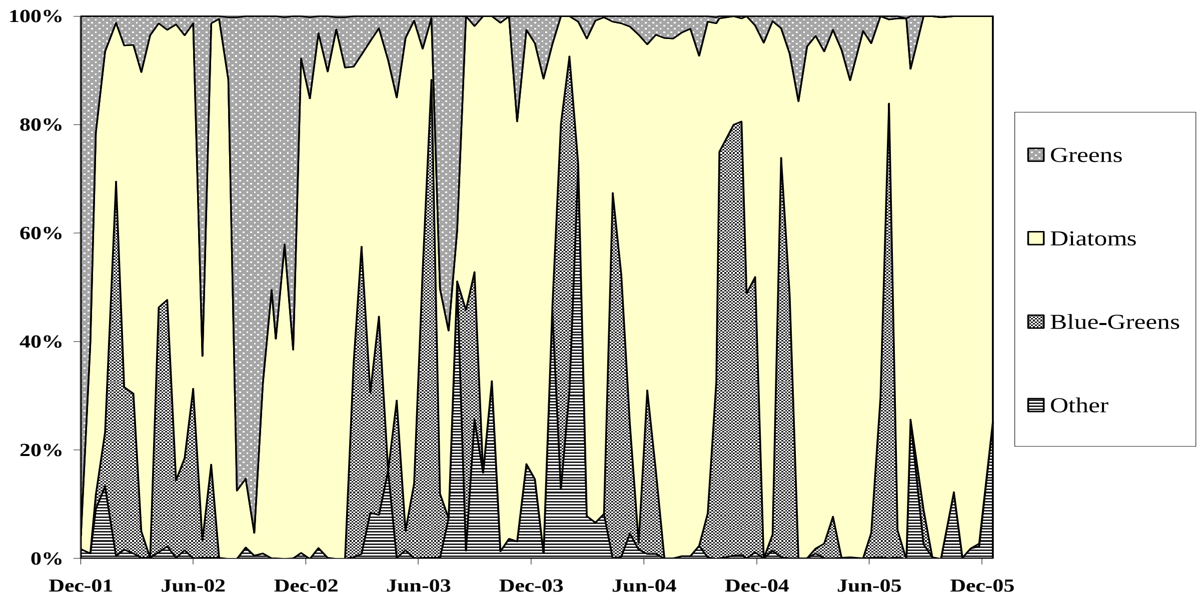
The soluble, bioavailable form of Si is soluble reactive Si (SRS). This element is an essential nutrient for diatoms, which represent two-thirds of the total biovolume of algae in the Pond. The concentration of SRS varied considerably in Keālia Pond, with a median concentration of 2.5 ppb and a range from less than 0.1-17.1 ppb. Approximately 10 percent of the water samples had concentrations below the detection limit of 0.1ppb. The concentration of SRS tended to be lower with greater diatom biovolume, but the relationship was not very strong. Other factors like water depth, light availability, macronutrient concentrations, and salinity may be controlling diatoms as well.

Algae

High salinity, sediments, turbid waters, and wind-driven waves limit the growth of any rooted emergent or submergent vegetation and favor the growth of phytoplankton in the Main Pond. Algae are responsible for most of the primary productivity in the Pond and were monitored regularly at the Main Pond from 2002-2005. The following information is based on the results from this monitoring.

The species, densities, and biovolume of algae varied considerably seasonally and interannually (Figure 3.10). There was an average of 11 species of algae. Reynolds (1994) states that nutrient-rich environments will usually have fewer niches to exploit and therefore, fewer number of algae species. The three most common algal groups were diatoms, green algae, and blue-green algae or cyanobacteria, as is common in small, highly enriched water bodies. Diatoms were the dominant group, representing an average of 67 percent of the total biovolume of algae in the Pond. Green algae were the second most dominate algal group. Generally speaking, diatoms and green algae seem better adapted to fluctuating light conditions in well-mixed waters than cyanobacteria. Being non-motile and non-bouyant, they typically occur in well-mixed waters whereas positively bouyant algae, like planktonic cyanobacteria, persist in stable waters and still, windless conditions.

Figure 3.10. Algal group biovolume as a percent of total biovolume at Keālia Pond, 2002-2005.



All of the algae in the Main Pond are generally smaller-bodied, planktonic algae, with higher growth rates and lower sinking losses. They are generally tolerant of a wide range of salinities and light environments and typically found in nutrient-rich waters. Most were non-flagellate, most were small (geometric mean biovolume is 134 um^3 per cell), and many were osmotrophic. The dominance of diatoms and other small-bodied algae may be because the Pond is continually disturbed through wind-mixing, and runoff events, causing perennial "spring-like" conditions in this system. Very shallow lakes are often arrested in a single successional stage, which explains their greater simplicity and lower degree of seasonal variation in phytoplankton communities (Lewis 1996).

3.5 Topography/Bathymetry

The area around Keālia Pond has undergone substantial changes since the 1900s. Reportedly, Native Hawaiians used the Pond for an easy supply of ʻamaʻama and oʻopu and salt was mined from the northeast shore of the Pond by European visitors. During the 1920s and 1930s, accelerated erosion from agricultural development upstream of the area likely caused a great deal of sedimentation in the Pond. Combined with the diversion of inflows, the Main Pond depth and volume were reduced substantially. Since the 1930s, it has been intermittently dry, probably due to a combination of sedimentation from the surrounding agricultural development and alteration and diversion of surface flows to the Pond (Smith and Medeiros 1952).

The apparent decrease in Pond depth and capacity has generated a lot of interest and concern about sedimentation in the Pond. One of the factors driving this concern is the dust that blows from the exposed sediments of the Pond bottom during periods when it is dry. Dry periods during summer correspond with the season of maximum wind speeds and frequencies. The blowing dust may be viewed as a potential ecological threat to the coral reefs; however, Maciolek (1971) postulated the dust had little impact on the reefs and is less detrimental than the sedimentation from the outlet stream when all sediments are discharged at once.

An obvious concern is that the reduced depth and capacity of the Pond has resulted in an increase in the frequency of dry conditions and exposed sediments in the Pond. Several earlier studies have been focused on the question of whether or not the Pond is filling in due to sedimentation and, if so, at what rate. In the 1970s, there were three elevation surveys of the Pond and the surrounding area to address this question. These were done by the U.S. Army Corps of Engineers (USACE) in 1970, NRCS in 1972, and the Service in 1976.

In addition to the survey capacity curve, the NRCS did a sedimentation study in conjunction with an environmental assessment of the area by Maui Electric Company (MEC) at the request of the Maui Planning Commission. Based on the survey and the sedimentation study, the NRCS estimated that the capacity in 1910 was about 450 acre-feet and that there was a 55 percent loss of capacity in the Pond from 1910-1972 due to sedimentation. The corresponding Pond elevation at 450 acre-feet capacity is not stated in the report, and it is hard to compare it to other more recent capacity estimates without knowing the assumed water level elevation. Applying the 55 percent capacity loss to the 1910 estimate of a 450 acre-feet Pond means that the 1972 Pond capacity was about 200 acre-feet.

Included in the 1972 sedimentation study was an estimated sediment budget for the Pond. In 1972, the Pond was estimated to be receiving 10.5 acre-feet of sediment annually with about 5 acre-feet of this accumulated sediment lost to wind erosion and another 2.3 acre-feet lost to the Bay, leaving a net addition of 3.2 acre-feet in the Pond. The sedimentation estimates emphasize the importance of dry conditions and deflation to the Pond. The Pond acts as a settling and deflation basin maintained by wind erosion of deposited silt. If the Pond were permanently inundated, this would preclude deflation and may actually tend to channelize drainage directly to the ocean. While the blowing dust is a nuisance issue to neighboring residents, Maciolek (1971) did not believe the blowing dust is harming coral reefs offshore, pointing out that much of the material is deposited further, beyond inshore Mā‘alaea waters.

A current elevation survey of the Pond was one of the most important information needs identified by a Service workshop in 2000. In October 2000, the Service completed an elevation survey of the Pond. The results of that survey are shown in Figure 3.11 and 3.12. It is not clear that the datums for the older surveys are accurate and comparable to the newer survey information. However, if the Pond has continued to accumulate 3.2 acre-feet of sediment per year as estimated in 1972, then an additional 100 acre-feet or more of capacity should have been lost by now. This would represent a 50 percent loss of the estimated capacity in 1972, which appears unrealistically high, based on observations by Refuge staff. The current maximum surface acreage is estimated at 197.

Figure 3.11 – Elevation & Contours

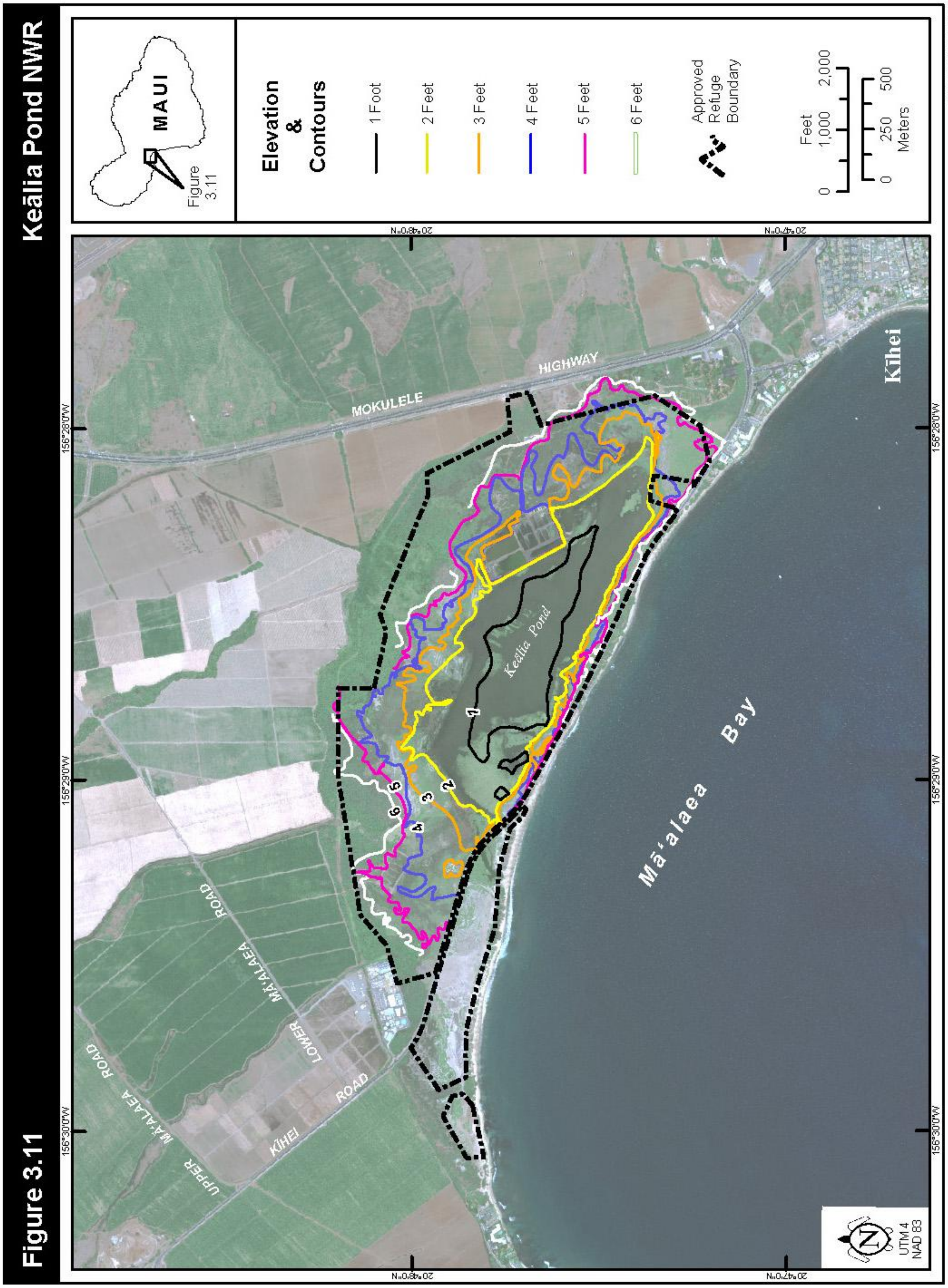


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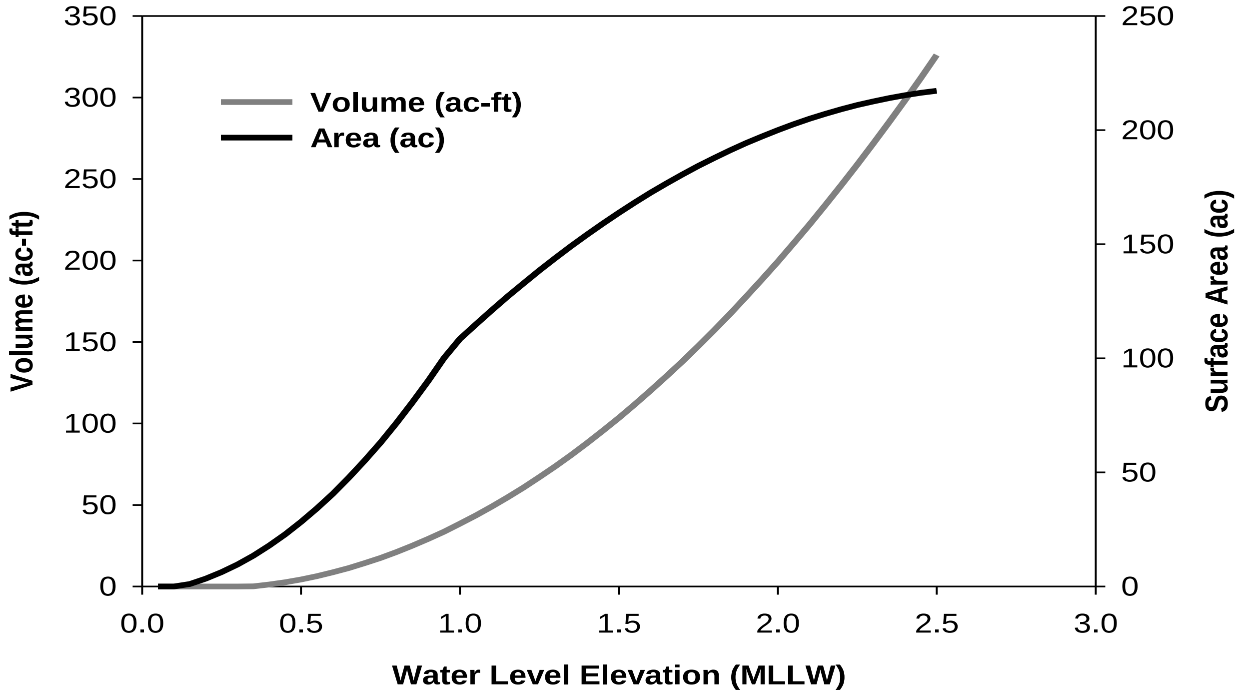
Figure 3.12. Pond volume and area as a function of water level elevation, USFWS 2000.



Changes in land use and water management upstream may have affected the sediment input to the Pond. Most of the sugarcane fields in the area were converted from furrow irrigation to drip irrigation in the 1970s. Engot and Vanna (2007) report that furrow-irrigation efficiency ranges from 0.3-0.7 while drip-irrigation efficiency ranges from 0.8-0.95. More efficient irrigation in recent years has likely reduced erosion and runoff into the Pond. Runoff through ditches from furrow irrigation may have contributed to small increase in sediment loads during non-rain events. However change in land use such cattle ranching in and adjacent to the Main Pond may have been the source of high sediment loads during rain events (Wilcox 1996).

3.6 Environmental Contaminants

A study of environmental contaminants at Keālia Pond NWR was completed in 1992, prior to its establishment as a Refuge. The purpose of the survey was to determine contaminant concentrations within and adjacent to the proposed acquisition boundary, specifically for pesticides, heavy metals, petroleum byproducts, and certain physical parameters (e.g., particle size of sediment). Given the history of the property and adjacent lands at the time, these analyses were essential in identifying the present and future quality of the wetland (USFWS 1992).

The chemical analyses for approximately 80 pesticides and related breakdown product residues were at levels below the analytical detection limits of the pesticide scan for samples within the Refuge boundary; therefore, no detectable levels of pesticides were reported for soil samples collected.

These results corroborate a 1986 contaminant survey of Keālia Pond which reported no detectable levels of pesticides, including lindane, heptachlor epoxide, heptachlor, aldrin, DDD, DDT, ametryn, and atrazine. These results suggest that soils at the Refuge are neither pervasively nor acutely contaminated with traditional persistent pesticides above analytical detection limits of the scan. These findings were unexpected given the long history of agriculture within the Waikapū watershed.

The study also included chemical analyses for 20 heavy metal compounds (mercury, lead, arsenic, cadmium, chromium, copper, nickel, selenium, and zinc) from soil samples. With the exceptions of cadmium, chromium, and nickel, the results did not indicate widespread or pervasive contamination by heavy metals within the Refuge. Detectable levels of these exceptions were thought to be due to the historical and then current use of the property by the military and aquaculture facilities (see Land Use section 3.7).

Site inspection screening was performed during this same period, concentrating in areas of historical use within and beyond the Refuge boundary, and areas used by the operational aquaculture facilities. Evidence of petroleum-based waste was observed; however, the sources were identifiable. These sites included areas around the old Maui airport at Māʻalaea Flats along with over 40 abandoned vehicles, and household and industrial items. Many of these sites were beyond the final boundary delineation; however, they remain in the wetland within a much larger watershed and pose a potential risk to wildlife and habitat. Following the contaminants survey and prior to the acquisition, most of the potential contaminant sites had been remediated by the landowner (A&B) or their tenants.

The aquaculture facility was in operation in 1992 and was also evaluated for contaminants. Unlabeled bags, bottles of chemicals, and oil patches in and around the former laboratory were observed. These were cleaned up or removed by the County of Maui in accordance with their lease agreement with A&B. The MEC surveyed their pole-mounted electrical transformers within the Refuge and replaced one transformer that contained regulated levels of polychlorinated biphenyls (PCBs). Currently, all transformers within the Refuge contain non-PCB fluid.

The Refuge will always be subjected to activities occurring in the upper watershed, thus it is beneficial to periodically re-evaluate the soils. For this reason, a contaminants study was conducted in 2001 to determine contaminant levels in superficial sediments throughout the Pond and streams that supply runoff and assess potential hazards to aquatic biota. Of the 129 possible contaminants, 12 tests resulted in detectable levels of organic contaminants (polyaromatic hydrocarbons, acetone, and methyl chloride). Polyaromatic hydrocarbons result from emissions of gasoline engines and municipal incinerators; whereas volatile organics (acetone) result from domestic and industrial solvents as well as emissions of gasoline engines. Although organic contaminants were detected in sediment samples, none of these contained concentrations above effects levels (Kilbride 2002).

Endangered waterbird and migratory bird tissue is sampled only when dead birds are retrieved from the wetland and submitted to the USGS National Wildlife Health Center in Honolulu. Aside from testing for avian diseases, the tissue is analyzed for lead. To date, lead has not been detected in birds from the Refuge. A small sample (10) of live tilapia was collected from Keālia Pond in 1999 to test for organic contaminants. Results indicated no detectable levels in the tissue. The fish in the Pond have yet to be sampled for metals but will need to be prior to consideration of any public fishing program.

Changes in upstream land use and presence of agricultural fields since the early 1900s have resulted in deposition of sediments within the soil profile of the Pond. The potential for contaminants entering into the Refuge will continue to be a concern and requires periodic monitoring to prevent accumulation into the habitat and wildlife species.

3.6.1 Molokini Contaminants

The USACE has designated Molokini and 157 acres of the surrounding waters as Unexploded Ordnance Removal, Formerly Used Defence Site, and confirmed the site has munitions and explosives of concern originating from military activities. The Navy was tasked to conduct a surface survey of Molokini. Two site surveys conducted in December 2006 and March 2007 found three ordnance items that had to be disposed of prior to the turnover of islet: a 250-pound old-style bomb, a 105mm projectile, and a 5-inch rocket with 3.25-inch motor. These items were destroyed in place.

3.7 Land Use

A diversity of land uses occur in the vicinity of Keālia Pond NWR, a majority of which is agriculture. The towns of Kīhei and Māʻalaea are nearby the Refuge to the east and west, respectively. One of the two power plants operated by the MEC borders the Refuge to the west. The Waikapū watershed, beyond the Refuge boundary, has residential and commercial development.

Since the early 1900s, sugarcane has been the predominant crop cultivated within the lower sections of the watershed and the fields surrounding the inland margins of the Refuge boundary. The three channelized streams that feed into Keālia Pond from West Maui Mountains have been diverted to irrigate the sugarcane fields creating minor flow to the ocean. Agricultural activities over the years have drastically altered the landscape of the watershed through excessive vegetation clearing and subsequent downstream sedimentation (Maciolek 1971, USFWS 1978).

The HC&S operates the only sugarcane plantation in Maui County and Hawaiʻi as a whole. The HC&S owns the 34,900-acre plantation surrounding Keālia Pond and produces over 172,000 tons of raw sugar annually. In addition, HC&S employs over 900 Maui residents. Currently, the company is researching new commercial uses of sugarcane, including alternative fuel (Maui County 2009).

On the northwest side of the Refuge boundary is the MEC's Māʻalaea Power Plant. The company's high voltage electric transmission line runs from the Māʻalaea Power Plant east towards Kīhei, between the Refuge's north boundary and the sugarcane fields.

The Puanani o Kula nursery, operating since 1989, is adjacent to the Refuge's east boundary. This landscaping operation grows both native and exotic plants on land leased from A&B. The KNUI radio transmitting facility is also located on their property.

The closest town to the Refuge is Kīhei, with condominiums starting across the eastern side of the Refuge along Māʻalaea Bay. Occupants of these buildings include full- and part-time residents and vacationers. Constructed in the early 1970s, the largest condominium is Sugar Beach Resort with more than 200 units. Continuing east, S. Kīhei Rd. follows the shoreline with commercial development (resorts, condominiums, businesses) and residential housing.

A couple of transportation corridors are adjacent to the Refuge. Mokulele Hwy. is 6.5 miles in length and situated north-south, connecting the towns of Kahului and Kīhei. The Refuge's entrance road is off this four-lane highway. The south boundary is bounded by N. Kīhei Rd. that bisects the Refuge from Māʻalaea Bay. This two-lane highway separates Keālia Pond (open water Pond and flats) from Māʻalaea Flats. The coastal property parallel with N. Kīhei Rd. is narrow, approximately 1.25 miles long, and owned by A&B from the road right-of-way to the high water line. This property continues westward to the Māʻalaea community along the south boundary of the Refuge's Māʻalaea Flats.

Land use beyond the Refuge's boundary includes the community of Māʻalaea, located more than 3 miles west of the Refuge. This area is primarily condominiums adjacent to Māʻalaea Harbor (developed in the 1950s) where numerous tour boats are docked. A new residential community at Māʻalaea (Ohana Kai Village) is currently under construction and will include 1,100 single-family homes within 257 acres at the intersection of N. Kīhei Rd. and Honoapiʻilani Hwy. and adjacent to Pōhākea Stream. A rock quarry and construction dump site is also located at this intersection on the southwest side of Pōhākea Stream.

The former Naval Air Station (NAS) Puʻunēnē is less than 1 mile northeast of the Refuge and topographically directly upgradient. This area is currently used for drag racing and is behind the National Guard's training center off Mokulele Hwy. Further up the gradient within the Waikapū watershed, beyond the sugarcane fields, is the town of Waikapū consisting of residential and commercial development. Area above the town's housing is too steep for development.

3.7.1 Previous Land Uses

The first Maui airport was constructed at Māʻalaea Flats in 1929. On November 11, 1929, the first scheduled air service from Honolulu to Maui was inaugurated. Planes used were eight-passenger Sikorsky S-38 Amphibians. Māʻalaea Airport was a level dirt field and was unusable in wet weather. In 1935 the Inter-Island Airways began adding 16-passenger Sikorsky S-43s to its fleet; however, the field was too small and too close to the mountains to meet desired safety criteria. Due to these safety concerns, the airport was moved to Puʻunēnē, a few miles north of the Refuge. Evidence of the paved runway from this former airport, now almost completely obscured by vegetation, can still be seen in the Māʻalaea Flats, beyond the Refuge boundary. A number of small concrete pads or foundations are in the vicinity of the airport runway. Two large concrete foundations, approximately 100 feet square, are on the west of the former runway (USFWS 1992).

During World War II (WWII), the military used Māʻalaea Flats for training activities. A concrete wall, approximately 100 feet long and 15 feet tall, oriented parallel to the shoreline with soil piled up to the top of the wall on the mauka side. The 1954 USGS Māʻalaea Quadrangle refers to this structure as a "Sea Wall". Longtime local residents remember this structure as a gunnery range used by the Marines for military training. The Navy used Molokini for target bombing practice because its size and shape was somewhat similar to a battleship.

Anecdotal information implied a potential landfill was located in Keālia Pond; however, the County of Maui Department of Public Works, whose file information on landfills begins in the late 1960s, has no information on this possible landfill. In addition, this landfill could not be located during the preacquisition contaminants survey conducted in 1992. Mink (2000) mentions the use of the area as a rubbish dump between 1925 and 1930 but there is no official record of this use. It is probable that illegal dumping of residential and commercial waste did occur, however.

In 1970, Fish Farms Hawai‘i leased 25 acres of land on the northern boundary of the Main Pond to harvest Malaysian prawn (*Macrobrachium rosenbergii*). Pacific Aquaculture Corporation purchased this commercial operation in 1972 (Shallenberger 1977). Due to poor water quality, prawn aquaculture ceased and Pacific Aquaculture Corporation began generating approximately 100,000 pounds of catfish (*Ictalurus punctatus*) annually. Cultivation of a catfish species (*Clarias* sp.) began in 1984 after Pacific Aquaculture Corporation sold the facility to Maui County. When Keālia Pond NWR was established in 1992, the aquaculture facility was called Keālia Fish Farm, Inc. This facility stopped operations on September 30, 1995, and Keālia Fish Farm, Inc. officially closed on December 31, 1995. The Refuge still uses these ponds; however, they have been redesigned for waterbirds and access by the public. In 2005 the Refuge hired a contractor to redesign the old Keālia Fish Farm ponds for bird use and installed water distribution lines.

On the west side, near the Mā‘alaea Power Plant, Maui County funded a project in 1978 to provide an alternate source of baitfish for the aku fishery. The project raised Cuban molly along with ‘ama‘ama (striped mullet) and ‘awa (milkfish). Funding for the project ended in 1987. The ponds were partially restored 1990-1998 when a County-funded program used the area. These small ponds (still called the Baitfish Ponds) are within the Refuge and managed for endangered waterbirds. In 2007, the Refuge combined the original six small ponds into one wetland management unit and installed a pump on the existing sump to flood the Pond, as needed. Use of the area within the Refuge boundary for cattle is evident from kiawe posts, barbed wire in forested habitat, and water troughs but the period in time is unknown (DeLeon 1987).

Molokini navigation aid beacon
© Forest & Kim Starr

3.7.2 Molokini Land Use

Molokini was withdrawn from lands ceded by the Republic of Hawai‘i to the United States of America and set aside by Territorial Governor W. F. Frear on September 13, 1910, to be administered by the USCG for lighthouse purposes. In 1911, a 16-foot-tall tower was erected on the southwest rim of the crater where it had a focal plane of 173 feet above the water. Rabbits were introduced some time around 1915 but apparently died out on their own by the 1960s.

In 1925, the Molokini light tower was replaced by another tower 187 feet above the water. This second light marked Molokini for 22 years until it was replaced in 1947 by another tower, which displayed an electric light powered by batteries stored in a shack built inside the base of the tower. In April of 1989, a powerful storm toppled the 1947 tower and sent it tumbling down the crater. The USCG erected a temporary beacon and later the metal pole and solar-powered Aids to Navigation System light that they currently maintain on the islet (Dean 1991).

The marine environment surrounding Molokini, beginning from the high water mark at the islet shorelines to depths of 180 feet (30 fathoms), has been designated by the State of Hawai‘i as the Molokini Shoal Marine Life Conservation District, managed by DLNR and further included in NOAA’s Humpback Whale National Marine Sanctuary.

Mā'alaea Flats Laura Beauregard/USFWS

Chapter 4. Refuge Biology and Habitat

This chapter addresses the biological resources and habitats on the Refuge. The chapter begins with a discussion of biological integrity. It then presents pertinent background information for each conservation target identified in the CCP.

4.1 Biological Integrity Analysis

The Administration Act directs the Service to ensure that the BIDEH of the Refuge System are maintained for the benefit of present and future generations of Americans. The Service's policy on BIDEH (601 FW 3) also provides guidance on consideration and protection of the broad spectrum of fish, wildlife, and habitat resources found on refuges, and associated ecosystems that represent BIDEH on each refuge.

Biological integrity lies along a continuum from a completely natural system to a biological system extensively altered by considerable human impacts to the landscape. No modern landscape retains complete BIDEH. However, we strive to prevent the further loss of natural biological features and processes. Maintaining or restoring biological integrity is not the same as maximizing biological diversity. Maintaining biological integrity may entail managing for a single species or ecological community at some refuges and combinations of species or communities at other refuges. Maintaining critical habitat for a specific endangered species, even though it may reduce biological diversity at the refuge scale, helps maintain biological integrity and diversity at the ecosystem or national landscape scale.

On refuges, we typically focus our evaluations of biological diversity at the refuge scale; however, these refuge evaluations can contribute to assessments at larger landscape scales. We strive to maintain populations of breeding individuals that are genetically viable and functional. Evaluations of biological diversity begin with population surveys and studies of flora and fauna. The Refuge System's focus is on native species and natural communities such as those found under historical conditions. We strive to manage in a holistic manner the combination of BIDEH. We balance all three by considering refuge purpose(s), Refuge System mission, and landscape scales. Where practical, we support the return of extirpated native species in the context of surrounding landscapes.

The BIDEH of the Keālia Pond NWR (Table 4.1) and its watersheds have undergone major alterations since pre-settlement times, primarily by agricultural practices and urbanization. There are ditches and sluice gates that were built at least 400 years ago to let fish such as awa and ʻamaʻama into the pond. Large-scale sugarcane and pineapple farming began sometime in the early 1900s, operations that eventually covered the lower elevations of central Maui. Any large acreage not in pineapple or sugarcane production was used for cattle ranching.

Little is known about the pristine coastal wet vegetation due to early Polynesian settlers creating fishponds and irrigated farmlands in the area. A small number of native plants still occur at Keālia Pond, but their distribution before introduction of nonnative species is difficult to reconstruct. By the early 1900s, upland conversion to farming dewatered streams that discharged into Keālia Pond. This would have reduced the size of the wetlands, increased salinity levels, and likely reduced plant diversity. The vegetated wetlands are now dominated by pickleweed. Native plants common in this habitat are kaluhā and ʻakulikuli with few pockets of makaloa and ʻele.

Statewide migratory waterfowl numbers have shown a large decline since the 1950s. At Keālia Pond, koloa māpu numbers fluctuated in the 1950s, but peak numbers are similar to the past 10 years. However, peak koloa mohā numbers had a large decline since the 1950s. Most of the common shorebirds inhabiting Keālia Pond may also occur in non-wetland habitats. At Keālia Pond, counts of kōlea , ʻūlili , ʻakekeke, and hunakai show no obvious trends.

Nonnative mosquito fish and tilapia are the dominant fish species in Refuge's Main Pond. We have monitored the fish population since the late 1990s. Large tilapia die-offs frequently occur when the water level recedes. The decomposing fish can produce a strong odor that permeates nearby neighborhoods. However, over the past several years, the biomass of dead fish has declined. This is probably due to recent drought conditions that reduced the residence time of deep water. Tilapia did not have sufficient time to grow and produce large populations as observed in the 1990s. In the past 5 years we had 3 fish kills, but the last major die-off occurred in 2005.

Table 4.1. Biological Integrity, Diversity, and Environmental Health Characteristics.

Habitats	Population/Habitat Attributes	Natural processes responsible for these conditions	Limiting Factors
Emergent wetland	Seasonal, semi-permanent, permanent Potential conservation species: endangered waterbirds, migratory waterfowl, and shorebirds	Periodic flooding; seasonal fluctuations/ drying, but more permanent water situations than typical seasonal wetlands	Pest species (California grass, California bulrush, marsh fleabane, pickleweed, red mangrove; mongoose, rats, cats and dogs); ditching, diked-impoundments; limited quantity and control of water resources; diverted and unpredictable surface water flow; and human development
Coastal mudflat	Seasonal Potential conservation species: endangered waterbirds and, migratory shorebirds	Periodic flooding; seasonal fluctuations/drying	Pest species (pickleweed, mongoose, rats, cats, and dogs); limited water availability and control; road kills of endangered species along N. Kīhei Rd.
Coastal dunes	Beach strand/dune communities Potential conservation species: seabirds, shorebirds, endangered ‘īlio-holo-i-ka-uaua and honu ‘ea, threatened honu	Onshore winds, salt spray, sandy soil, wave and tidal action	Pest species (marsh fleabane, kiawe, buffel grass); pickleweed, spiny amaranth, mongooses, rats, cats, dogs, human disturbance; marine debris, and SLR
Coastal dry forest and shrubland	Naupaka kahakai, hinahina, ‘ilima, nai‘o Potential conservation species: ‘ōka‘i ‘aiea, seabirds, shorebirds	Windblown accumulation of sand; seasonal flooding; salt spray	Pest species (kiawe, Guinea grass, Bermuda grass; marsh fleabane, rats, cats and dogs); human disturbance (squatting/camping); vehicular access and damage; wind and water erosion
Offshore islet	Seabirds, native plants Potential conservation species: seabirds, ‘ihi	Isolated eroding cinder cone; ocean winds, salt spray, volcanic tuff soil, wave action	Pest species (buffel grass and ants)

4.2 Conservation Targets

Conservation targets are those species or habitats that are most important to the management of the Refuge. Management for these focal species and the habitats that support them will benefit other native species that are present on the Refuge. Table 4.2 identifies the priority resources of concern for Keālia Pond NWR. As native species are referenced by their Hawaiian names, Appendix A contains a list of all scientific, English common names, and Hawaiian names.

Ae'o chick Laura Beauregard/USFWS

4.2.1 Conservation Target Selection

In preparing this plan, the Service reviewed other local, regional, and national plans that pertain to the wildlife and habitats of the Islands of Maui and Molokini. The Service also sought input from Hawai'i State conservation agencies, nongovernmental organizations, and the general public. The Refuge purpose (see Chapter 1) was reviewed as was the Refuge's contribution to maintenance of BIDEH. Potential management actions will be evaluated on their effectiveness in achieving Refuge goals and objectives for the priority resources of concern.

Table 4.2. Priority Resources of Concern.

Focal Species	Habitat Type	Habitat Structure	Life History Requirements	Other Benefiting Species
'Alae ke'oke'o	Flooded wetlands	Open water (< 18 in. depth)	Foraging, loafing	Migratory waterfowl, shorebirds, ae'o, and koloa maoli
	Emergent wetland	Hemi-marsh with kaluhā sedge	Nesting, brood rearing, cover	
	Mudflats	Moist, saturated soil	Foraging, loafing	
	Levees	Ground cover vegetation	Foraging, loafing	
Ae'o	Flooded wetland	Shallow water (< 7 in. depth)	Foraging, loafing	Migratory waterfowl, shorebirds, 'alae ke'oke'o, and koloa maoli
	Mudflats	Adjacent vegetation (cover) and shallow water	Nesting, brood rearing	
'Īlio-holo-i-ka-uaua	Beach areas; sand spits and islets, including all beach crest vegetation; inner reef waters; and open ocean	Sandy shoreline, rocky areas, and emergent reefs; as well as vegetated areas for shelter	Pupping, nursing, resting, and molting	Honu, honu 'ea, shorebirds, and seabirds

Focal Species	Habitat Type	Habitat Structure	Life History Requirements	Other Benefiting Species
Honu	Dunes and coastal strand; shallow, protected water with abundant aquatic vegetation; coral reefs; sand spits and islets; and open ocean	Open beaches with a sloping platform and minimal disturbance are required for nesting	Basking and nesting	ʻĪlio-holo-i-ka-uaua, honu ʻea, shorebirds, and seabirds
Honu ʻea	Dunes and coastal strand; shallow, protected water with abundant aquatic vegetation; coral reefs; sand spits and islets; and open ocean	Compacted sand; open beaches with a sloping platform and minimal disturbance are required for nesting	Nesting	ʻĪlio-holo-i-ka-uaua, honu, shorebirds, and seabirds
ʻŌkaʻi ʻaiea	Dry to mesic forest and shrubland; host plants such as *Nothocestrum* spp.; native nectar sources including koaliawa, *Ipomoea*, maiapilo, and ʻilieʻe	Sea level to 5,000 ft elevation, native shrubs and trees	Adult and larval feeding and reproduction	Native plants, moths, and butterflies
ʻIhi	Leeward coasts of Molokini and Kahoʻolawe; under extremely dry conditions	Volcanic tuff, loose rock at the base of sea cliffs and on steep rocky slopes	Propagation, germination, growth	Native plants, seabirds

Management of Refuge focal species and habitats that support them will benefit many of the other native and migratory species that are present on the Refuge. Our management priorities may change over time and since the CCP is designed to be a living, flexible document, changes will be made as needed and at appropriate times as identified by Refuge personnel. Our conservation targets for management are grouped by system and species (Table 4.3).

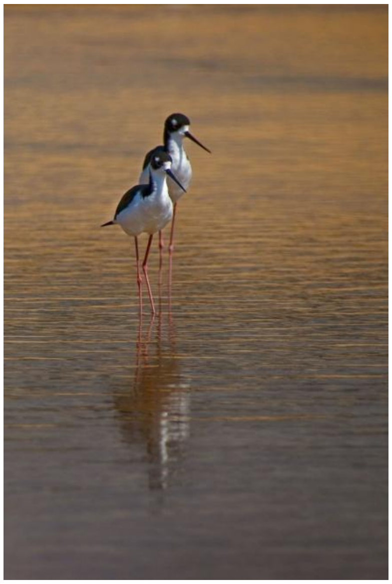
Table 4.3. Conservation targets for the CCP.

System Targets	Benefiting Resources
Wetland and deepwater habitat	Migratory waterfowl, shorebirds, and endangered waterbirds
Dunes habitat	‘Īlio-holo-i-ka-uaua, honu, honu ‘ea, shorebirds, and native plants
Upland shrub/forest habitat	Native plants and endangered ‘ōka‘i ‘aiea
Molokini islet	Native plants, nesting and roosting seabirds, and other migratory birds
Species Group Targets	**Benefiting Resources**
Endangered species	‘Īlio-holo-i-ka-uaua, ae‘o, ‘alae ke‘oke‘o, honu ‘ea, and ‘ōka‘i ‘aiea
Waterbirds	All waterbirds, migratory waterfowl
Shorebirds	All migratory shorebirds
Seabirds	All birds that frequent coastal waters and nest and/or loaf on Molokini

4.3 Endangered Hawaiian Waterbirds

Keālia Pond NWR was established to provide protected habitat for two of Hawai‘i’s endangered waterbirds, the ae‘o and ‘alae ke‘oke‘o. Statewide, the primary causes of their population decline include loss of wetland habitat, predation by introduced animals, altered hydrology, habitat alteration by nonnative plants, and disease. In addition, environmental contaminants may also potentially threaten populations in certain areas. No critical habitat has been designated for any of Hawai‘i’s endangered waterbirds.

The general recovery objectives for the endangered waterbirds, as described in the Draft Revised Recovery Plan for Hawaiian Waterbirds, are the following: stabilize or increase species populations to greater than 2,000 individuals; establish multiple self-sustaining breeding populations throughout their historic ranges; protect and manage core and supporting wetlands Statewide; eliminate or control the threat of introduced predators, diseases, and contaminants; and remove the Statewide threat of the koloa maoli hybridizing with mallards.



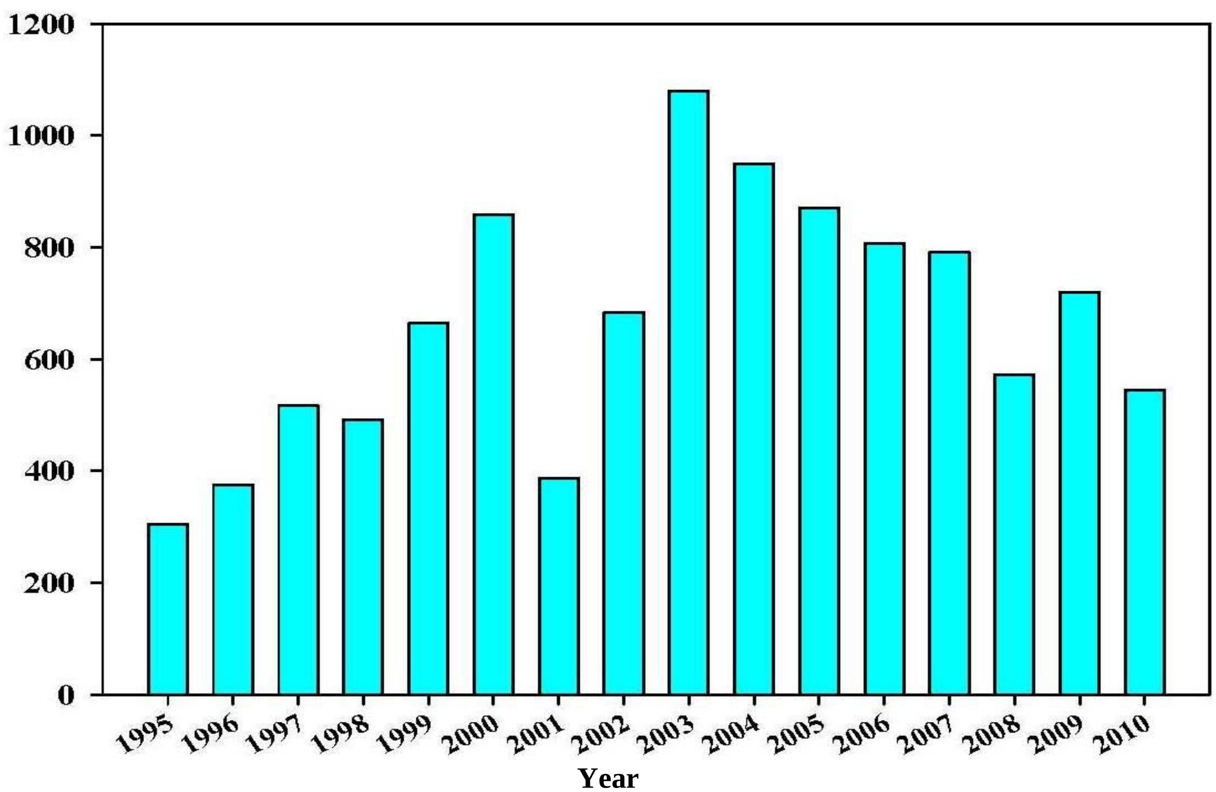
Ae'o pair © Brian Barker

4.3.1 Ae'o (*Himantopus mexicanus knudseni*) or Hawaiian Stilt

The ae'o is an endangered endemic subspecies in the Hawaiian Islands, which is part of a superspecies complex of stilts found in various parts of the world. The State population of this shorebird fluctuates between 1,200-1,500 birds with a 5-year average of 1,350 birds. Adult and juvenile dispersal has been observed both intra- and inter-island. As many as 1,079 ae'o have been observed at the Refuge at one time (Figure 4.1). The count of over 1,000 birds in 2003 was also 50 percent of the Statewide population criterion for delisting the ae'o (USFWS 2005, Robinson et al. 1999).

Ae'o favor open wetland habitats with minimal vegetative cover and water depths less than 9.4 inches, as well as tidal mudflats. Ae'o nest from April-July in simple scrapes on low relief islands or on exposed flats around the perimeter on the Main Pond after water has receded. They will use ephemeral wetlands to exploit seasonal abundance of food, feeding on small fish, crabs, polychaete worms, terrestrial and aquatic insects, and tadpoles. Known predators include barn owls, pueo (Hawaiian short-eared owl), mongooses, cats, rats, dogs, 'auku'u, cattle egrets, 'akekeke, laughing gulls, and large fish (Robinson et al. 1999, Rauzon and Drigot 2002).

Figure 4.1. Peak counts of ae'o at Keālia Pond, 1995-2010.



4.3.2 ‘Alae ke‘oke‘o (*Fulica alai*) or Hawaiian Coot

‘Alae ke‘oke‘o Laura Beauregard/USFWS

The ‘alae ke‘oke‘o is an endangered species endemic to Hawai‘i. The State population has fluctuated between 2,000-4,000 birds with the Maui population between 200-1,000 birds. Inter-island dispersal is most likely influenced by seasonal rainfall patterns, wetland condition, and food abundance. The highest count of ‘alae ke‘oke‘o at Keālia Pond was 1,126 birds in 2009 (Figure 4.2). Cats, dogs, and mongooses are the main predators of ‘alae ke‘oke‘o. Other predators include ‘auku‘u, cattle egret, and large fish. ‘Alae ke‘oke‘o are susceptible to avian botulism outbreaks (Brisbin et al 2002, USFWS 2005).

‘Alae ke‘oke‘o prefer freshwater ponds or wetlands, brackish wetlands, and manmade impoundments with open water that is less than 12 inches deep for foraging. They favor nesting habitat that has open water with emergent aquatic vegetation or heavy stands of grass. Nesting occurs mostly December-April when water partially floods emergent vegetation, with opportunistic nesting occurring year-round depending on rainfall. ‘Alae ke‘oke‘o will construct floating nests of aquatic vegetation, semi-floating nests attached to emergent vegetation, or in clumps of wetland vegetation. ‘Alae ke‘oke‘o feed on seeds and vegetative parts of aquatic and terrestrial plants, freshwater snails, crustaceans, tadpoles of marine toads, small fish, and aquatic and terrestrial insects (Brisbin et al. 2002).

Figure 4.2. Peak counts of ‘alae ke‘oke‘o at Keālia Pond, 1995-2010.

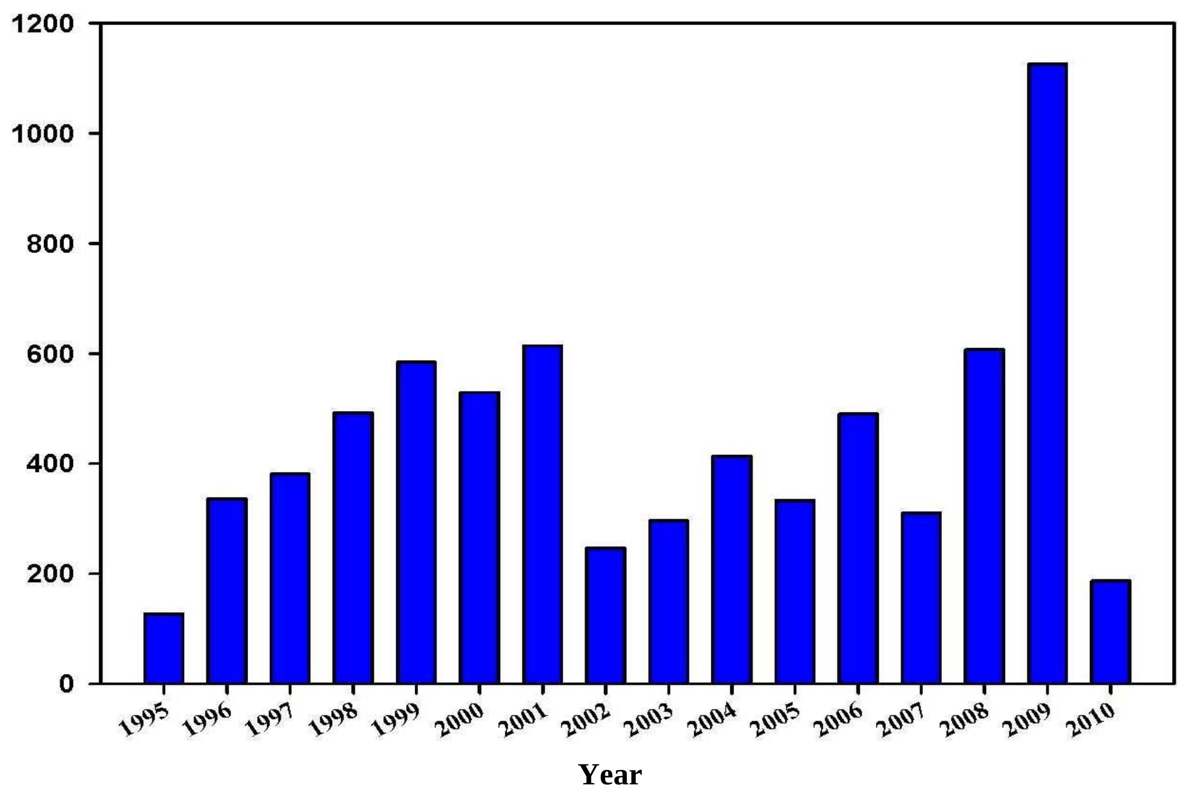


Figure 4.3 - ‘Alae ke‘oke‘o (Hawaiian Coot) Nesting Areas

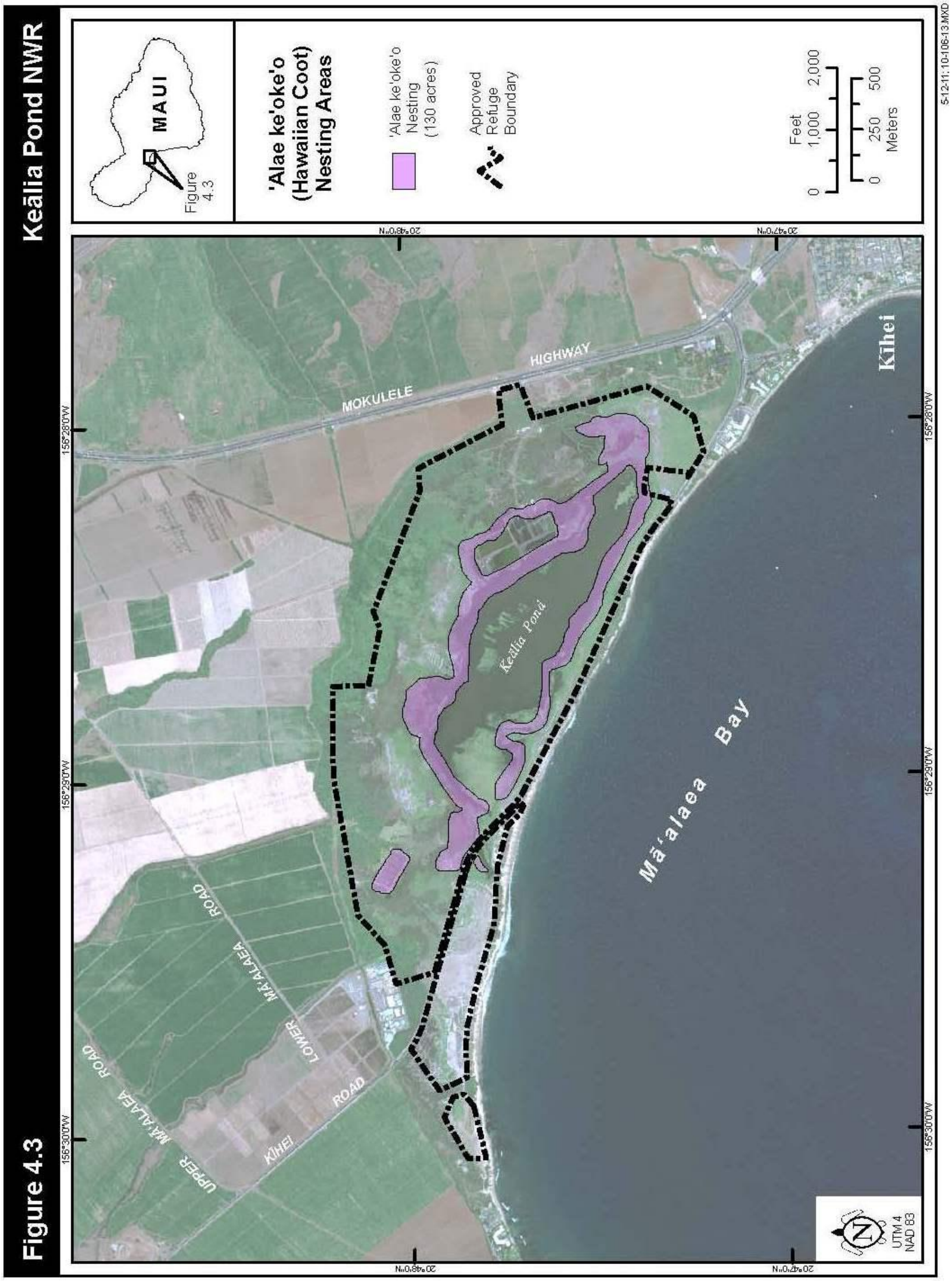


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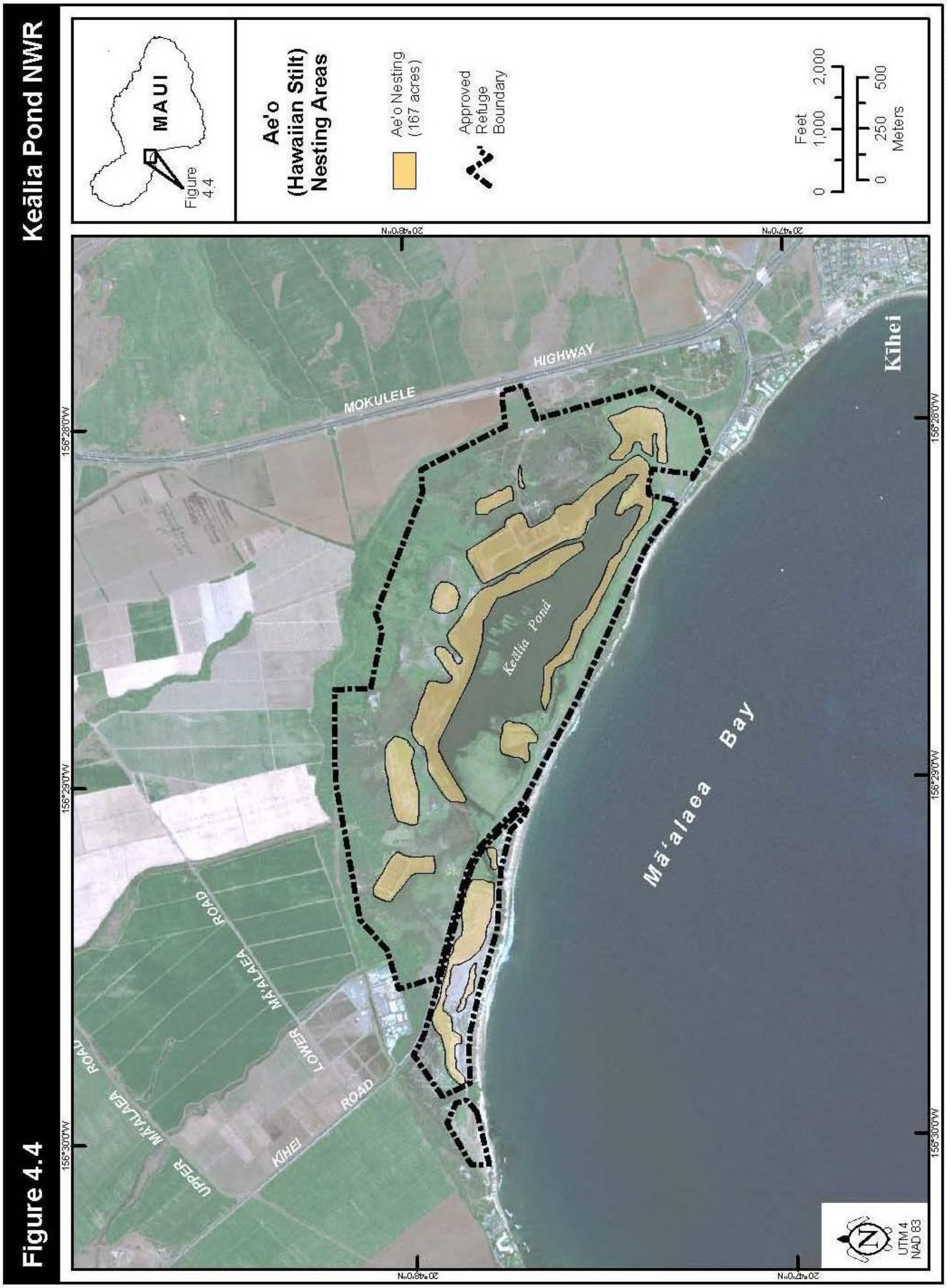
Figure 4.4 - Ae‘o (Hawaiian Stilt) Nesting Areas



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4.3.3 Koloa maoli (*Anas wyvilliana*) or Hawaiian Duck

Koloa-mallard hybrids Mike Silbernagle/USFWS

The koloa maoli is an endangered waterfowl endemic to the Hawaiian Islands. The former range of the koloa maoli includes all the main Hawaiian Islands except Lana‘i and Kaho‘olawe. The current Statewide population of pure koloa maoli is estimated at 2,200 birds. There is a high degree of threat due to hybridization with mallards, the greatest threat to this species' continued existence.

In 1989, 12 captive-bred koloa maoli were released on Maui; however, because mallards were not removed before the release, hybridization has resulted in more hybrids present on Maui than koloa maoli. The population of pure koloa maoli on Maui is probably fewer than 20 birds. In order for pure koloa maoli to successfully breed on Maui, the removal of all hybrids and domestic resident mallards in the State will need to occur. Birds on both O‘ahu and Maui are thought to be primarily koloa-mallard hybrids, with estimated counts of 300 and 50 birds, respectively (Engilis et al. 2002, Hawai‘i Audubon 2005, Uyehara et al. 2007).

The koloa maoli uses lowland wetlands, flooded grasslands, aquaculture ponds, and agricultural areas. The Refuge provides suitable habitat for foraging, loafing, pair formation, and breeding. Nests are placed in dense shoreline vegetation of small ponds, streams, ditches, and reservoirs. Types of vegetation associated with the nesting sites of koloa maoli include fetched and bunch-type grasses, rhizominous ferns, and shrubs. The diet consists of aquatic invertebrates, aquatic plants, seeds, grains, green algae, aquatic mollusks, crustaceans, and tadpoles (Engilis et al. 2002, USFWS 2005).

Known predators of eggs and ducklings include mongooses, cattle egrets, cats, dogs, and possibly rats and Samoan crabs. ‘Auku‘u and bullfrogs have been observed to take ducklings. Avian diseases are another threat to koloa maoli with outbreaks of avian botulism occurring annually throughout the State. In 1983, cases of adult and duckling mortality were attributed to aspergillosis and salmonella.

4.3.4 Nēnē (*Branta sandvicensis*) or Hawaiian Goose

The nēnē is a medium-sized goose endemic to the Hawaiian Islands. Adult males and females are mostly dark brown or sepia with a black face and crown, cream-colored cheeks, and a buff neck with black streaks. Females are smaller than males. Compared to other geese, nēnē are more terrestrial and have longer legs and less webbing between their toes. The nēnē was listed as endangered in March 1967, and is the State bird of Hawai‘i.

Nēnē Laura Beauregard/USFWS

Nēnē historically occurred in lowland dry forests, shrublands, grasslands, and montane dry forests and shrublands. Habitat preferences of contemporary populations are likely biased as preferences may be influenced by the location of release sites of captive-bred birds. Nēnē can be found from 0-7,900 ft (Mitchell et al. 2005, USFWS 2004).

In 1951, the wild nēnē population was estimated at 30 individuals. All populations since then are being supplemented by captive-bred birds. As of 2005, the population was estimated at between 1,300-1,500 individuals, with 295-325 birds on Maui. Four nēnē were observed at Keālia Pond in February 2009, however, they departed after a couple days. Keālia Pond has potential habitat for this species, providing forage within the flats north of the Main Pond (Mitchell et al. 2005).

Current threats include: predation by mammals; insufficient nutritional resources; a lack of lowland habitat; human disturbance; problems related to captive propagation; and inbreeding depression. Predators of nēnē eggs and goslings include dogs, cats, rats, and mongooses. Dogs and mongooses are also responsible for most of the known cases of adult predation. In recent years, nēnē have been struck and killed by golf balls and vehicles (USFWS 2004b).

4.4 Other Hawaiian Waterbirds

ʻAukuʻu looks for prey   Laura Beauregard/USFWS

ʻAukuʻu (*Nycticorax nycticorax hoactli*) or Black-crowned Night-Heron

The indigenous ʻaukuʻu is a cosmopolitan species resident to the main Hawaiian Islands. The black-crowned night-heron is a species of moderate concern in North America; however, ʻaukuʻu in Hawaiʻi are not given this designation. ʻAukuʻu feed throughout the Refuge. They breed in kiawe trees west of Kanuimanu Ponds.

The ʻaukuʻu is known to forage on crustaceans, insects, fish, frogs, and mice. They have been observed eating the eggs and young of the endangered aeʻo, koloa maoli, and ʻalae keʻokeʻo. Nesting occurs in colonies in December-May in Hawaiʻi. ʻAukuʻu are susceptible to human disturbance during nesting (Davis 1993, Mitchell et al. 2005).

4.5 Migratory Waterfowl

For centuries, migratory ducks, geese, and other waterfowl have wintered in the Hawaiian Islands from September-May. Up to 300 koloa mohā (Northern shoveler) and 200 koloa māpu (Northern pintail) have been counted at Keālia Pond. Other common winter migrants observed at the Refuge include green-winged teal, American wigeon, Eurasian wigeon, scaup, and mallard. Migratory mallards do not pose the same hybridization threats to koloa maoli as the domestic, resident mallards because they rarely breed during their winter stop-overs (Staples & Cowie 2001).

Koloa mohā © Michael Walther

Statewide surveys in the early 1950s estimated wintering populations of up to 8,000 koloa māpu and 2,000 koloa mohā. Surveys from the early 1980s have averaged less than 900 koloa māpu and fewer than 800 koloa mohā Statewide. At Keālia Pond, koloa māpu numbers fluctuated in the 1950s, but peak numbers ranged around 70-80 birds. In the last 10 years the counts had a similar range. Peak koloa mohā numbers in the 1950s at Keālia Pond were 400-600 birds. For the past decade, peak counts have ranged from 100-200 birds.

Waterfowl use the open waters of the Main Pond, vegetated wetlands along the pond shoreline, and the north ponds where open water is interspersed with emergent vegetation. Impounded wetlands provide habitat to a small number of waterfowl. Table 4.4 highlights attibutes, indicators, and conditions for Refuge management for waterfowl. Low fall/winter water level below the vegetated portion of Keālia Pond would restrict waterfowl populations to impoundments. Pest plant species that displace emergent vegetation reduce food and cover. Waterfowl are susceptible to avian botulism. Deterioration of water quality with increased urbanization would impact aquatic invertebrates needed by migratory waterfowl for food.

Table 4.4. Waterfowl Ecological Attributes, Indicators, and Condition Parameters.

Key Ecological Attributes	Indicators	Desired Conditions
Hydrology regime	•Water level	Water extends into emergent vegetation
Species abundance	•Population counts	Stable or increasing
Food availability	•Coverage of emergent vegetation •Abundance of invertebrates	•Stable or increasing coverage •High densities, but below nuisance level that affect neighboring communities

4.6 Migratory Shorebirds

The Pacific Island Region functions as essential migratory habitat for maintaining global shorebird populations. Keālia Pond supports one of the largest populations of migratory shorebirds in Hawaiʻi. Migration begins in August and most shorebirds leave by April. Abundant migrants include kōlea, ʻūlili, ʻakekeke, hunakai, pectoral sandpiper, and dowitcher. Shorebirds frequently use Māʻalaea Flats and the east portion of the Main Pond, however, the entire Refuge provides shorebird habitat.

ʻAkekeke forages during island visit © Michael Walther

Shorebird numbers have remained relatively stable with fluctuations depending on winter water levels. Vegetation control in the wetlands has provided shallow water habitat during years of high water. Shorebirds primarily use unvegetated mudflats, wetlands and tidal flats; however, estuaries, grasslands, and uplands are also important habitats. Grasslands and beaches are important habitats for the kōlea and the kioea (bristle-thighed curlew). Table 4.5 notes attibutes, indicators, and conditions for Refuge management for shorebirds. See Figures 4.5 and 4.6 for kōlea and ‘ūlili counts.

Table 4.5. Shorebird Ecological Attributes, Indicators, and Condition Parameters

Key Ecological Attributes	Indicators	Desired Conditions
Hydrologic regime	•Water level •Water coverage	•1.8 ft MLLW •80% coverage
Species abundance	•Counts	•Stable or increasing
Food availability	•Invertebrate density	•High density, but below nuisance level

Threats to shorebirds in the Pacific Region include habitat loss, pest plants and animals (predation, disease, and competition), human disturbance, and environmental contaminants. The kōlea is the most common shorebird in the Pacific Region, with Hawai‘i supporting a substantial portion of the Alaskan breeding population during winter. The kioea is the only migratory species that exclusively winters in the Pacific. Thus, the Pacific Region is considered to be a critical area for supporting hemispheric populations of both these species. Table 4.6 highlights the shorebirds of primary conservation importance in the Pacific region (Engilis and Naughton 2004).

Table 4.6. Shorebirds of Primary Conservation Importance in the Pacific Region

Species	Hawai‘i Winter Population	Regional Trend	Conservation Category
Kōlea	15,000–20,000	Unknown	High Concern
Ae‘o	1,200–1,600	Unknown	Highly Imperiled
Kioea	800	Unknown	High Concern
‘Ūlili	1,000	Unknown	Moderate Concern
‘Akekeke	5,000–7,000	Unknown	Low Concern

Threats specific to Keālia Pond include: fall/winter water level extending to the upper reaches of the wetlands; pest plant species encroaching onto unvegetated pond bottom; and deterioration of water quality with negative impacts to aquatic invertebrate densities.

Figure 4.5. Peak counts of kōlea at Keālia Pond, 1994-2006.

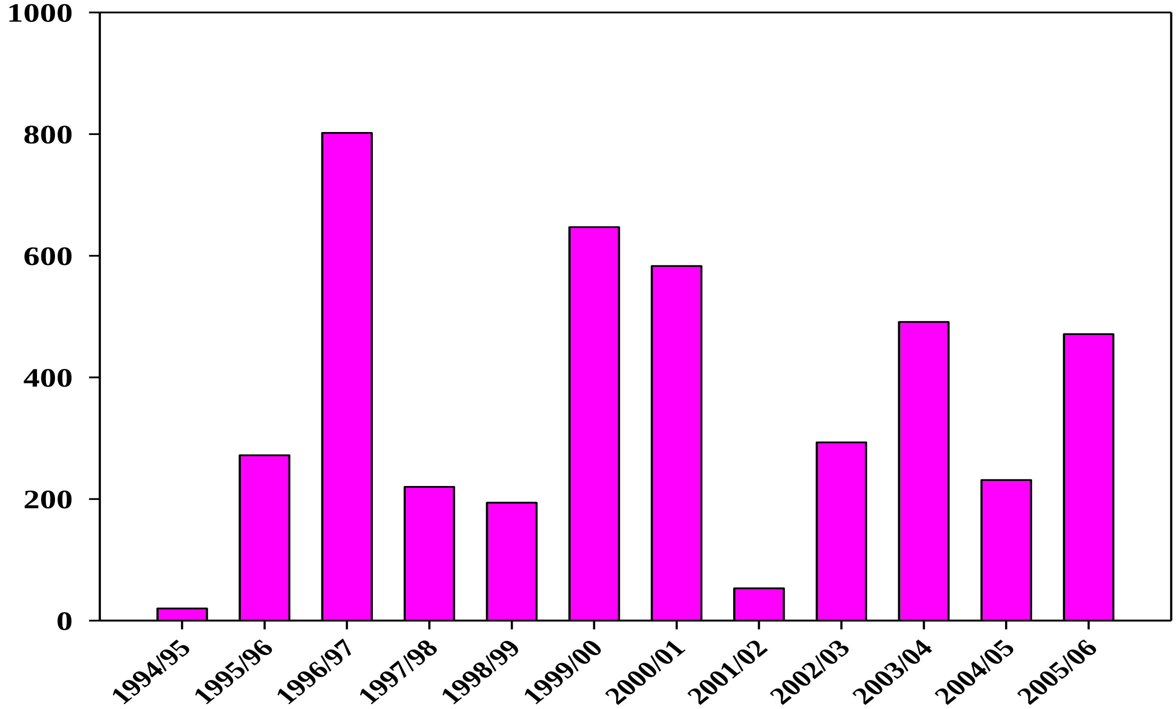
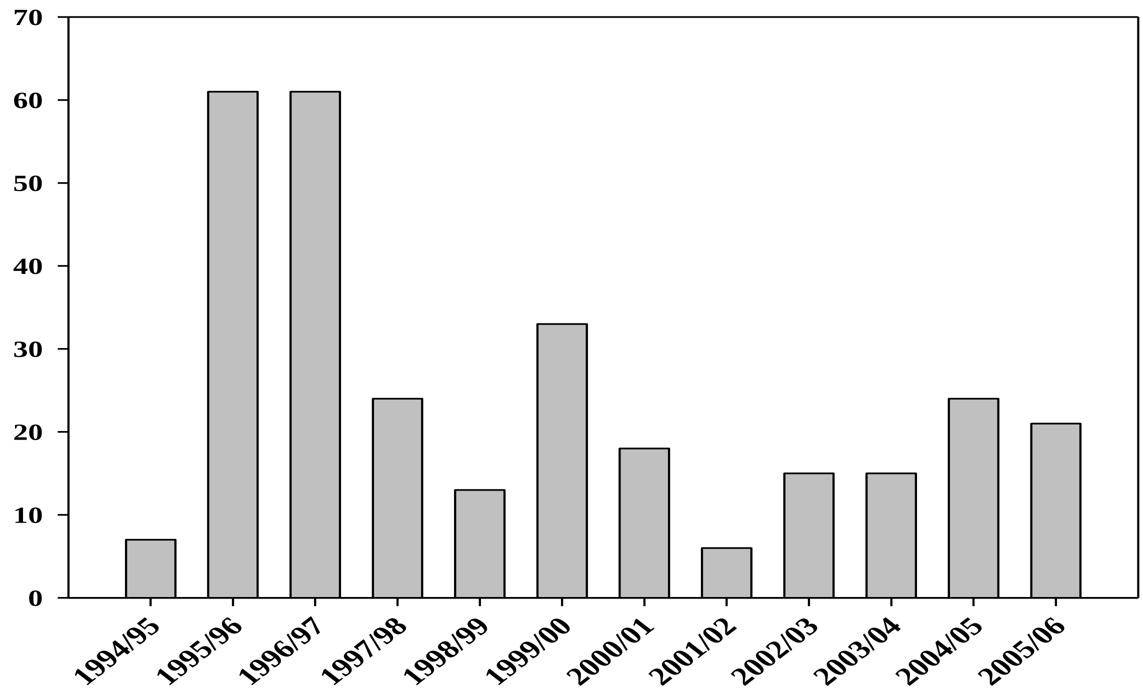


Figure 4.6. Peak counts of ʻūlili at Keālia Pond, 1994-2006.



4.7 Raptors

Barn owl © F. and K. Starr

4.8.1 Barn Owl (*Tyto alba)*

Barn owls were introduced to Hawai‘i in 1958 by the sugar plantations in an attempt to control rats. While they are excellent mousers, they also prey upon native birds. A night predator, both males and females have dark eyes in a heart-shaped facial disk. The legs are long and feathered with gray-colored feet (Denney 2010).

Pueo © Tom Dove

4.8.2 Pueo (*Asio flammeus sandwichensis*) or Hawaiian Short-eared Owl

Yellow eyes and a round facial disk differentiate this species from the Barn Owl. Unlike most owls, pueo are diurnal and are occasionally seen hovering or soaring over open areas. Like short-eared owls in continental environments, those in Hawai‘i primarily consume small rodents, insects, and rarely, birds. The Refuge offers breeding and foraging habitat for the pueo, although no nesting has been documented to date. Males perform aerial displays known as a sky dancing display to prospective females.

Found on all the main Hawaiian Islands from 0-8,000 feet, pueo are likely susceptible to the same factors that threaten other native birds, including loss and degradation of habitat, predation by introduced mammals, and disease.

4.8 Seabirds

Migratory seabirds are occasional visitors to the Keālia Pond NWR on Maui. With the inclusion of the Molokini Unit, nesting habitat for seabirds will also be within the Refuge.

Resting ʻuaʻu kani © Michael Walther

ʻOu in rock crevice Eric Vanderwerf /USFWS

4.8.1 ʻUaʻu kani (*Puffinus pacificus*) or Wedge-tailed Shearwater

ʻUaʻu kani are widespread throughout the tropical and subtropical Pacific and Indian Oceans. There are at least four large ʻuaʻu kani nesting colonies on Maui. All of these colonies are threatened with predation by cats and dogs, seriously decreasing fledging success. The dunes adjacent to Māʻalaea Flats has the potential for ʻuaʻu kani nesting and in 2010 calls were heard but nests were not located.

The largest colony occurs on Molokini where mammalian predators are absent and fledging success is high. Adult birds arrive in March to re-establish pair bonds and burrowing activity with a short hiatus in April before eggs are laid. A majority of the burrows appear to be remnants from the previous year's nesting season and, despite the rocky substrate, some burrows extend beyond arms reach. Other burrows are shallow and merely situated in rock crevices. In general, one egg is laid in June and hatches in July (incubation averages 50 days), and parental care is relatively long, lasting up to 3.5 months. During nesting, parents share duties with incubation and chick rearing (Whittow 1997).

4.8.2 ʻOu (*Bulweria bulwerii*) or Bulwer's Petrel

Indigenous to Hawaiʻi, ʻou have long pointed wings, a long pointed tail, a black bill, and pale short legs. They are known to nest in rock crevices on Molokini; however, the number of nesting pairs, active nests, and fledging success is unknown. It is not often seen due to its nocturnal habits and its small size makes it particularly vulnerable to predation by rats and barn owls on islands where these pests have been introduced (Megyesi and O'Daniel 1997).

Noio kōhā USFWS

4.8.3 Noio kōhā (*Anous stolidus)* or Brown Noddy

Noio kōhā are medium-sized, dark brown birds. Adults have an ashy-white forehead and crown sharply demarcated from black lores, merging evenly into gray nape. They have a long, narrow, wedged-shaped tail. The bill is black and stouter than the black noddy and the legs and feet are dark brown. Young birds have a more restricted white cap on forehead than adults. Noio kōhā are common in the NWHI, and also nest on several of the offshore islets. They typically remain near their breeding colonies year-round. Noio kōhā feed by diving for small fish. They often prey on the same fish as aku (skipjack tuna), and can be used to find tuna schools, leading to the common name "aku bird" (Chardine 1996, Berger 1972).

Noio Glen Fergus/USFWS

4.8.4 Noio (*Anous minutus)* or Black Noddy

Noio resemble the closely-related noio kōhā, but are smaller with darker plumage, a whiter cap, a longer, thinner bill and shorter tail. Noio nest from March-August on ledges of coastal cliffs and caves of the main islands and on several offshore islets. Nests are usually located in sea caves or on high ledges. One egg is laid each season, and nests are re-used in subsequent years. Chicks usually fledge in 5-7 weeks, although rearing of individual chicks may be prolonged during periods of low prey availability (Flint 1999).

Soaring ʻiwa USFWS

4.8.5 ʻIwa (*Fregata minor)* or Great Frigatebird

ʻIwa roost on several of the offshore islets, including Lehua, Mokumanu, and Molokini, and can be seen flying high in the sky almost anywhere in the main islands, but they are not known to nest on any of them. ʻIwa feet, like many seabirds, are located more posteriorly than land birds which makes walking difficult, but in the air they are graceful and acrobatic. ʻIwa means "thief" in Hawaiian and as their name suggests, they obtain food by piracy, chasing down other seabirds and forcing them to relinquish their catch (Flint 1999).

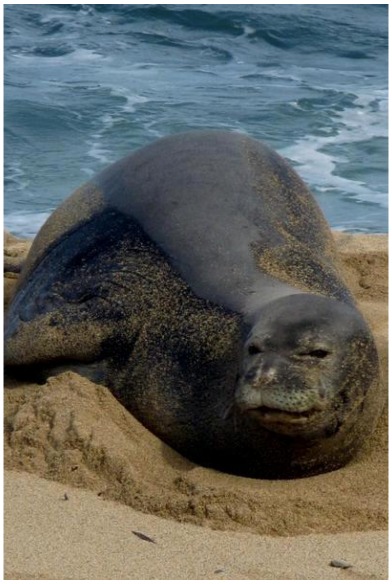
ʻIwa are known to regularly predate on ʻuaʻu kani chicks from shallow burrows on Molokini. State biologists have counted as many as 163 ʻiwa on Molokini, hunting and grabbing ʻuaʻu kani chicks.

4.9 Endangered Mammals

ʻĪlio-holo-i-ka-uaua (*Monachus schauinslandi*) or Hawaiian Monk Seal

ʻĪlio-holo-i-ka-uaua are among the most critically endangered mammals in the world. Only about 1,200 seals are alive today. Most seals live in the NWHI, but there is a small and potentially growing population of seals in the main Hawaiian Islands where a 2005 survey observed 76 individuals.

Its Hawaiian name means "the dog that runs in the rough seas." They frequently haul out on shorelines to rest and molt. Females also haul out on shore for up to 7 weeks to give birth and nurse their pups. Pups and moms stay ashore until weaned. Mating occurs in the spring and early summer.



ʻĪlio-holo-i-ka-uaua rests on beach
© Jim Collin/ AP

Gestation is approximately 1 year. Pupping occurs in late winter and spring. ʻĪlio-holo-i-ka-uaua can live to 25 years of age.
They feed on reef fishes, heʻe (octopus), squid, and lobsters down to depths of 1,000 feet. Juveniles feed on a higher proportion of nocturnal fish species. Food seems to be a limiting factor for population growth at this time. Terrestrial habitat is used about one-third of the time and requirements there include haul out areas for pupping, nursing, and resting, primarily on sandy beaches, but virtually all substrates are used. Beachside vegetation is used for protection from wind and rain.

Conflicts and interactions with a variety of ocean and beach users are becoming more frequent and significant in the main Hawaiian Islands. Dogs have attacked ʻīlio-holo-i-ka-uaua, and they carry diseases that are potentially lethal to them. Human disturbance, especially of mothers with pups, may be a threat at the Refuge.

4.10 Terrestrial Invertebrates

ʻŌkaʻi ʻaiea (*Manduca blackburni*) or Blackburn's Sphinx Moth

ʻŌkaʻi ʻaiea © James Bruch, KIRC

The ʻōkaʻi ʻaiea is one of Hawaii's largest native insects with a wing-span of up to 5 inches. Adults are overall gray with black bands across the top of their wings and five orange spots on each side of their abdomen. Caterpillars are large and populations contain two color morphs, bright green or gray. Both morphs have scattered white speckles across their back and a horizontal white stripe on the side of each segment. Caterpillars feed on plants in the nightshade family (Solanaceae), especially native trees in the genus *Nothocestrum,* but also on nonnative solanacious plants such as commercial tobacco, tree tobacco, eggplant, tomato, and Jimson weed. Adults have been observed feeding on the nectar of koaliawa. The dry upland forest provides habitat potentially suitable habitat for the ʻōkaʻi ʻaiea.

Believed to be extinct in the late 1970s, the species was rediscovered in 1984 on East Maui. Additional populations recently have been found on Kahoʻolawe, Lanaʻi, and the Island of Hawaiʻi. Historically, the species likely occurred on Kauaʻi, Oʻahu, and Molokaʻi as well. ʻŌkaʻi ʻaiea can be found across a broad elevational gradient from 0-5,000 feet. This native Hawaiian moth was the first Hawaiian insect to be added to the endangered species list. The Service is currently funding research examining its life history, captive rearing, and conservation biology (USFWS 2003).

4.11 Aquatic Invertebrates

Aquatic invertebrates are present in all wetland habitats with more species diversity in palustrine wetlands. Midges are seasonally abundant in all wetlants except Māʻalaea Flats and water boatmen are abundant in all habitats year-round. Midges were quantitatively sampled in 1997 and the first monitoring began the following year when the Main Pond had a density of 993 midge larvae per square yard. A large emergence occurred in 2000 when densities of 25,977 larvae per square yard were recorded. Monitoring showed a relationship between partial drying of the Main Pond and the pond filling the following winter. Water boatmen are a common invertegrate at Keālia Pond NWR may be a predominant food source for endangered waterbirds. Although abundant, they usually do not create a nuisance. For example, in 2007 the Refuge recorded a maximum of 48,462 water boatmen per square yard; however, the Refuge did not receive any complaints from neighboring residents reporting a nuisance. Inventories of other invertebrates included 92 families of both terrestrial and aquatic species. Five aquatic invertebrate families commonly occur in the Main Pond (Wirwa 2007).

4.12 Marine Reptiles

Honu ʻea Caroline Rogers/USGS

4.12.1 Honu ʻea (*Eretmochelys imbricata*) or Hawksbill Turtle

The endangered honu ʻea, or just ʻea, is one of the smaller sea turtles and takes its species name (*imbricata*) from the overlapping plates on its upper shell and its common name from the shape of its hooked jaw. The carapace (top shell) of an adult ranges from 25-35 inches in length and has a "tortoiseshell" coloring, ranging from dark to golden brown, with streaks of orange, red, and/or black.

Honu ʻea use different habitats at different stages of their life cycle, but are typically found around coastal reefs, rocky areas, estuaries, and lagoons. Its narrow head and jaws allow it to get food from crevices in coral reefs. They eat sponges, anemones, squid and shrimp. At night, from May-October, mature females (20-50 years old) crawl ashore and excavate chambers above the high-tide line, in which they lay their eggs. In 7-10 weeks the eggs hatch and the tiny hatchlings make their way to the surface and out to sea (Perrine 2003).

Little information exists on the feeding behavior of post-hatchlings and juveniles living in pelagic habitats, but most likely they are exclusively carnivorous (e.g., soft-bodied invertebrates, jellyfish, and fish eggs). Subadult and adult turtles residing in nearshore benthic environments are almost completely herbivorous; feeding primarily on limu (algae) and sea grasses. Marine debris can prove deadly when it entangles honu or is mistaken for food and ingested. Plastics are particularly harmful as they may remain in the honu's stomach for long periods of time, releasing toxic substances, and can clog the digestive system. Noise, lights, and beach obstructions are disruptive to nesting areas. Rats, mongooses, and dogs prey on the eggs (Perrine 2003).

4.12.2 Honu (*Chelonia mydas*) or Hawaiian Green Turtle

Honu Laura Beauregard/USFWS

The Hawaiian honu is listed as threatened under the ESA. The name “green turtle” is derived from the color of their body fat, which is green from the limu they eat. Adult honu can weigh up to 500 pounds and are often found living near coral reefs and rocky shorelines. Hawaiian honu grow slowly compared to other populations, with an average annual growth rate of approximately 0.5-2 inches. Turtles often reach sexual maturity at 35-40 years of age (Gardner 1996).

Females may lay up to 6 clutches per season, with each clutch containing about 100 eggs. Evidence shows that Hawaiian honu only migrate throughout the 1,500-mile expanse of the Hawaiian Archipelago, and so make up a discrete population. Hatchlings and juveniles live in pelagic waters. A majority migrate to French Frigate Shoals for nesting; however, within the past decade, there has been an increase in number of honu nesting on the main Hawaiian Islands. There are a few periodic reports of nesting honu on Maui prior to 2000 but it was not until that year when a female nested regularly (every 2 years) until 2008. Between 2000 and 2010, there has been at least one female nesting on Maui.

The same threats face honu as the honu ‘ea. Sea Turtle Dawn Patrol volunteers conduct early morning walks on Mā‘alaea Beach from June-September to look for turtle tracks from the previous night. Once observed, they contact the Refuge or DAR who are partners in the Maui sea turtle monitoring program. Through this program, researchers collect information on clutch size, hatching and emergence success, and genetics.

Honu and honu ‘ea crawling ashore to nest suffer fatalities when they start crossing roads. State DAR staff reported turtle fatalies by vehicle prior to 1992. Since the refuge was established, fatalities occurred in 1993 and 1996 and more recently in 2009 when hatchlings (emerging from nests next to the North and S.Kihei Roads) were attracted to lights across the road and were run over. These losses prompted the Service to collaborate with A&B to install a fence within the coastal strand parallel with N. Kihei Rd. The Refuge maintains the turtle fencing along the coastal strand to prevent adult turtles from entering onto the road.

New adult turtle fence Laura Beauregard/USFWS

4.13 Native Plants

Native Hawaiian plants arrived to the archipelago via natural means such as wind, water, or birds. According to Wagner et al. (1999), the native Hawaiian flora is comprised of roughly 956 species within 87 families. Approximately 89 percent of these species are endemic (found only in Hawaiʻi), while the remainder are indigenous (naturally found in Hawaiʻi and elsewhere). Since their establishment, populations of Hawaiʻi's native vegetation have greatly declined. Few native plants have escaped the impacts of urbanization and agriculture on the coastal and lowland habitats. Coastal alterations such as agriculture, residential developments, recreational parks, military installations, golf courses, and roads, have permanently displaced much of the native flora. With potential expansion of the Refuge at Māʻalaea Flats and Molokini, protection and outplanting will improve the native plant diversity and distribution (Cuddihy and Stone 1994).

Although the Refuge was designed to protect waterbirds, native plant species do occur. Several restoration efforts have contributed to native plant populations. Native species planted include ʻakiʻaki, ʻakulikuli, kaluhā, naio papa, ulei, naupaka, akia, and makaloa. A 2006 botanical survey of Maui's offshore islets included a visit to Molokini. Native species pāʻūohiʻiaka (*Jacquemontia ovalifolia*) and ʻilima (*Sida fallax*) were found scattered about the islet. It was noted that the diversity of plants increased in open areas not dominated by invasive buffel grass. Along the lower portions of the islet, close to the ocean, ʻena ʻena, ʻakulikuli, ʻōhelo kai, and ʻihi were found. Of the 35 plant species observed during the survey, 9 (26%) were native and 26 (74%) were not.

ʻIhi (*Portulaca molokiniensis*)

The extremely rare coastal ʻihi grows on volcanic tuff on Molokini. It is a low-lying herb with thick, fleshy green leaves and small, bright yellow flowers. Federally listed as a species of concern, ʻihi is currently found in low numbers on Molokini, ʻAleʻale, and Puʻukoaʻe islets; as well as Kahoʻolawe.

It was first collected in 1913 by Charles Forbes who identified it as *Portulaca aff. lutea*. Robert Hobdy described it as a distinctly new species, *Portulaca molokiniensis,* in 1982, noting that it differs from *P. lutea* "in its conspicuous vegetative growth and larger leaves, and especially in its dense head-like clusters of flowers and spinose seeds." During the 2006 botanical survey, ʻihi was observed in a thicket of buffel grass. Restoration plans include carefully removing nearby pest grasses, allowing the ʻihi to spread. Additional plants could be propagated through seeds or cuttings and out-planted in areas free of buffel grass.

ʻIhi with buffel grass nearby © Forest & Kim Starr

4.14 Pest Species

For the purpose of this CCP, a pest species is defined as a species whose migration and growth within a new range is causing detrimental effects on the native biota in that range. Mammals, birds, fish, amphibians, invertebrates, and plants can all be considered invasive. These species become invasive because their population and growth are no longer balanced by natural predators or biological processes that kept them in balance in their native ecosystems. In the absence of these restraints, invasive species have the potential to compete with native species for limited resources, alter or destroy habitats, shift ecological relationships, and transmit diseases. Native species as well as nonnative species can become invasive when their natural ecosystem is out of balance.

Pest species are one of the most serious problems in conserving and managing natural resources. In particular, the ecological integrity of Pacific Island environments is greatly threatened by invasive species. Hawai‘i, which existed in isolation for millions of years, is an exceptionally ideal environment for these species. Most native species lost their natural defense mechanisms and are more vulnerable to introduced species (Pattison et al. 1998, Ikuma et al. 2002, Middleton 2006).

4.14.1 Mammals

Rat (*Rattus* spp.)

Three rat species are found throughout the Hawaiian Islands. Polynesian rats arrived from the central Pacific 1,500 years ago with the Polynesians; Norway rats reached the Hawaiian Islands after the arrival of Captain Cook in the 1770s; and black rats most likely arrived in the 1870s. It is estimated that these three species have populated nearly 82 percent of the major islands.

Black rat © Jack Jeffrey

Polynesian rats and Norway rats nest exclusively in terrestrial habitats, while black rats are arboreal nesters. This nesting difference may contribute to a larger population of black rats in Hawai‘i due to the presence of nonarboreal mongoose predators (Tobin and Sugihara 1992, Hays and Conant 2007).

All three species in Hawai‘i are known predators of eggs, nestlings, young, and occasionally adults of endangered waterbirds, seabirds, migratory shorebirds, and forest birds. Ground- and burrow-nesting seabirds are particularly vulnerable to rat predation, even by the arboreal black rat. Rats also consume plants, insects, mollusks, herpetofauna, and other invertebrates. Because these prey species are also eaten by birds, a reduction in these populations may indirectly affect avian populations (Olson and James 1982, Harrison et al. 1984, Brisbin et al. 2002, Engilis et al. 2002, Mitchell et al. 2005).

The use of snap-traps and ground-based application of diphacinone rodenticide to control rats in the main Hawaiian Islands has shown a positive effect in native bird survival. Rat control is conducted year-round near public use areas at Keālia Pond NWR with various methods including the use of live-traps and snap-traps.

Mongoose on the prowl © Chuck Babbitt

Small Indian mongoose (*Herpestes javanicus*)
The small Indian mongoose was intentionally introduced to numerous island ecosystems during the 1800 and 1900s and has since expanded to large portions of Asia, Africa, Europe, Oceania, and the Americas. In 1883, the species was introduced to the main Hawaiian Islands as a biocontrol agent against rats in sugarcane fields. The mongoose inhabits all habitat types from 0-10,000 feet on the islands of Hawai‘i, Maui, O‘ahu, and Moloka‘i. In other areas of the world, mongooses appear to avoid wet areas; however, in Hawai‘i, dense populations of mongooses are concentrated in wet habitats.

The home range of a female in Hawai‘i is about 3.5 acres, and the main reproductive period occurs from February-August. The high density of mongooses in the Hawaiian Islands is due to abundant food and the lack of natural predators. They are voracious omnivores, consuming insects, reptiles, mammals, amphibians, crabs, plants, and birds. In Hawai‘i, mongooses are diurnal predators that primarily eat invertebrates and secondly small mammals. They are a major threat to any ground-dwelling and -nesting species in Hawai‘i. These mammals are known to eat eggs, young, and adults of endangered waterbirds, seabirds, and shorebirds. In addition, mongooses are known to consume young honu (Staples and Cowie 2001, Mitchell et al. 2005, Hays and Conant 2007).

Mongoose populations have been managed at the refuge since 1996 using traps near waterbird nesting areas during breeding seasons.

Cat (*Felis catus*)
Cats arrived in Hawai‘i in the early 1800s on European ships and are now found on all the main Hawaiian Islands from 0-10,000 feet. They are frequently observed on the Refuge and are occasionally caught in our trapping program.

Cats are natural hunters with their sharp teeth; the upper teeth overlap the lower, giving them a firm grasp to shake or tear prey to death. Food habits of cats in Hawai‘i include insects, centipedes, crustaceans, lizards, mice, rats, bird eggs, and birds (Scott and Thomas 2000, Mitchell et al. 2005).

Neutered and released cat with endangered waterbird © Michael Walther

Dog (*Canis lupus familiaris*)
The dog is a domesticated form of the gray wolf, a member of the Canidae family of the order Carnivora. Abandoned, escaped, or pet dogs allowed to run loose can cause great harm to native species and ecosystems. Dogs have caused terrible damage to native ground-nesting seabird colonies. Dogs typically attack a large number of birds in a single incident by grabbing and shaking the birds around with their mouths and leaving them for dead before heading to another nest or burrow.

Axis Deer (*Axis axis*)
Axis deer originate from India and are also known as cheetal deer. Its coat is reddish-brown, marked with white spots, and its underparts are white. It stands about 3 feet tall at the shoulder and weighs about 185 pounds. Its lifespan is 20-30 years. It has a protracted breeding season due in part to the tropical climate, and births can occur throughout the year. For this reason, males do not have their antler cycles in synchrony and there are some fertile females at all times of the year. In 1959, nine deer were introduced to Maui by the Territorial Legislature for increased hunting opportunities and to provide subsistence for island residents. In 1968, the Maui population was estimated to be 85-90 animals. Today, reports of deer sightings occur throughout Maui from Hāna to Kapalua with numbers estimated in the thousands. The growing population of axis deer has created a number of concerns ranging from vehicle accidents, poaching, ecosystem damage, and disease to crop damage (Maui Axis Deer Group 2002).

4.14.2 Birds

There are a number of nonnative species that have been introduced through human activity. Maui's native birds coevolved in isolation and developed specialized life history requirements in order to minimize competition. Most of the nonnative birds have been introduced just within the last 100 years and use the same habitats, eat the same foods, and use similar foraging strategies as our native birds. Direct competition for limited food and habitat is a serious issue. These species are resistant to avian pox and malaria and may serve as carriers for transmitting these devastating diseases.

Nonnative bird species are fairly common to abundant, and also play a role in spreading the seeds of pest plants into native habitats. More study is needed and close monitoring is critical. One of the nonnative birds identified as a pest species is the cattle egret.


Cattle egret
Laura Beauregard/USFWS

Cattle egret (*Bubulcus ibis*)
The cattle egret was introduced to Hawai‘i in 1959 from Florida for insect control on cattle and has become widespread. Rookeries were documented on Ni‘ihau, Kaua‘i, O‘ahu, Hawai‘i Island, Moloka‘i, Lana‘i, and Maui by the mid-1980s. Cattle egrets were known to roost and nest in stands of red mangrove (now removed) east of Kanuimanu Ponds and in kiawe adjacent to the access road to those ponds.

Its diet primarily consists of grasshoppers, crickets, spiders, flies, frogs, and nocturnal moths, but the bird will also consume prawns, mice, crayfish, and the young of native waterbirds. Cattle egrets have been documented taking chicks of all endangered waterbirds species occurring on the Refuge. If numbers increase and predation on endangered waterbirds exceeds our target limit, population control measures identified in the IPM will be implemented (Brisbin et al. 2002, Engilis et al. 2002, Hawai‘i Audubon Society 2005).

4.14.3 Amphibians


Cane toad   Laura Beauregard/USFWS

Cane toad (*Bufo marinus*)
Cane toads or Pacific giant toads, which are native to Latin America, have a broad geographic range that includes a majority of the Pacific region. The toads were brought to the Hawaiian Islands in 1932 to control insect pests. The adults only require water for breeding, an event which results in thousands of eggs per mating occurrence. Cane toads are active at night and primarily feed on cockroaches, crickets, grasshoppers, grubs, earthworms, slugs, spiders, centipedes, and snails. In addition, these highly invasive amphibians could be a potential predator of endangered waterbird eggs and young (Yamamoto and Tagawa 2000, Staples and Cowie 2001).

4.14.4 Invertebrates

Although the Hawaiian Islands support a large number of native invertebrates, wide arrays of pest invertebrates have invaded marine and freshwater habitats.

Spotted-winged midge (*Polypedilum nubifer)*
A common, widely-distributed insect in tropical and subtropical waters, the spotted-winged midge is a nonnative aquatic invertebrate that was first identified on O‘ahu in the 1940s. It is unknown when the species first appeared on Maui but accounts from lifetime residents indicate that similar flying insects existed on Maui long before midges were initially identified in 1997 by Bishop Museum when the nuisance issue arose. This midge species' life history is comprised of a larvae form in the upper layer of the pond sediment and a flying adult. Larval midges pass through four instars (or phases) with individuals increasing in size in successive instars. Larvae are present in the top aerobic layer of pond sediment where they feed on detritus and algae. At the completion of the fourth instar, the midge larvae undergoes a metamorphosis, travels up through the water column and emerges as a flying insect. Upon emergence, the adult's objective is to mate, lay eggs, and die. A common behavior during this period is for adults to congregate, or swarm, increasing their changes to find the opposite sex. When the weather is calm, this behavior can be seen from a distance – a black column that can rise to great heights.

Adults are not strong flyers and are attracted to light sources (and thus the nuisance aspect for neighboring condominium residents). The length of the adult stage of this species is unknown: however, studies on other midge species report that the adult life-span ranges from 3-5 days, with the primary objective of reproduction. Once eggs are laid the adults die. Egg capsules will attach to vegetation, or any structure in the pond, or are observed floating on the water surface. Upon hatching, the first instar larvae move down through the water column to the pond sediment and the cycle continues. The larvae-to-adult cycle is approximately 3 weeks, plus or minus a few days.

Midges are important in the diets of endangered waterbirds and are not considered a pest for the recovery of the endangered Hawaiian waterbirds. At Keālia Pond, the spotted-winged midge has received the attention of nearby residents when there are more than sufficient populations of midges to support waterbirds and swarms are attracted to artificial light sources. Therefore, to reduce impacts to adjacent residences, a variety of studies have been conducted since 2000 to moderate large emergences through habitat manipulation. Several insecticides were tested during this period and methoprene, an insect growth regulator, was found to provide relief to adjacent residents. There are no other products with similar results so its application must to be carefully monitored to reduce the potential that midges would become resistant to it. Recent observations show promise that moderately low water level during the winter months reduces midge production below nuisance levels.

Ants

Hawaiʻi is one of the few places on Earth believed to harbor no native ant species. Today, at least 47 ant species in 7 subfamilies and 24 genera have become established. Ants are a growing concern since they can have negative effects on native and endangered plants and animals. Ants are known to attack, injure, or kill young birds. Ants are also implicated in having negative effects on native and endangered plants. Control of ants has potential on the Refuge to protect trust resources. The Service is currently studying the efficacy of various baits and approved toxins on pest ants on Oʻahu and Johnston Atoll. It is anticipated that the Refuge will adopt IPM methods to control ants based on the results of these studies.

4.14.5 Plants

At the ecosystem level, pest plants have been shown to be capable of changing fire regimes, altering nutrient cycling patterns, and modifying the surface runoff of water. Nonnative plants can physically displace native species, and/or supersede them in competition for water, nutrients, or other limited resources. They can provide habitat for pest animals such as rookeries for cattle egrets in stands of kiawe or red mangrove. They can also be vectors and hosts for introduced pests and diseases to which the native species lack natural defenses. Almost half the flora of the Hawaiian Islands is comprised of naturalized nonnative plants, approximately 1,100 species. According to Staples and Cowie (2001), pest plants in Hawaiʻi share the following biological and reproductive characteristics:

- Adaptable to and capable of thriving in different habitats;
- Tolerant of variable conditions (such as light, temperature, moisture);
- Fast growing;
- Tolerant of disturbance;
- Easily dispersible to new localities by seeds, fruits, spores, or vegetative parts;
- Produce small seeds/spores early in life;
- Long reproductive periods; and
- Dispersed by animals and with no special germination requirements.

The control and eradication of pest plants has been the top priority of natural resource managers in Hawaiʻi. In the wetland habitats of the Refuge, pest plant species can drastically reduce the value of wetland habitat to native species. Pest species outcompete more desirable plant species here, as well as invade openwater and mudflat habitats. In addition, the high biomass characteristic of pest grasses produces a high amount of fuel for fire. A combination of IPM techniques are employed at Keālia Pond including chemical, mechanical (hand and tractor), prescribed burns, and water level manipulations. Restoration efforts are continuous. Pest plants on the Refuge include California grass, California bulrush, Indian marsh fleabane, kiawe, Mexican fan palms, red mangrove, and the large acreage of pickleweed covering the mudflats. Pest plants targeted for removal on Molokini include buffel grass, golden crown-beard, sourbush, Indian marsh fleabane, koa haole, and sandbur.

California grass (*Brachiaria mutica*)
California grass is a sprawling perennial with culms up to 19 feet long. Stolons and leaf sheaths are densely hairy. It is suspected to have originated in sub-Saharan Africa and occurs pantropically as a pasture grass. California grass occurs in aquatic environments and is reported to be well-adapted to a wide range of soil conditions (sandy to clay). It tolerates moderate shade but prefers full sun (Cook et al. 2005).

California grass Mike Silbernagle/USFWS

It grows prolifically in wetland habitats, but it can also withstand severe drought. In addition to displacing native plants, California grass alters and destroys aquatic environments, causing a reduction in bird habitat. The grass also interferes with streamflow and poses a nuisance to marine navigation when rafts of the grass float out to sea. The Hawai‘i-Pacific Weed Risk Assessment, conducted by University of Hawai‘i (UH) and the U.S. Forest Service, identifies California grass as “documented to cause significant ecological or economic harm in Hawai‘i” (Stone et al. 1992, Motooka et al. 2003).

Indian marsh fleabane (*Pluchea indica*)
Indian fleabane is an erect shrub that grows up to 6.6 feet tall. It is native to temperate and tropical Asia and northern Australia and is naturalized elsewhere. In Hawai‘i, it occurs in lowland, coastal habitats such as wetlands and fishponds. Initially recorded on O‘ahu in 1915, Indian fleabane has been identified on Maui, O‘ahu, Kaua‘i, and Ni‘ihau. It prefers marshes and saline soils (Motooka et al. 2003, GRIN on-line database).

Pluchea indica Mike Silbernagle/USFWS

Indian fleabane will out-compete native sedges on the Refuge, reducing forage and nesting habitats for birds. It tends to harbor huge nests of paper wasps, which are a hazard to Refuge staff and the public. The Refuge uses mechanical and chemical techniques to control this pest species.

California bulrush (*Schoenoplectus californicus*)
California bulrush is a perennial sedge found in marshy areas from southern and western North America to South America. It has tall, thin, dark green stems which are usually triangular in cross-section and woolly, bristly tan or brown flowers in panicle inflorescences. It has characteristics common in the sedge family, such as creeping. It is intolerant of shade, but can spread rapidly by vegetative means (Wagner et al. 1999, NRCS 2008).

California bulrush Mike Silbernagle/USFWS

Pickleweed (*Batis maritima*)

Pickleweed, native to tropical and subtropical America and the Galápagos Islands, is a maritime shrub that grows up to 2-3 feet long. The stems are cylindrical with small succulent leaves and tiny green flowers. The fruit is red, and is spread by floating across the water surface.


Pickweed at Kanuimanu ponds USFWS

Extremely invasive, pickleweed grows so thickly that it can prevent young birds from moving between Refuge ponds in attempts to gain access to foraging areas. In a 2004 partnership with Ducks Unlimited, levees were built up and widened to prevent flooding. Slopes were formed to provide shallow water when ponds were full. Prior to the work, all pickleweed plants were removed and Refuge volunteers have out-planted native vegetation on the levee slopes. Pickleweed also remains a pest species in the mudflats.

Red mangrove (*Rhizophora mangle*)

The red mangrove is native to tropical America and was introduced to Moloka'i in 1902 for erosion control. It is found on six of the main Hawaiian Islands and forms dense, monospecific thickets that will overtake fringing reefs and tidal strand, saltwater wetlands, and other riparian habitats. Red mangroves grow on prop roots, which arch above the water level. Propagules become fully mature plants before dropping off the parent tree. These are dispersed by water until eventually embedding in the shallows.


Red mangrove roots Steve Hillebrand/USFWS

Red mangroves have posed a problem since the Refuge was established. One restoration project addressed an old stand of trees that were so dense that nothing grew under its canopy and it served as a rookery for cattle egrets that pose a threat to nesting waterbirds. When the mangrove was removed, the native sedge kaluhā spread and established in its place.

Mexican fan palm (*Washingtonia robusta*)

Native to Mexican desert washes where underground water is continuously available, the Mexican fan palm was introduced as a landscape ornamental. It has naturalized in Hawai'i to become invasive in disturbed areas. This palm is known to create monospecific stands in riparian areas where the water helps disperse its seeds. Dead fronds of the tree can create a fire hazard. The easiest way to control the species is by removing the seedlings (Starr et al. 2003).


Invasive Mexican fan palm
Jason Hanley/USFWS


Kiawe thorns & seed pods F & K Starr

Kiawe *(Prosopis pallida)*
Kiawe is native to Peru, Colombia, and Ecuador. Over 150,000 acres of kiawe forests in Hawaiʻi are descended from a single tree planted in 1828 by Father Bachelot, the first Catholic priest in the Hawaiian Islands. By 1840, progeny of the tree had spread to dry, leeward plains on all of the islands. Most kiawe have thorns with strong, 1-inch-long spines. It usually flowers January-March, but in years with wet summers it also flowers September-October. The small flowers are borne in pale yellow spikes 3-4 inches long and 0.5-inch in diameter (Nelson and Wheeler 1963).

On windy or dry sites, kiawe grows as a shrub or small, twisted tree only 10-16 feet tall. Kiawe was considered a valuable tree for a variety of reasons: its pods and seed are nutritious fodder; a small honey industry depends on kiawe flowers; the wood is is used directly for fuel and is also made into charcoal; and, the heartwood is durable and preferred for fence posts (Felker 1981).

Kiawe overshadows native plants and its deep taproots use all available water. Dense kiawe thickets have replaced native plants in the coastal dry forest at Keālia Pond NWR.


Buffel grass © F & K Starr

Buffel grass (*Cenchrus ciliaris*)
Most native plants on Molokini are observed in open areas where there is a break in the buffel grass, a species native to Africa, Asia, Iran, and the extreme south of Europe. It is a perennial grass growing to 20 inches tall. It spreads very quickly and will often kill native plants by taking away nearby water. Removal of buffel grass is the primary management action needed to restore the habitat for native plant species on Molokini (Starr et al. 2003).

4.14.6 Diseases

Avian botulism
Avian botulism is a paralytic disease caused by ingestion of a toxin produced by the bacteria, *Clostridium botulinum*. This bacteria is widespread in soil and requires warm temperatures, a protein source and an anaerobic (no oxygen) environment in order to become active and produce toxin. Decomposing vegetation and invertebrates combined with warm temperatures can provide ideal conditions for the botulism bacteria to activate and produce toxin.

Birds either ingest the toxin directly or may eat invertebrates (e.g., chironomids, fly larvae) containing the toxin. Invertebrates are not affected by the toxin and store it in their body. A cycle develops in a botulism outbreak when fly larvae (maggots), feed on animal carcasses and ingest toxin. Ducks that consume toxin-laden maggots can develop botulism after eating as few as 3 or 4 maggots. Outbreaks can occur most anytime on the Refuge, but typically occur during the summer months during warm to hot weather. Thousands of birds have been know to die during a single outbreak in areas of high waterfowl concentrations. There is no seasonal pattern to this disease in Hawaiʻi.

Botulism is one of the few wildlife diseases we can actually manage effectively. Although we do not know all the environmental triggers that cause *Clostridium botulinum* to start producing toxin, we do know that if mortalities are detected early enough, certain management techniques, if implemented quickly, can rapidly stop and mitigate the magnitude of waterbird mortality. Because animal carcasses are an excellent source of protein, removing them reduces the potential for spreading. Draining or flooding the wetland can change the environmental conditions sufficiently so as to stop the production of toxin. The Refuge experienced a large outbreak in 1999 that prompted a standard protocol to check areas for dead birds, especially when water starts receding or if a carcass is found. In the event weak birds are found, the Refuge sets up a rehabilitation area to care for birds until they show signs of recovery. Birds are released in “clean” (no incidents of botulism) wetlands on Maui (with permission). Unfortunately, recovered birds do not become immune to botulism and remain susceptible (USGS 2007).

Fibropapilloma tumor disease

Fibropapillomatosis (FP) of marine turtles is a debilitating neoplastic disease with a global distribution that was originally described in honu in Hawaiʻi in 1958. The prevalence in certain coastal habitats has increased or remained high since systematic surveys were started in the early 1980s. These tumors can result in debilitation and even death to individual animals. Refuge staff and Sea Turtle Dawn Patrol volunteers monitor the frequency and severity of FP occurring on honu observed along the shoreline. These observations are reported to the National Marine Fisheries Service. Research continues as to the cause and potential future remedies for this disease (Herbst 1994, Balazs 1991).

4.15 Habitats

4.15.1 Coastal Dune/Beach Strand

Māʻalaea beach strand Laura Beauregard/USFWS

The Coastal area paralleling the shoreline, also referred to as the beach strand, includes beaches, coastal dunes, and the zone immediately inland of the dunes. Beaches are the most seaward portion of the coastal region and are composed of sand or other loose materials that are constantly exposed to waves and tides.

Coastal dunes are ridges or mounds of sand located immediately landward of the beach. These mounds are formed by an accumulation of windblown sand that is trapped via obstacles such as vegetation. Dunes are dynamic features that erode during periods of high waves (a process termed scarping) and rebuild when heavy wave action subsides. The coastal dune ecosystem in Hawaiʻi functions as a natural, elevated buffer against erosion, flooding, high waves, storms, tsunamis, and other coastal hazards (Wagner et al. 1999, UH 2006).

Native vegetation on sandy or dune areas typically includes ʻakiʻaki, pōhuehue, hinahina, naupaka, pōhinahina, nanea, alena, *Reichardia picroides*, ʻohai, and nama. In addition to providing habitat for native flora, the coastal dune areas at Keālia Pond NWR provide resting habitat for the endangered ʻīlio-holo-i-ka-uaua, and nesting habitat for endangered honu ʻea and threatened honu. Dunes provide resting and foraging habitat for seabirds and shorebirds including the kōlea and kioea, two shorebird species designated as a high conservation concern. These coastal dune areas formerly provided nesting areas for the endemic pueo (Mueller-Dombois and Fosberg 1998, Hawaiʻi Audubon Society 2005).

Recreational and coastal development pressures have severely impacted coastal dunes throughout the State of Hawaiʻi and the Island of Maui. Commercial and residential developments along the coastline level the dune environment. Grading and landscaping alter the naturally occurring topography and ecology of dunes. Soil filling compacts and traps dune sands and sand that is removed by waves cannot be replaced. This trapping causes a continual decrease in sand and loss of the beach environment. In addition, the continuous trampling by vehicles and pedestrians on the dunes causes erosion and sand movement. Vogt (1979) found that fewer than 10,000 pedestrians walking over sand dunes during a single season can eliminate dune vegetation and result in erosion. Because the beach area in Hawaiʻi is attractive to both visitors and residents, pedestrian traffic has a significant impact on these areas (Tabata 1980, UH and Maui Planning Department 1997, DLNR 1999).

Dune management tools at the Refuge include planting native coastal vegetation; controlling pest plants; and prohibiting vehicles (including all-terrain vehicles); and using fencing to block turtles from entering the roadway.

4.15.2 Wetlands and Deepwater Habitats

Lacustrine and palustrine wetlands occur at Keālia Pond NWR as delineated by the National Wetlands Inventory. Lacustrine wetlands occur in a treeless depression and exceed 20 acres. Palustrine wetlands are non-tidal and dominated by trees, shrubs and emergent vegetation (Cowardin et al. 1979).

Wetland habitat Laura Beauregard/USFWS

Lacustrine wetlands

Keālia Pond NWR is named after the main body of water that provides all 200 acres of lacustrine wetlands on the Refuge. In most years, major winter storms fill the pond and water level gradually drops throughout the rest of the year. By mid-spring, water coverage drops below the adjacent palustrine wetlands and the lacustrine bottom becomes exposed. By summer, water is supplemented through a water distribution system and a pump from a brackish-water well. The pond may remain nearly full in some years when stream diversions are reduced during the summer.

Palustrine wetlands

The vegetated and small unvegetated wetlands surrounding the Main Pond and Māʻalaea Flats to the west make up 150 acres of palustrine habitat. The wetlands adjacent to the Main Pond are directly influenced by its hydrology. Except for sedge stands fringing the lacustrine wetlands, nearly all vegetation is comprised of pest species, dominated by Indian marsh fleabane and pickleweed. The Kanuimanu and Baitfish Ponds have vegetated cover of sedges that ranges from a fringe along the side slopes to 40 percent coverage. Vegetation at Mā‘alaea Flats is dominated by similar pest species, and sparse stands of sedges. This area is influenced by the hydrology of the Main Pond only at extremely high water level when water backs up onto the flats. Supplemental pumping into the Main Pond does not feed the flats due to mud bars at the outlet stream and, consequently, the flats remain dry during the summer.

Installation of staff gauges in 1995 showed little change in sedimentation in the deeper areas of the Main Pond. Accumulation of wind swept sediments is frequently observed during most summers at the southeastern part of the Main Pond. Transect markers placed along the vegetation line measured vegetation encroachment of up to 45 feet. This was likely the result of pumped water being discharged in the area during the summer.

In the palustrine wetlands, Indian marsh fleabane appeared in the upper elevations of this habitat during a series of dry years. West of the Main Pond, *Pluchea* was mechanically removed in 2007, but has since become re-established. Pickleweed was mowed in 10-yard bands parallel to the Main Pond shoreline in 2008 and again in 2009. California grass, present since the Refuge was acquired, was mechanically removed in 2005. It has since grown back. Red mangrove was removed in 2003 east of Kanuimanu Ponds. Additional stands were removed in 2005 and 2011. Kanuimanu Ponds were formerly fish farm ponds that were re-contoured for waterbird habitat in 2006. The former Baitfish Ponds were redesigned in 2007.

Although Keālia Pond may provide over 100 acres of shorebird habitat, the absence of water control structures limits shorebird use of vegetated habitat most of the winter and birds are concentrated in exposed shallow-water edges. Mā‘alaea Flats is partially flooded only after the infrequent rains that fall on the Refuge. Conversely, water covers most of the mudflats at the Main Pond except in those years when the pond dries out in the fall.

4.15.3 Coastal Dry Forests

Hawaiian dry forests once supported a remarkable diversity of tree species, however, researchers estimate 99 percent of the original coastal dry forest has been removed. The arrival of humans caused the most severe environmental impacts to the lowlands because these areas were favorable for human habitation. Coastal dry forests were cleared with fire followed by slash-and-burn agriculture. Charcoal evidence from Maui has shown that lowland areas were subject to frequent fires after human settlement (Kirch 1982, Cabin et al. 2000, Burney and Burney 2003).

Kiawe-dominated dry forest   Laura Beauregard/USFWS

Coastal dry forest at Keālia Pond is species poor with the majority of plants introduced since the 19th century. Kiawe has replaced native plant species within the higher elevations of the Refuge, primarily along the northern border above the seasonally inundated zone. Trees are typically 30-40 feet tall. In open areas, understory of thick buffel grass is dominant with fingergrass. In wetter areas, pickleweed is the dominant understory species along with ‘akulikuli and Indian marsh fleabane. It can dominate semi-arid areas by using the brackish groundwater.

A variety of nonnative birds inhabit this forest including gray francolin, black francolin, Northern cardinal, red-crested cardinal, and house finch. The necessary biological requirements of ‘ōka‘i ‘aiea adults for foraging, sheltering, dispersal, breeding, and egg production are native, nectar-supplying plants and the dry to mesic habitats between the elevations of 0-5,000 feet. Although only a few ‘ōka‘i ‘aiea have been reported at Keālia Pond, with restoration management the coastal dry forest area of the Refuge has the potential to meet these requirements.

While nonnative plants are a threat to remaining fragments of dry forest, the complete or rapid removal of pest plants may have a negative impact on native species by changing forest structure, microclimate, and disturbance involved with plant removal activities. Thus, small scale and large scale experimental plots that remove some or all of the nonnative species may provide insight on how to best manage the coastal dry forest at the Refuge (Pau et al. 2009).

4.15.4 Offshore Islet (Molokini)

There are no known federally listed T&E species of migratory seabirds on the islet. The islet is important nesting and roosting habitat for at least six species of seabirds. A large colony of ‘ua‘u kani of approximately 3,200 adults was recorded in 1978. Molokini also has confirmed nesting of ‘ou, a species with a population of moderate concern. Other seabirds, including ‘iwa, ‘ā, and noio, frequently use the islet for roosting.

Molokini © F & K Starr

A banding program was initiated on Molokini in 1999 by DLNR. It is an annual effort for known colonies on Maui, Moloka‘i, Lana‘i and offshore islets ‘Ālau and Molokini (total of nine sites), providing a County-wide assessment. In comparison with other sites, Molokini consistently shows a much higher number of birds banded than other main island sites, primarily because of the absence of predators and human disturbance. From 1999-2010, the number of chicks banded ranged from 400-650 nestlings, which is approximately one-third of the total active nests. State biologists started banding adult birds at Maui colonies a few years ago and have recovered birds originally banded on Molokini, confirming the dispersal of birds from Molokini to other colonies. Unfortunately, colonies on the main Hawaiian Islands are subject to high predation by nonnative mammals and incidences of human disturbance (shooting, eating, caving-in burrows), resulting in very low fledging success (Fern Duvall, pers. comm.).

‘Ou are known to nest in rock crevices on Molokini; however, number of nesting pairs, active nests, and fledging success is unknown. This species cannot exist in the presence of mammalian predators that are prevalent on the main Hawaiian Islands, including mongooses, rats, and cats. This emphasizes the value of offshore islets such as Molokini for ground-nesting seabirds.

The earliest botanical surveys were conducted in 1913 (Forbes) and 1925 (Palmer). Only 10 species were common to both visits and, of the total 21 different plants, 11 were native species. In 2006, the Offshore Islet Restoration Committee (OIRC) recorded 35 plant species, only 9 of which were native. Molokini is vegetated with nonnative buffel grass and six of the native plant species, including ʻihi, paʻu o hiʻiaka, koali, ʻiwaʻiwa, ʻōhelo kai, and ʻilima. Tree tobacco, which is a host to the endangered ʻōkaʻi ʻaiea on Maui, is also present, in addition to other pest plant species (Starr et al. 2006).

One of the management objectives is to restore native coastal vegetation. It is expected that part of the habitat restoration program would allow for transplant and restoration of many of the native plants that were historically recorded on Molokini. This effort would increase the wildlife value of the islet which is already excellent habitat for migratory seabirds and increase the chances of continued survival for ʻōkaʻi ʻaiea. The islet has burrows for underground bird nesters and numerous plant species make for excellent above ground seabird nesting.

4.16 Ecological and Biological Research

The wetlands are an ecological unit that has a multitude of interconnections between and amongst the physical, biological, botanical, and environmental variables. The presence of nuisance issues (spotted-winged midges, tilapia, and windblown sediment) emphasizes the need to gain a better understanding of these interactions in order to address the individual issues. Changing one link in the chain may impact another function or process within the wetland.

In 2000, the Refuge held a workshop to discuss the existing and future potential of the Refuge to increase endangered waterbird abundance, define restoration activities to optimize habitat for waterbirds, and identify data gaps that need to be filled to gain a better understanding of the seasonal conditions. Results of the workshop provided a basis for subsequent research and inventory projects that were completed from 2001-2007. This information gathering phase was instrumental in identifying the Refuge's goals, objectives, and strategies.

Projects completed during this time period include:

- Topographic mapping of Keālia Pond (Figure 3.11);
- Preliminary soil characterization (soil composition, profiles) on the vegetated flats;
- Sediment samples from the Main Pond and stream channels that supply water to Kealia Pond analyzed for contaminants (organic compounds, metals, and nutrients);
- Capacity of existing brackish-water wells evaluated (groundwater feasibility study) and all three refurbished with two outfitted with more efficient pumps;
- Water distribution lines installed on wells A and C to deliver water to target areas;
- Staff gauges installed to monitor surfacewater levels;
- Piezometers installed to monitor groundwater levels;
- Datalogger installed for continuous water level recording in the Main Pond;
- Weather gauge replaced for weather data and future evaluation of evapotranspiration rates;
- Comprehensive water monitoring program, including data and analyses of surfacewater, groundwater, abiotic factors (pH, conductivity, DO, salinity, temperature, turbidity), and water quality (nitrates, phosphates, and TSS) 2001-2004;

- Chemical analyses of excess water from Māʻalaea Power Plant as a potential source of water for the wetlands: Although the water did not contain contaminants, this option was rejected because the water was nutrient-rich which could result in higher eutrophic conditions in the pond;
- Stream flow into Keālia Pond evaluated: USGS installed temporary staff gauges on the upper reaches of the streams to monitor periodicity and flow. The study also included seepage runs to identify how much water was reaching the bounds of the wetlands;
- Larvicide study to test the effectiveness of *Bacillus thuringiensis* var *israelensis (*Bti) and s-methoprene on the nuisance spotted-winged midges (2001). The Bti comes in a pellet form that sinks to the bottom and upon consumption, kills midges and other invertebrate larvae (not species-specific) whereas s-methoprene is an insect growth regulator that inhibits the midge larvae (species' specific) from changing from larvae stage to adult flying stage. Methoprene was more efficient at controlling midge abundance because it is specific to midge species, only needs to be in contact with midge larvae to become effective, effective period lasts for up to 28 days (compared to Bti's effectiveness of 2-4 days); and the methoprene only acts as a hormone suppressant that allows the larvae to live but not change to an adult (which is the nuisance). A literature search of methoprene did not result in any documentation that the pellets directly, or indirectly, impacted wetland bird species;
- Midge study (3-year) to investigate the life history, density, larvae-adult emergence, and control using methoprene. The life history information gained from this study was essential in defining the protocol for future monitoring and methoprene treatments. The study results provided us with information to develop a standard protocol for controlling midges based on available data. There are specific criteria that need to be met to reduce potential, unknown impacts to waterbirds and target the nuisance midge species with minimal impact to the native species. Spotted-winged midge abundance differs each year and their presence/absence in the wetland is due to a combination of ecological, biological, and environmental conditions that are difficult to separate in the field. Midge larvae densities are monitored from core samples which are the most effective method to identify the peak season when treatment can be performed. Only one treatment is conducted in a season to prevent resistance to the methoprene. The use of methoprene to control midges is considered a short-tem method while the Refuge investigates more "natural" forms of control. We have observed a lower density of midges when water level is low, even during December-January which hints at the potential to use water level as a control method;
- Native and introduced invertebrate community. A preliminary inventory of aquatic invertebrates (included in Appendix A) at Keālia Pond was produced from this study;
- A fish study was completed that provided preliminary assessment of fish population in the Main Pond, recruitment into the pond, morphology, and diet. As expected, there is low diversity of fish species in the pond, a majority of which were tilapia. The researchers were unable to identify any native fish species that could tolerate the seasonal conditions that occur in the wetland; and
- Kanuimanu Ponds were recontoured to provide safe access to the public and create habitat for endangered and migratory waterbirds. Physical improvements included: grubbing all vegetation from levees; removal of interior levees to create larger management units; buildup and compaction of pond levees; sloping sides to minimize erosion and create shallow water along the edges when water is high; outfitting Well C (brackish water) with a pump and electrical service; and installation of a water distribution line to direct water to individual ponds. This project and volunteers' native outplanting has created better quality habitat for foraging and nesting waterbirds.

Published studies include the following:

Rader, J.A. 2005. Response of Vegetation and Endangered Waterbirds to Habitat Management Techniques at Keālia Pond National Wildlife Refuge. University of Missouri, M.S. Thesis. 93pp.

The objective of this study was to measure and evaluate the response of vegetation and endangered waterbirds from mechanical treatment of vegetated flats. Results of the study indicated a difference in vegetation (primarily pickleweed) response from mowing and rototilling between areas of the flats resulted in an increased interspersion of open water; however, the plots differed in the type of vegetation that came in: plots on the east side of the flats came back as monotypic pickleweed and the western plots responded with a more diverse assemblage of native plants and annual pest species. Opening up the vegetation on the flats resulted in a higher use of the area by endangered and migratory waterbirds. Both ʻalae keʻokeʻo and aeʻo used the area for nesting and further observations indicated Hawaiian waterbirds depend on early successional habitat for nesting and foraging.

Wirwa, N.L. 2007. Macroinvertebrate Response to Management Strategies and Habitat Condition at Keālia Pond NWR, Maui, Hawaii. South Dakota State University, M.S. Thesis. 143pp.

The location of this study is on the vegetated flats that followed on earlier research by Rader (2005) but the objective was to determine the macroinvertebrate relationships within specific plant communities and habitat conditions, particularly areas associated with mechanical treatment of invasive pickleweed. This study emphasized the importance of vegetation to invertebrate diversity and density; however, it is also beneficial to maintain a diversity of habitat types (vegetated, mudflat, and open water) to maximize species diversity for endangered waterbirds.

Koshorek, J.L. 2007. The Benthic Community of Keālia Pond (Maui, HI): Native and Invasive Chironomids (Diptera: Chironomidae), Benthic Algae and their Interactions. Loyola University Chicago. M.S. Thesis. 150pp.

The objectives of this research were to investigate the diets of both invasive and native chironomids in Keālia Pond to identify their primary food resources, examine the factors influencing one possible food source (benthic algae) and to determine if midge densities were related to benthic algal biomass and/or community structure. A majority of the midge diet (from gut contents) was accounted for by detritus and algae. The study found algal biovolume remained stable in the presence of larval midge grazing; however, the population did not appear to be limited by algae as a food source, even when midge densities reached nuisance levels. These data provided invaluable information on algae species and midge diet that may be instrumental when evaluating control methods.

These research projects and monitoring programs have provided invaluable information for the Refuge to evaluate with respect to understanding the wetland ecology and endangered waterbird requirements, all of which need to be balanced with the need to ameliorate nuisance issues.

New Headquarters and Visitor Center USFWS

Chapter 5. Refuge Facilities and Public Use Programs

5.1 Refuge Infrastructure and Administrative Facilities

The Refuge headquarters is located at Keālia Pond NWR along the entrance road off of Mokulele Hwy. and includes a new office and visitor center building (HQ/VC), metal storage containers, constructed impoundments, and brackish water wells with pump and appurtenances. The infrastructure and facilities discussed in this section include fences and boundary markers, entrances, roads, trails, administrative and maintenance structures, and water-related structures (Figure 5.1, page 5-5). Facilities associated with specific public use programs (boardwalk, visitor/EE shelter) are discussed in section 5.2.

5.1.1 Headquarters and Visitor Center

The first office (1995) was in a leased building at 101 N. Kīhei Rd., across from the Refuge. In 1997, a double-wide trailer was placed near the Kanuimanu Ponds for the staff. In November 2006, a fire of unknown cause(s) damaged the office beyond repair and a leased office trailer is serving as the base of operations and visitor contact station until a new building is completed. Although operation and maintenance cost of the new building is expected to be more than the original trailer office, its energy efficiency will help minimize those costs.

The new Complex headquarters and Keālia Pond Visitor Center (HQ/VC) was funded by the American Recovery and Reinvestment Act of 2009. It will become the primary visitor contact station for the entire Complex. The building is located off the main entrance road and includes administrative offices, an exhibit hall, and multipurpose rooms. The design was based on Leadership in Energy Efficiency and Design (LEED) criteria with the goal of attaining Silver status. Our LEED elements include the use of photovoltaic panels for power and solar hot water system; water-efficient fixtures; design and building placement to take maximum advantage of ambient lighting; and landscaping with native plants.

The new VC exhibits portray the cultural history, ecology, and biology of the Refuge, and include three-dimensional hands-on displays. A multi-purpose room will be available for Refuge-related special events (e.g., guest lecturers and special presentations).

5.1.2 Maintenance Facilities

Our maintenance facilities are comprised of three metal shipping containers that serve as storage for hand and power tools, biological supplies, and maintenance supplies. These containers are set in a fenced maintenance compound where work materials and supplies (pumps, fencing, and carpentry tools), Refuge vehicles, and heavy equipment are also stored. The lack of a covered maintenance garage exposes our fleet and equipment to environmental elements and increased deterioration. Heavy equipment attachments are covered with tarps to provide some protection from the environment.

5.1.3 Trails

The Refuge has two areas accessible for pedestrian use. Although Kanuimanu Ponds and the Keālia Coastal Boardwalk encompass only a small percentage of the total acreage of the Refuge, they do provide quality experiences for the public while minimizing disturbance to endangered and migratory waterbirds.

The Kanuimanu Ponds (20 acres), located at the end of the entrance road, are earthen ponds constructed in 1970 by Global Marine, Co., that later transferred to Pacific Aquaculture Corp. operating as Hawaiʻi Fish Farm, Inc. The facilities raised freshwater prawns, Chinese catfish, tilapia, and apple snails in the ponds and raceways until 1995, 3 years after Keālia Pond was established as a national wildlife refuge.

The aquaculture operation was terminated by the Service primarily because of the conflict in management practices, including target species requirements for water coverage and depth, and native versus nonnative aquaculture species. Raising fish requires constant high water which limits waterbird use of the ponds, especially for wading birds like the aeʻo. The endangered status of aeʻo and ʻalae keʻokeʻo requires us to ensure that management practices are optimal for their foraging, resting, and nesting requirements.

The Kanuimanu Ponds' levees were severely undercut and covered with dense pickleweed and Indian marsh fleabane to an extent that areas had be closed to the public for safety reasons. In a collaborative effort with Ducks Unlimited, Inc., we implemented a restoration plan to enhance habitat for endangered waterbirds and also maximize visitor experiences in wildlife-dependent activities (e.g., wildlife observation). The removal of pest plants, increased elevation and width, and subsequent planting of native species has resulted in a safer path and creation of more diverse habitat for endangered waterbirds, throughout the year (e.g., shallow water habitat, better protection from mammalian predators, and chicks' access to adjacent ponds). The earth work was completed in 2004. Outplanting of native species and control of pest plants are continuous projects to maintain the integrity of the levees and habitat quality.

The 2,200-foot-long elevated Keālia Coastal Boardwalk is located off N. Kihei Rd. at Mā'alaea Flats. The $2.2 million cost for this boardwalk and parking area was primarily funded by Central Federal Lands Highway Division (CFLHD). We also received funding from other Federal, State, and County agencies, nongovernmental organizations, and local businesses. The purpose of the Boardwalk is to provide public access into an area that is sensitive to pedestrian and vehicular traffic, and prevent illegal entry onto the Flats when waterbirds are present.

Keālia Coastal Boardwalk © Sonny Gamponia

The decking, handrails, and cap rails of the boardwalk are constructed of recycled wood/plastic composite lumber, one of the prime uses for recycled plastic trash bags and waste wood fibers. The composite material contains no toxic chemicals such as those used in conventional treated lumber. Recycled wood/plastic composite lumber typically consists of a 50:50 mix of wood fibers from recovered saw dust and waste plastics that include high-density polyethylene, polyvinyl chloride (PVC), and others. This material has a longer lifespan than solid wood products, which results in lower maintenance and replacement costs, no matter how harsh the environment. Since the official opening of the boardwalk in September 2009, repair needs have been limited to defective boards which were replaced by the manufacturer.

5.1.4 Roads and Parking Areas

The Refuge's main access is the entrance road on a utility easement from A&B off Mokulele Hwy. The 0.5-mile asphalt road leads to the HQ/VC, greenhouse, and Kanuimanu Ponds. Another right-of-entry from A&B is for access to the old Baitfish Ponds through the sugarcane fields; however, this dirt road is not open to the public. Parking areas on the Refuge include the VC (30+ spaces), maintenance area, Kanuimanu Ponds (8 spaces), and the Keālia Coastal Boardwalk (15 spaces and 2 bus parking stalls).

5.1.5 Fences and Gates

The Refuge has both wood and chain-link fences and metal gates to maintain, some of which came with the perpetual conservation easement and, therefore, aged and in need of replacement. Most of these older fences and gates are located at the old Baitfish Ponds site. There are sections of barbed-wire/kiawe-post fences on the Refuge that are remnants of former grazing operations. Other old fences are in the forested areas and have lower priority for removal. Newer fences and gates are located at the Refuge entrance, maintenance area, and the boardwalk. The Refuge boundaries are delineated by signs but not an encompassing fence.

5.1.6 Wells, Pumps, Water Distribution Lines, and Water Control Structure

The priority facilities at the Refuge are the three brackish water wells and sump with associated water distribution lines. These must be kept in proper condition to manipulate water in the Main Pond and constructed ponds, particularly during the driest months. Originally, we used three wells that were constructed in 1970 for the aquaculture facility; however, the 25-foot casings (8 in. pipe) on two of the wells were extremely corroded and required continuous repairs. In 2010, these wells were abandoned and capped, and new wells were drilled. These new wells are outfitted with high-capacity (800 gpm) pumps that are more efficient in energy use and pumping capacity than past pumps. Each pump is tied in to a water distribution line that directs water to different areas of the wetlands: the Kanuimanu Ponds (Well C); the main body of water on the east side (Well A); and the north-central area of the Main Pond (Well D). All wells are 90-100 feet deep and contain brackish water (2-4 ppt salinity) used for wildlife and habitat management purposes.

Installation of pumps and electrical service on Wells C and D was completed in April 2011 and they are now in operation, primarily when conditions are typically the driest (August-December). The wells and pumps are expected to last 20 years, beyond the scope of this CCP.

The old Baitfish Ponds, located on the northwest side of the Refuge were recently (2007) reconfigured to combine the six individual ponds into one management unit. A sump, remnant of the aquaculture facilities, is used to pump water into the pond through a water distribution line. The current setup with a 425-gpm pump is the maximum capacity for drawing water from the relatively shallow (25 ft.) sump and meets the Refuge's needs for that area.

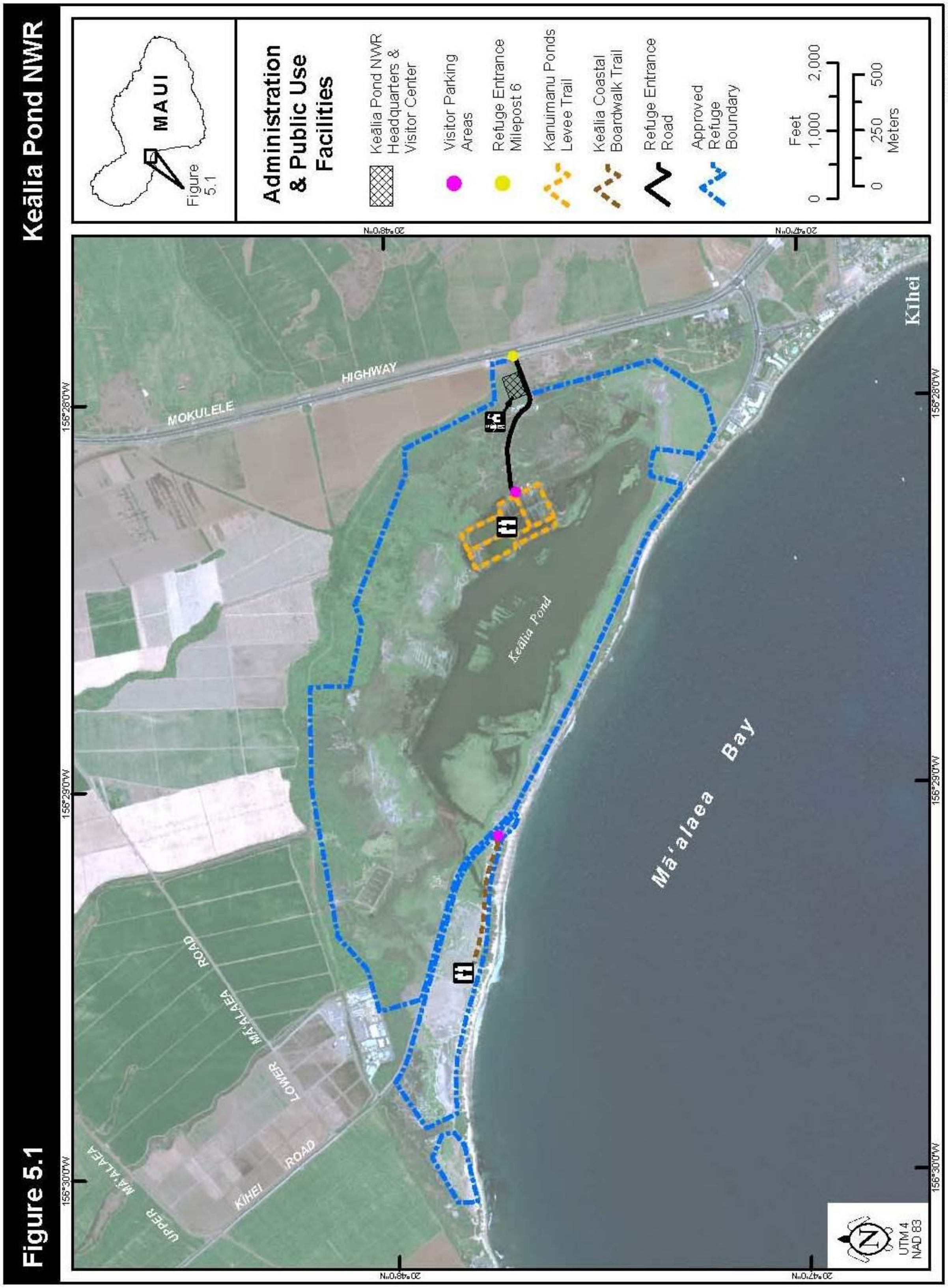
A concrete culvert under the N. Kīhei Rd. bridge connects the main body of water north of the highway to the ocean; however, a sandplug forms naturally and prevents continuous flow. This culvert was likely intended to only pass water through; however, it has become an important component of the Refuge's water management program and capabilities to hold water or release water for the benefit of endangered waterbirds. Ideally, the Refuge would like this culvert to serve as a water control structure with gates and flashboards in order to maintain high water during ʻalae keʻokeʻo nesting season and provide the capability of releasing water, as needed. The design for this water control structure has been prepared; however, the estimated $350,000 in funding for construction has not been provided.

Sandplug between ponds and ocean USFWS

5.1.7 Visitor and Environmental Education Shelter

A 2.5-sided shelter is under construction at the Kanuimanu Ponds on the old office trailer footprint. The steel and wood structure is on a concrete and asphalt pad that allows accessibility to all visitors and will include interpretive panels highlighting the resources the visitor can expect to see. The project is funded by the CFLHD discretionary program and is intended to provide visitors and school groups relief from the sun and wind.

Figure 5.1 – Administration & Public Use Facilities



To preserve the quality of the map, this side was left blank intentionally.

5.2 Visitor Services

When the Refuge was established in 1992, management oversight was from the Hawaiian and Pacific Islands NWR Complex office in Honolulu. The first refuge manager, wildlife biologist, and refuge ranger were hired in 1994 to provide on-site management. At that time, the aquaculture facilities, with buildings, fish tanks, and pumps, were still in operation. The initial priorities were to monitor the resources (primarily waterbird use) and interact with the community. During the first year open to the public (1994-95), 95 visitors came to the Refuge. Visitation has increased to nearly 10,000 in 2009-10, primarily as a result of increased visibility (entrance signs, cleared entrance, and expansion of Molulele Hwy.), outreach (off-site interpretation, special events, and public meetings), and additional structures that are accessible by the public (Keālia Coastal Boardwalk).

The Refuge has the option of closing areas to public access during critical periods of endangered waterbird breeding seasons. In past years, some or all of the Kanuimanu Pond levees have been closed during ae‘o nesting and chick-rearing periods, and to a lesser degree ‘alae ke‘oke‘o nesting season. These closures are temporary and intended to prevent human disturbance to waterbirds and protect the public from aggressive birds protecting their eggs or chicks, primarily ae‘o that are most susceptible to disturbance (April-July). These closures have not totally impaired visitors' opportunities to view birds as many of the birds are visible from the parking area. Increased numbers of waterbirds nesting in these ponds has resulted in more opportunities to observe birds and their chicks.

The Refuge also has the option of closing all, or portions of, the Keālia Coastal Boardwalk if the public activity is shown to disturb endangered waterbirds. This has not yet been necessary given the current water conditions (e.g., Mā‘alaea Flats becomes dry in June/July) and the minimal, or absent, nesting activity.

Our new visitor services manager has oversight of the public programs including the VC, volunteers, EE, and interpretation. Although a majority of the visitors arrive from the continental United States, the Refuge also receives a large number of international visitors (Canada, Asia, and Europe) and the highest visitation is usually during January-February.

5.2.1 Accessibility of Recreation Sites and Programs

The Keālia Coastal Boardwalk is 8 feet wide and can accommodate 2 passing wheelchairs and slopes are within Americans with Disabilities Act (ADA) requirements. The new HQ/VC is also designed to meet ADA standards. The earthen levees of the Kanuimanu Ponds have some limitations on accessibility. The levees are wide, flat, and compacted to allow minimal effort for wheelchairs; however, due to the nature of the ponds there aren't handrails or hold bars available. An advantage at this site is the close proximity of waterbirds to the parking area and start of the levees. All of the Refuge visitor facilities have accessible parking stalls marked for "Placard or Special License Plate Required."

5.2.2 Special Use Permits

All activities on the Refuge are evaluated to ensure they are compatible with the Refuge purpose. Public use activities include, but are not limited to: wildlife observation, photography, EE, and interpretation. Compatibility Determinations (CD) for these activites were approved in 2004. These CD were updated and included in Appendix B. The areas open to the public are concentrated in a relatively small percentage of the Refuge's total acreage mainly to take advantage of what already existed when the Refuge was established. Wildlife observation and photography are general uses; however, EE programs require a SUP to identify specific activities and general conditions that are allowed while performing the activity, particularly since the programs include sampling for educational purposes.

Periodically, the Refuge receives requests to access the wetlands beyond these public areas for research, photography, or other purposes. If approved by the refuge manager, a SUP is issued. Examples of past approved uses include: outside research projects (universities) and Federal, State, and County investigations (e.g., updating flood zone maps and streamflow surveys).

5.3 Wildlife Observation and Photography

The Kanuimanu Ponds provide the primary wildlife viewing and photography access at the Refuge for visitors. A walking trail around the ponds is an easy stroll and, although it is an earthen path on pond levees, it is accessible to visitors in wheelchairs. Access is permitted when the gate is open and staff is present. These ponds are the most heavily used by visitors, many of whom are birdwatchers and amateur photographers. The highest quality wildlife viewing opportunity occurs August-April when there is a high diversity and abundance of endangered waterbirds and migratory bird species.

The Keālia Coastal Boardwalk at Māʻalaea Flats has interpretive panels and three kiosks that tell the story of the wetland and its ecological and biological functions. The boardwalk includes three ramps that provide access to the beach. Access to the boardwalk is provided year-round (365 days, including Federal holidays) from 6:00 a.m. to 7:00 p.m. Gates were installed to prevent nighttime parking and camping at the facility. The Boardwalk's location off the highway makes it very visible and popular with visitors and residents.

Photography for professional or commercial use on the Refuge requires a SUP.

5.3.1 Desired Future Conditions for Wildlife Observation and Photography

The Refuge has identified additional opportunities for the public to engage in wildlife observation and photography. Viewing into the Main Pond from the Kanuimanu Ponds can be enhanced by creating higher elevation platforms off the levees. This would require widening areas of the levees bordering the Main Pond. This would allow visitors a better vantage point on a relatively flat surface. In addition, photo blinds would benefit photographers and birdwatchers. A vegetated blind was considered; however, woody vegetation impairs the integrity of the levee so our preferred option is to construct a blind that would blend with the environment and withstand the regular tradewinds. Although the location of the boardwalk is beneficial for informing and educating the public, the quality of wildlife observation is low due to the current lack of water management capabilities at

Māʻalaea Flats. In most years, the Flats are dry from mid-June-December so wildlife observations are limited to the pond outlet. The value of the visitors' experience can be increased if the Refuge had the capability to maintain shallow water habitat on the Flats during the dry season. This could be accomplished by constructing a well, pump, and waterline on the upper flats.

Parking at the Kanuimanu Ponds is limited and is not likely to accommodate the increased visitation expected with the new HQ/VC. An alternative to driving further down the Refuge road to access the ponds is to walk along the road (0.3 mile) and, in the future, construct a boardwalk from the HQ/VC to the ponds. The path of this boardwalk would traverse through kiawe forest, pass by a small permanent pond on the west side of the road and terminate at the Kanuimanu Pond parking area. This would facilitate interpretation of nonnative passerine birds, pest species, and other related topics.

The Refuge has limitations on opening new areas to public access because our priority is to protect endangered waterbirds. Currently, only the Boardwalk is open 365 days a year. Kanuimanu Ponds and the current office are open Monday-Friday, except for Federal holidays. With additional staff and volunteers, we plan to have the VC and Kanuimanu Ponds open on weekends in the future.

5.4 Interpretation

Interpretation at Keālia Pond NWR is in the form of displays, exhibits, and verbal communication that highlight the ecology, biology, and cultural history of the area to accommodate a diversity of visitor interests. The VC exhibit hall will provide 2- and 3-dimensional displays and hands-on activities for the public. The diversity of topics that can be interpreted on the Refuge includes everything from watersheds to aquatic invertebrates and careers in natural resource fields.

The Keālia Coastal Boardwalk is not staffed so the interpretive panels are essential for informing the public about the resources and the ecological and biological functions that are either visible or hidden from view. A map indicates the location of the HQ where visitors will be able to have one-on-one interaction with Refuge staff and volunteers.

Currently, visitors check-in at the temporary office and are on their own to explore open areas of the Refuge. Interpretive tours are available upon request and are typically given to school or other groups rather than individuals. The tours are designed to meet the needs or interests of the group with the intention of supplementing their in-class curriculum. Most school group tours include hands-on exploration, including: water quality sampling, invertebrate sampling, pest plant removal, and native planting. The interpretive program is popular with groups that are limited on time (2-3 hours) but want participants to experience the natural environment.

Off-Refuge interpretive programs are provided by staff and volunteers, as requested and if time permits. These programs have been held for school groups, County of Maui programs (Kaunoa Senior Center, Parks and Recreation), and Mainland groups (Elderhostel, birding groups).

5.4.1 Desired Future Conditions for the Interpretation Program

We would like to increase outreach to local groups and visitors to direct more attention to the Refuge as an outdoor learning experience. Specialized tours could be developed to meet the needs of the public. This will increase the Refuge's visibility as part of the community where people can explore the natural resources and gain a sense of stewardship in becoming involved with refuge programs.

5.5 Environmental Education

Our goal is to provide a high-quality EE program with specific learning objectives and diverse hands-on opportunities. We seek to have the students engaged outside where all senses are utilized. Thus, the new HQ/VC does not include an indoor classroom; an EE shelter is located outdoors near wildlife habitat and acts as a staging area. Environmental education (as opposed to interpretation) is a formal program geared towards school curriculum for specific grade levels and compliant with DOE requirements. Our current EE program is minimal due to staff availability to plan, design, and implement an appropriate wetland education program.

Students at Keālia Pond © Jay Franey

In lieu of Service staffing, EE is a collaborative effort with nongovernmental educational organizations that have developed a wetland curriculum based on DOE standards. The organizations that regularly use the Refuge for EE are Hawai'i Nature Center (since 1997) and Maui Digital Bus (since 2005). Under a SUP, these groups coordinate the schedule and provide the instructors for the school group while the Refuge provides the site. This has proven to be a worthwhile cooperative effort, which brings more than 1,300 students to the Refuge annually. A majority of the students are within the Hawai'i Nature Center program. Their wetland curriculum is popular with teachers and includes all aspects of the wetlands, including wetland function, bird observations, invertebrates, and biology (food chain, bird behavior, mucking in the mud for invertebrates).

Maui Digital Bus has an innovative program that teaches students the use of technologically advanced equipment, including: water quality dataloggers, digital microscopes, and geographic information system (GIS). A small bus was renovated into a mobile laboratory where students can examine their samples (water, invertebrates), map locations with GPS, and gain hands-on experience using advanced field equipment. This organization is growing in popularity and is continually expanding upon their programs. Currently, the Refuge is working with Maui Digital Bus to formalize an EE program specific to Keālia Pond NWR.

5.5.1 Desired Future Conditions for the Environmental Education Program

Refuge-specific EE programs will be developed for school groups of varying age levels. Development of all programs will include pre- and post-visit materials for the teachers use once they return to the classroom. Teachers' workshops will be held annually to introduce the teachers to the opportunities so they can incorporate an onsite visit with their classroom activities. Volunteers would be recruited and trained to assist with the program. All EE programs will have a stewardship component where students would participate in a wetland restoration project. Currently, this includes hand removal of pest plants and outplanting native plants.

A program for upper-level students (9-12th grades) will be developed based on scientific methodology. Students would be given a management issue and within the school year or semester, they would develop the methods to sample, evaluate, and form conclusions to what they observed. Other opportunities will likely become apparent as the Refuge implements programs and receives feedback from teachers and educators. We are open to creating new partnerships for EE with other organizations.

5.6 Volunteers

Refuge volunteers are a vital component to the operations and management of Keālia Pond NWR. Currently, 45-60 volunteers provide over 4,000 hours of labor on the Refuge annually. Our volunteer projects include: Dawn Patrol, habitat management, pest species management, propagation and outplanting of native plant species, maintenance, and interpretation.

5.6.1 Desired Future Conditions for the Volunteer Program

With additional staffing, we will put more effort into recruiting volunteers for all programs (biological, habitat, visitor services, education and interpretation). Development of a Friends group “Friends of Keālia Pond NWR” is a high priority. Through the friends group we plan to recruit and train new volunteers for staffing the VC and Boardwalk. Volunteers will enable us to operate the VC despite our limited staff positions.

5.7 Partnerships

Since 1997, the Refuge has collaborated with National Marine Fisheries Service (NMFS), DAR, and Hawai‘i Wildlife Fund to monitor sea turtles (honu and honu ‘ea) nesting on Maui. As a partner, the Refuge recruits, trains, and manages a group of 40-50 volunteers, called the Dawn Patrol, who are assigned to walk sections of beach from Mā‘alaea to Mākena and Lahaina to Kā‘anapali, June-September. Information on individual nesting females and hatching/emergence success for Maui contributes towards protecting and providing for threatened and endangered marine life, and contributes to the Statewide monitoring effort.

The growing concern and stewardship of Maui’s terrestrial, wetland, and ocean resources has resulted in numerous other collaborative efforts between Federal, State, County, nongovernment organizations, and individuals in the form of partnerships. The Refuge participates in partnerships to share information and work towards common goals of preserving, restoring, and outreaching stewardship opportunities to others. Partnerships are primarily ecosystem based with the common denominators concentrating on shared issues or problems. An increasing effort to combine resources has brought together the sharing of information and a more cohesive identification of Maui's target issues. Additional partnerships include:

- Southeast Maui Watershed Partnership
- Maui Pest Species Committee
- Maui Conservation Alliance
- Maui Wildland Fire Working Group
- West Nile Virus Working Group
- Hawaiʻi Pacific Joint Venture
- Maui Conservation Alliance
- Maui Nui Botanical Gardens
- Hawaiian Native Plant Society

5.8 Law Enforcement

The Refuge is located between two urban areas (Kīhei and Māʻalaea) and susceptible to a myriad of law enforcement issues, including theft, vandalism, and trespassing. The highest number of incidents occurs along N. Kīhei Rd. where vehicle accidents occur at least six times per year. All these vehicle accidents have resulted in damage of Federal property: sea turtle fence made of recycled plastic; guardrails maintained by HDOT, and the pipe gates at the boardwalk. Of the accidents reported to the Maui Police Department, contributing causes range from sleeping at the wheel to alcohol consumption. The sea turtle fence has sustained repeated damage from vehicles bumping into it and requires ongoing repair by Refuge staff.

The Keālia Coastal Boardwalk is located within the Refuge boundary; however, it is disconnected from the entrance road making it difficult to monitor. Vandalism to the boardwalk occurs frequently in the form of graffiti, trash dumping, and trespassing during closed hours. Frequent cleanups are needed after tresspassers have used the area to party and drink alcohol. In 2007, a bronze turtle sculpture located at the westernmost kiosk was stolen. It was returned to police a couple months later. On another occasion, vandals removed the nuts/bolts of one section of the same kiosk for what appeared to be a jumping-off site for mountain bikes or a motor bike. This is one of the more challenging areas to manage and protect because it is visible from N. Kihei Rd. The gates to the boardwalk are opened at 6:00 a.m. and closed at 7:00 p.m. by a contracted vendor. Although lights may be an advantage to the safety and security of the boardwalk, the Refuge has not installed these due to light pollution, sea turtle nesting season (May-December), and nocturnal seabird concerns.

Theft of Federal property is a continuous concern despite the precautionary measures that are in place. The isolation of the Refuge from surrounding lighted areas has been a disadvantage and there is a high cost of stolen equipment and supplies.

5.8.1 Desired Future Conditions for Law Enforcement

The Refuge will continue to have law enforcement issues, particularly with increased visitation and exposure. The Pacific Islands' Zone Law Enforcement Officer is stationed on Oʻahu and is available, as needed; however, due to his/her schedule and availability, the timing is only after an incident has occurred and no apprehension or citations have been given. We have identified the need to hire a dedicated Refuge Officer for the Complex in our implementation plan (Appendix C) in order to help minimize or prevent incidents from occurring.

5.9 Outdoor Recreational Opportunities and Trends on Maui

The coastal and inland areas surrounding the Keālia Pond NWR have high potential for public recreation. Located adjacent to one of Maui's main population centers, the area provides easy and safe public access to both the aquatic and terrestrial natural resources. The 1998 Kīhei-Makena Community Plan states that although careful resource management must be employed to protect existing parks, shoreline recreational opportunities and access "must be increased to meet the growing needs of the region and island residents." In addition to the wildlife-dependent recreation opportunities available on the Refuge, local area recreation includes: beachgoing, picknicking, swimming, diving, fishing, snorkeling, and canoeing (Maciolek 1971).

5.9.1 Federal, State, and County Recreational Parks

There are other Federal, State, and County parks on the Island of Maui that provide different or similar types of opportunities for the public. Two other Federal agencies devoted to natural and cultural resources are located on the Island of Maui: the National Park Service manages Haleakalā National Park, located approximately 40 miles from the Refuge (or 1.5 hour driving) and NOAA oversees the Hawaiian Island Humpback Whale National Marine Sanctuary from a facility in Kīhei, 3 miles from the Refuge. Many of the Refuge visitors engaging in birdwatching also visit Haleakalā where they can observe native forest birds and pristine Hawaiian forests. As a sister agency, the Refuge welcomes opportunities to collaborate on programs for the public.

Other wetland managed areas on Maui include Kanahā Bird Sanctuary managed by DLNR and Waiheʻe Refuge managed by Maui Coastal Land Trust. Both located on the north shore of Maui. These wetlands complement Keālia Pond NWR biologically (waterbird use) and provide visitors different vantages and experiences.

Chapter 6. Cultural Resources, Social, and Economic Environment

6.1 Refuge Cultural Resources

The Service's Cultural Resources Policy defines cultural resources as archaeological sites, historic places, objects of antiquity, cultural items, or traditional religious values. This section provides a summary of the historical and cultural resources at Keālia Pond NWR, within the surrounding Waikapū ahupua‘a, and Molokini. It discusses the Native Hawaiian and Euro-American cultural history of the area, within the context of the broader history of the Island of Maui and the State of Hawai‘i.

The early settlement history of the island is a subject of some debate. Some believe that the first Polynesians arrived in Hawai‘i around 100 to 300 BCE from the Marquesas and were followed by Tahitian settlers around 1100-1300 CE who conquered the original inhabitants. Others believe that there was only a single, extended period of settlement. Polynesians developed a new Hawaiian culture while maintaining much of the social and political structure of their homeland.

According to Kamakau (1961), traditional Hawaiian land tenure was a system formed in order to care for the land (malama ‘aina). Around the 14^{th} century, various individual island mo‘i (kings) believed the land should be surveyed and permanently marked in order to institute a boundary system that would settle disputes between neighboring ali‘i (chiefs). A kahuna (priest) named Kalaika‘ohia is said to have carved Maui into 12 moku (districts), which were controlled by an ali‘i ‘ai moku. These lands were further divided into ahupua‘a, a wedge-shaped land unit that traditionally subdivided resources from the uplands to the shore thereby allowing access to marine and mountain resources. Ahupua‘a varied in size and were generally delineated by topographical or natural boundaries such as mountain ridges and streams. Keālia Pond lies in the Waikapū ahupua‘a, one of the four ahupua‘a that make up the entire southern portion of the larger moku of Wailukū. Molokini islet is in its own moku of Molokini (Chinen 1961, Handy and Handy 1972, Orr 2006).

The idea of holding land was not synonymous with owning it, but more like a trusteeship between the caretakers and the nature gods Lono and Kane (Handy & Handy 1972:41). The ahupua‘a is the most well known of all traditional land divisions and is still relevant today. Traditionally, the areas were governed by a konohiki (designated caretaker) and those residing within the region had designated access to all mountain and marine resources. Chinen (1961:5) explains that all chiefs and commoners were entitled to a portion of the mountain and marine resources.

Wailuku District is frequently mentioned in historical texts and oral tradition as being politically, ceremonially, and geographically important during traditional times (Cordy 1981, 1996; Kirch 1985). Wailuku was considered a "chiefly center" (Sterling 1998:90) with many of the chiefs and much of the area's population residing near or within portions of ‘Īao Valley and lower Wailuku. The importance of the district is reflected by the relatively large number of heiau (temple sites) that were reportedly present in pre-contact times. Oral tradition accounts surrounding these heiau provide examples of how religion tied into political power in the traditional Wailuku setting. Indeed, the period immediately preceding contact with the Europeans was one of considerable upheaval and conflict.

Political power emanating from Molokaʻi was an active element during the mid-18th century. The resulting battle at Kalaeʻiliʻili in 1765 CE led to the expulsion of Keʻeaumoku and the Molokaʻi aliʻi and the beginning of Kahekili's reign (Kamakau 1992). Kahekili successfully defended his capital in Wailukū throughout the 1770s, until his defeat at the hands of Kamehameha I's forces.

Closer to the current Refuge area, in the southwest corner of Wailukū District, pre-contact settlement was not as dense as concentrations to the north. Climate had much to do with that trend, as the Māʻalaea area is a more arid environment than the rain-soaked fields to the north. According to Tomonari-Tuggle and Tuggle (1991), the majority of the pre-contact population was located west of the Refuge, near what is now Ukumehame Beach State Park.

6.1.1 Mythological and Traditional Accounts

The Wailukū moku covers the entire isthmus between East and West Maui. This area was also referred to as Na Wai ʻEha, meaning "the four waters," and is named after the four major streams (Waikapū, Wailukū, Waiehu, and Waiheʻe) flowing in the windward portion of West Maui. Wailukū and its coastal environs are thought to have been initially settled around 1100-1200 CE. Keālia Pond lies in the traditional district of Waikapū, which has now been absorbed by the Wailukū District. Place names may help determine pre-contact Hawaiians' perspectives toward individual areas. Waikapū translates literally to "water of the conch" (Pukui 1974:222). W.K. Kaualililehua, in Ka Nupepe Kuokoa, cited in Sterling (1998:93), describes the origin of the name:

> This place, Waikapū, has a cave away up the stream, about a mile or more from the village. On the left side of the stream is a cave and in the cave was the conch. It sounded all the time, unseen by the public, but a prophet of Kauaʻi listened for it and came to seek with the idea of finding it.
>
> On the northeast side of that stream on the opposite side of the conch that sounded, on the cliff, was a dog named Puapualenalena. Because he heard it, he sought diligently to find it but he did not succeed. Those who guarded the conch were very watchful. The dog kept studying ways of obtaining it.
>
> The owners of the conch did not believe, perhaps, that any supernatural being would succeed in taking it away, so they began to be a little careless. It was not taken, but on the day that Puapualenalena did get it away, they had been utterly careless. After he took it, it sounded no more to this day. It used to be heard everywhere in these islands and was annoying to some people. From this conch, the whole of the place was named Waikapū (water of the conch).

A second hypothesis on the origin of the name was described by G.W. Bates in Sandwich Island Notes, cited in Sterling (1998:93):

> The first village of any note on the way to Wai-lu-kū is Wai-ka-pū. It contains a population of about five hundred. Here the forces of Kamehameha the Great once assembled for battle at the sounding of the conch-shell. Hence its name, Wai-ka-pū.

Sunset over Molokini L. Beauregard/USFWS

Molokini

Many Hawaiian mythologies involve shape-shifting spirits, beings who could change at-will from animal to human form. According to legend, the beautiful moʻo (shape-shifting water lizard) Puʻuoinaina married Lohiau, a chief who lived at Māʻalaea. Unfortunately for her, the volcano goddess Pele was also in love with Lohiau. In a jealous rage, Pele cut Puʻuoinaina in two and turned her into stone. Her head became the 360-foot tall cinder cone called Puʻu Ōlaʻi, or Red Hill, which rises above Mākena Beach at the south end of Wailea. Her tail became Molokini Islet (Kalakaua 1989).

Hawaiians visited Molokini to fish and probably also to harvest seabirds, eggs, and feathers. A variety of stone sinkers and lures, used in traditional fishing techniques, are still present in waters around the islet (Starr et al. 2006).

Keālia Pond

The word "keālia" means "encrusted with salt" and it is said that its "most excellent salt" was made using the salt pans in the immediate vicinity of the pond. There are ditches and sluice gates that were built at least 400 years ago to let fish stock such as ʻawa, ʻamaʻama, and other nearshore fish into the pond. Ashdown noted alternate names for the area (1971:22-24):

> "Keālia was the huge fishpond attributed to King Uni-a-Liloa after the death of Piʻilani in Lahaina. It was called the pond of Ka-lepo-lepo because, in one story, Uni made his people carry him atop the huge akua stone which was to be placed at one part of the pond. The load was so heavy that the workmen dropped it and the king fell into the lepolepo (dirty water). Others have insisted that the great chief never did suffer such an indignity, like a commoner, but that the name should be Kalepa, meaning the fluttering of the flags of canoes there when the area was a port of call since ancient times."

6.1.2 Pre-contact History

In pre-contact times, all land from the base of the Waikapū ahupuaʻa to below the valley was used for extensive wet-taro planting. Handy and Handy (1972) note that the Waikapū Stream, which flows down the center of the island isthmus from the West Maui Mountains into Māʻalaea Bay, was "diverted into loʻi and its overflow was dissipated on the dry plains." However, most evidence of the traditional terraced taro culture has since been eliminated by extensive sugarcane cultivation. Near the southern portion of the ahupuaʻa, on the flat coastal plains of Kīhei and Māʻalaea, Handy (1940) states that traditional fishing settlements and isolated fisherman houses could be found. In addition, sweet potatoes were cultivated in the sandy soil near the shore in these areas.

Wailukū, meaning "water of destruction," succinctly describes the area in the late 1700s. Political power emanating from Molokaʻi was an active element during the mid-18th century. In 1776, the chief of the Island of Hawaiʻi, Kalaniopuʻu, gathered 800 warriors just east of Keālia Pond at Kīheipukoa. He then led them across the Waikapū commons to attack Kahekili, the chief of Maui, whose warriors were hiding at the sand dunes of Waikapū. It is estimated that 1,600 people were killed in the Battle of Kakanilua. Only 2 of the Maui warriors survived. Another battle took place in the area shortly after when Kamehameha the Great landed southeast of Keālia Pond at Kalepolepo and invaded the island (Fornander 1969, Athens et al. 1996, Sterling 1998, Desha 2000).

6.1.3 Euro-American Cultural History

In 1778, British explorer Captain James Cook on the *H.M.S. Resolution* is credited with being the first European to visit Hawai‘i. There is some evidence that Spaniards, who first crossed the Pacific Ocean in 1522, also made landfall in Hawai‘i but they never correctly mapped or claimed credit for their accomplishment. Cook recorded sighting Maui in November 1778, anchoring near Kahului but not coming ashore. In 1786, French Admiral Jean-François Lapérouse of the ill-fated *Boussole* was the first European explorer to come ashore on Maui in an area south of Mākena now known as La Perouse Bay. The *Boussole* and its crew vanished in 1788 and the shipwreck was later found in the South Pacific in the current Republic of Vanuatu (Bateson 1972, Speakman 1978).

Keālia Pond lived up to its name as a source for much needed salt for early sailors to the Island of Maui. P. Corney, in *Voyages in the Northern Pacific*, cited in Sterling (1998:95) recounts:

> Feb. 1, 1817… We now made sail towards Mowee, our ship, as usual, full of natives. Next morning we passed Morokenee (Molokini), and made sail up Mackerey (Mā‘alaea) bay; here we lay until the 6th, and took on board a great quantity of hogs, salt, and vegetables… On this neck of land are their principal salt-pans, where they make most excellent salt.

Contact with Europeans began a series of plagues for which the Native Haweaiians had no immunities. Their population fell from 300-500,000 in 1778 to only 30,000 by 1900. As trade and shipping brought Hawai‘i into contact with a wider world, it also enabled the acquisition of Western goods, including arms and ammunition. In 1795, Kamehameha the Great of Hawai‘i assembled the largest army the Hawaiian Islands had ever seen, with over 10,000 men and 1,200 war canoes, equipping them with European muskets and cannon. He established the Kingdom of Hawai‘i with the subjugation of the smaller independent chiefdoms of O‘ahu, Maui, Moloka‘i, Lāna‘i, Kaua‘i, and Ni‘ihau over the period 1795-1810.

Lahaina, Maui, became the new capital of the Kingdom of Hawai‘i and it was the center of government for nearly five decades. ‘Iliahi (sandalwood) was the first major item of external trade. By 1805, ‘iliahi had begun to reach China, and by 1809 it was a regular commodity. In 1810, American merchants reached an agreement with Kamehameha for a monopoly on the ‘iliahi trade in exchange for a quarter of the profits. These merchants took a convoy of ‘iliahi ships to China in 1812, making a good profit on their sales. This agreement stood for only one shipment, though, and shortly thereafter the War of 1812 resulted in a British blockade of Hawai‘i for 2 years (Daws 1989).

When trade resumed in 1814, King Kamehameha claimed the trees as his own in a near-monopoly and organized the cutting and transport of ‘iliahi under his public works program. The ‘iliahi trade encouraged the transition to a cash economy, the purchase of luxury goods, and became the main source of revenue for the Hawaiian chiefs. Kamehameha had established commercial trade and foreign business ventures as the best means of obtaining the luxury items and other goods.

Kamehameha's death in 1819 triggered a dramatic change in the social, political, and religious systems of the country. Members of the ali‘i had acquired many of the outward manners and dress of

European civilization during the final years of Kamehameha's reign. His successor Liholiho (Kamehameha II) ended the kapu system and ordered the destruction of images and heiau throughout the Kingdom. Fires were set in the forests to detect ‘iliahi trees by their sweet scent. While mature trees could withstand the fire, the flames wiped out new seedlings. By 1830, the ‘iliahi trade had completely collapsed (Gast and Conrad 1973, Judd 1966).

The introduction of horses and cattle around the turn of the 19th century aided in transition from the ‘iliahi trade to ranching. Cattle hides, tallow, and meat became important commodities of local and international trade. Hawai‘i was a major supplier of beef to California during the Gold Rush and subsequently to the visiting whaling ships. At the height of the whaling era (1840-1865) as many as 500 ships anchored in Lahaina’s port (Cowan-Smith and Stone 1988).

6.1.4 The Mahele, 1848-1851

Among other things, foreigners demanded private ownership of land to insure their investments. Influenced by these foreign investors, King Kamehameha III instigated the Great Mahele of 1848 and drastically altered the Hawaiian land system by redistributing land ownership between the kings, ali‘i, foreigners, and maka‘ainana (common people who were fishermen, craftsmen, and farmers). Once lands were made available and private ownership was instituted the maka‘ainana were able to claim the plots on which they had been cultivating and living, if they had been made aware of the foreign procedures for Land Commission Awards (LCA). These claims could not include any previously cultivated or presently fallow land, stream fisheries or many other resources necessary for traditional survival (Kelly 1983; Kame‘eleihiwa 1992; Kirch and Sahlins 1992).

If occupation could be established through the testimony of two witnesses, the petitioners were awarded the claimed LCA and could then take possession of the property. The land that maka‘ainana received was less than one percent of total lands. A total of 88,000 people submitted 14,195 requests for land and of these only 8,421 were awarded. In 1850, it became legal for foreigners to purchase land and they received large portions for reduced prices. At this time, many Native Hawaiians lost access to their lands due to mortgage default. Land Commission Awards from that time offer written records and insight into the historic land use of the area. In the Waikapū ahupua’a, claims were concentrated on the southeastern edge of Keālia Pond. Nine of the claims surrounding the pond refer to salt lands (for salt collection), while four claims document house lots (Chinen 1961, Athens et al. 1996, Orr 2006).

6.1.5 Post-1850s History

Another influence that brought change to Maui was foreign commercialism. Two Chinese brothers, Ahung and Atai, of Honolulu’s Hungtai Company set up one of its earliest sugar mills. Atai soon created a plant that processed sugarcane cultivated by Hawaiians, named the Hungtai Sugar Works (Dorrance and Morgan 2000:15-16). In 1862, The Wailukū Sugar Company was established and would expand sugar production over the next 126 years. By the turn of the century, a large portion of Waikapū was under sugarcane cultivation. Wailukū Sugar Company ended production in 1988, having averaged over 30,000 tons of sugar produced annually at its pinnacle in the 1970s (Dorrance and Morgan 2000).

The Kingdom of Hawai‘i lasted throughout most of the 19th century, when expansion of the sugar industry meant increasing U.S. business and political involvement. Through the *Reciprocity Treaty* *between the United States of America and the Hawaiian Kingdom of 1875*, the United States obtained exclusive rights to Pearl Harbor in exchange for allowing Hawaiian sugar to enter the United States duty-free. In 1893, Queen Liliʻuokalani was deposed in a coup d'état led by American citizens supported by the landing of U.S. Marines. The sovereignty of the Kingdom of Hawaiʻi was lost to a Provisional Government led by the conspirators, later briefly becoming the Republic of Hawaiʻi, before eventual annexation to the U.S. in 1898.

Kīhei was transformed by the advent of WWII. The U.S. military development began on Maui in June 1940 at the NAS Puʻunēnē located north of the present Refuge. The area surrounding Keālia Pond and Māʻalaea Bay was used as a training site for the 4th Marine Division in preparation for the Pacific war theater. Over 5,000 marines were housed there. Immediately west of the Refuge boundary there is evidence of a firing range and airstrip. While preparing for the Marianas campaign in 1943 and 1944, military personnel practiced amphibious landings on the beachfront and mudflat areas near the Refuge. Artifacts of these landings, such as concrete and steel barriers, or rock jacks, are still found within the area. Molokini was used for target practice (Athens et al. 1996, Tome and Dega 2004).

Following WWII, the Kīhei coastline returned to the peaceful activities of ranching and development of residential areas. During the 1960s, development of the area as a vacation haven for tourists and homebuyers began, a trend which continues to the present day.

6.1.6 Refuge Archaeological/Cultural Surveys

Athens et al (1996) identifies a “place of note” located northwest of Keālia Pond in Pōhākea. Pu’u Hele is a sacred area where a cinder cone once stood near the junction of the Lahaina, Wailukū, and Kīhei roads. Ancient prophecy avowed that Puʻu Hele was a former moʻo who would “cover all Maui when the foreign tide envelopes our land and people.” The cultural significance of the hill has changed since the cinders were used for road building at the NAS Puʻunēnē and the hill was eliminated.

In 1979, the Service conducted a 3-day reconnaissance survey of Keālia Pond, which recorded no evidence of historical or archaeological resources at the pond or in the immediate vicinity. Athens et al (1996) lead five trench surveys near the coastal dunes and a paleoenvironmental core analysis in the mudflat area for the proposed boardwalk, kiosk, and parking project. No historical or cultural remains (pre-contact Hawaiian or WWII) were found during the survey. Athens et al. (1996) concluded that it is not likely that cultural resources are present within the Refuge boundary due to the site’s close proximity to an active beach and the nearness of the upper soil deposits to the water table.

The most recent archaeological and cultural investigation occurred in 2009 and was specific to 13 acres in the forested habitat along the entrance road prior to construction of the new HQ/VC. There is no pre-contact evidence within this area; however, the investigation confirmed the area was used for cattle ranching from the rock area with cattle troughs. The researchers did not find any new evidence of Hawaiian occupation within or adjacent to the Refuge.

6.1.7 Archaeological Resources

The Archaeological Resource Protection Act of 1979 defines archaeological resources as the following: "Any material remains of past human life or activities which are of archaeological interest" and "at least 100 years of age" (16 U.S.C. 470bb(1)). According to 36 CFR Part 296.3, remains are considered of archaeological interest if the resources are "capable of providing scientific or humanistic understandings of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques such as controlled observation, contextual measurement, controlled collection, analysis, interpretation and explanation."

Several archaeological surveys and literature reviews have been conducted for Keālia Pond NWR and additional projects in the vicinity. These studies show that Keālia Pond was an important site for gathering salt and may have been used as a fishpond. Apart from the pond itself, no archaeological items or sites have been encountered in the area. Any areas that may have been suitable for habitation and/or cultural activities were most likely eliminated or modified by amphibious landings during WWII (Athens et al. 1996).

6.1.8 Paleontological Resources

Unless found in an archaeological context, "nonfossilized and fossilized paleontological specimens, or any portion or piece thereof," are not considered archaeological resources (16 U.S.C. 470bb(1)). However, paleontological resources are protected under the Paleontological Resources Preservation Act of 2009. Paleontology resources include life forms that existed in prehistoric or geologic times, as represented by the fossils of plants, animals, and other organisms. Ziegler (2002) defines fossils as "biological remains, whether permineralized or not," that were "deposited in the islands before the time of European contact (CE 1778) *and* are not definitely components of prehistoric archaeological midden (human food refuse and other cultural debris)." Fossils have been uncovered in a variety of sites throughout Hawaiʻi, including sand dunes, sinkholes, lava tubes, and pond deposits.

Olson and James (1982) state that no substantial avifaunal fossil deposits have been found on Maui. Although the isthmus between East and West Maui may have been a potential fossil site due to its calcareous sand composition, the area is largely developed or vegetated. A paleoenvironmental core sample was conducted by Athens et al. (1996) to a depth of 17.16 feet within the mudflat area of Keālia Pond. In addition to providing information on traditional Hawaiian activities in the area, the core was intended to gather data on the prehistoric environment and vegetation. No animal fossils or fossils of other organisms were encountered on site during this survey. Radiocardon dating of the paleoenvironmental core documented a 5600-year-old sequence. Consistent with investigations on other Hawaiian Islands, the chronology of the core suggested that the sand berm along Keālia Pond developed when sea level was regressing around 3,700-4,000 years ago (Athens et al. 1996).

Well-preserved pollen and spore samples provide insight into the lowland vegetation of Maui prior to human settlement. Overall, the area most likely fluctuated between a parkland/shrubland and a dry forest. Similar to studies conducted on Oʻahu, the pollen record in the core showed that the pre-human vegetation at Keālia Pond during the Holocene epoch was influenced by a series of climatic shifts. The earliest pollen assemblage (5,600 years ago) was characterized by lowland forests, indicating that the climate was warmer and wetter. About 2,000-4,500 years ago, the climate became drier. This change is associated with significant volcanic activity, as supported by a period of high charcoal particles in the core. Finally, the pollen record from 1,800-2,000 years ago indicates that conditions became wetter again. Periods of concentrated charcoal particles in the core reveal that natural fires were common in the lowlands of Maui throughout the Holocene (Athens et al. 1996).

6.2 Social and Economic Setting

The purpose of this section is to address the local economy and social environment surrounding the Refuge, including population estimates and economic indicators. Keālia Pond lies between the towns of Māʻalaea and Kīhei within the County of Maui, which encompasses the Hawaiian Islands of Kahoʻolawe, Lanaʻi, Maui, and Molokaʻi. There is no habitation on Molokini.

6.2.1 Population

The 2010 Census data shows Maui County experienced significant population growth in the past decade with a 21 percent increase to 154,834 residents. Of these, 144,444 are living on the Island of Maui. The State Department of Business, Economic Development, and Tourism's (DBEDT) released data on Maui's racial make-up from the 2010 Census. The white race group had the largest number of people with a count of 74,329 and they comprised 52 percent of the population; meaning that about 1 in every 2 persons was at least partially white in Maui County. The Asian group was the next largest with 66,925 people or 46 percent of the population. The Native Hawaiian and Other Pacific Islander race group consisted of 36,971 people and made up 26 percent of Maui's population. This meant that about 1 in every 4 of Maui's residents claimed to be at least partially Native Hawaiian and/or Other Pacific Islander with regard to race (Census 2010).

Data numbers specifically refer to the "race alone or in combination", and include all people that belong to a certain race group, whether the person reported that they were only of that single race or whether they reported that they were that race in combination with one or more of the other major race groups. Therefore, individuals may be counted in more than one race category.

For the first time, the combined communities of Kīhei and Wailea have taken the lead as Maui's largest town with a population of 26,918 in 2010. There has been a tremendous influx of new residents compared to 1970 when the Census Bureau did not even acknowledge the existence of a community in South Maui. A much smaller community, Māʻalaea saw a 22.5 percent population decrease since the 2000 census for a current count of 352 (DBEDT 2011).

Table 6.1. Population figures for selected areas.

Area	Population (1990)	Population (2000)	Population (2010)	Density per Sq Mi (2010)
Kīhei	11,107	16,749	20,881	2,055.3
Māʻalaea	443	454	352	73.8
Maui Island	92,566	118,371	144,444	198.7
Maui County	100,374	128,094	154,834	133.6
Hawaiʻi State	1,108,229	1,211,537	1,360,301	211.8

Source: U.S. Census Bureau 2010

6.2.2 Housing

Since 2000, Maui County's strong local economy, low mortgage interest rates, and mainland investment in real estate, have spurred a huge demand in housing. Off-island buyers are contributing to the increased housing demand with nearly a fifth of the housing units in the County not inhabited by County residents. Within the County, the median household income in 2005 was $57,573, and the median housing value was $573,400. The Census Bureau estimated that Maui residents paid an average of $24,204 per year in mortgage costs, 42 percent of their income. The generally accepted definition of affordability is for a household to pay no more than 30 percent of its annual income on housing. Families who pay more than 30 percent of their income for housing are considered cost burdened and may have difficulty affording necessities such as food, clothing, transportation and medical care. The majority of Maui County residents are paying an unsustainably high percentage of their income toward housing (Maui County Planning Department (MCPD) 2006, MCPD 2010).

Homelessness and the difficulties associated with finding affordable, legal, and safe housing are growing problems throughout Hawaiʻi. According to the Homeless Service Utilization Report (2009), there were 1,115 people in homeless shelters in Maui County in 2009. Several service organizations throughout the County assist in providing emergency and transient housing.

6.2.3 Education

In 2005, the Census Bureau estimated that 86.6 percent of County residents age 25 or older have graduated high school and 23.8 percent have a bachelor's degree or higher. While the high school graduation rate of Maui County is slightly higher than that of the remainder of the United States, the percentage of residents with higher-level degrees is lower. Until 2009, Maui Community College was one of seven community colleges in the UH System. In the spring of 2010, the Western Association of Schools and Colleges approved the name change from "Maui Community College" to "University of Hawaiʻi Maui College" to provide a more accurate reflection of the college's three baccalaureate degrees. The main 78-acre Maui campus is in Kahului, Maui with additional education centers located in Hāna, Maui and on the islands of Molokaʻi and Lanaʻi. The student population numbered around 4,400 students in the spring semester of 2011.

The City of Kīhei has three public elementary schools, one private elementary school, one public intermediate school, and one public high school. The Kīhei-Makena Community Plan (1998) identifies the elementary school environment as one of the most important problems facing the community, describing classrooms as "crowded, uncomfortable, and generally poor" (MCPD 1998, MCPD 2006).

6.2.4 Economics

The median household income for the Island of Maui in 2009 was $64,150. In 2007, the Census Bureau reported that Maui County was home to 2,111 businesses owned by "Native Hawaiians and Other Pacific Islanders." Unemployment figures for the island in January 2011 were at 7.9 percent, almost double the 4 percent unemployment rate in 2005. The most recent income figures for communities near the Refuge are shown in Table 6.2 (MCPD 2006, DBEDT 2010, Census 2010).

Table 6.2. Census Bureau estimated median and per capita income, 2009.

Area	Median Household Income	Median Family Income	Per Capita Income
Kīhei	$63,223	$75,926	$29,519
Mā'alaea	$64,875	$120,268	$51,259
Maui County	$64,150	$72,367	$29,121

Source: U.S. Census Bureau 2010

The economy on Maui is largely based on tourism. As the second most popular Hawaiian Island behind O'ahu, there were 1,932,357 visitors to the Island of Maui in 2009 with an average daily count of 41,608 people. The hotels and service industry employs the largest amount of Maui residents, with 17,836 jobs in 2009 bringing in $565,032,534 in wages. Major employers include: Town Reality of Hawai'i, Grand Wailea Resort Hotel, and Hyatt Regency Maui Resort & Spa (DBEDT 2010).

The main tourist attractions for Maui island visitors include: Maui Ocean Center, historic whaling town of Lahaina, the road to Hāna, Ka'anapali beaches, Haleakalā National Park, and Kīpahulu. The areas surrounding Mā'alaea Bay and coastal Kīhei, which have seen extensive development of resort hotels, condominiums, and other commercial structures, are particularly important sites for tourism. Recreational visits to Keālia Pond NWR also directly contribute to the local economy. Visitor expenditures include food, lodging, transportation, and other expenses while engaging in activities on the Refuge. Approximately 2,700 people have visited the Refuge each year for bird watching, photography, EE, and various habitat restoration projects. Visitation is expected to increase with the new VC and EE programs (Speakman 1978, CH2M Hill, Inc. 1997).

Agriculture remains an important component of Maui's economy. Top products in Central Maui (near Keālia Pond) include: bananas, cattle, flowers, hogs, nursery products, pineapples, sugarcane, taro, and vegetables. The HC&S dominates the agriculture industry on the Island. They are looking to diversify with a study on producing advanced biofuels from sugarcane grown on Maui. The Office of Naval Research is budgeting $2 million annually for the project through 2015, with a focus on producing diesel and jet fuel from sugar (MCPD 2010, UH 2010).

The State of Hawai'i is investing in the advanced commercial high technology sector on Maui. Specific areas of interest include information technology, telecommunications, biotechnology, and space science. Kīhei, which contains two high-technology centers, has become a prime location promoting the development of this sector. Both the Maui High Performance Computing Center and the Maui Research and Technology Center are important elements in promoting the State as a center for innovative technology and ensuring a competitive economy in the future. Maui is also an important center for advanced astronomical research. The Haleakalā Observatory was Hawaii's first astronomical research and development facility at the Maui Space Surveillance Site electro-optical facility where satellite tracking facilities are co-located with a research and development facility (MCPD 2010).

Appendix A. Species Lists

Animal Species		
Common Name	**Scientific Name**	**Hawaiian Name**
Fish		
Australian mullet	*Chelon engeli*	
Chinese catfish	*Clarias fuscus*	
Hawaiian flagtail	*Kuhlia sandvicensis*	‘Āholehole
Hawaiian sleeper	*Eleotris sandwicensis*	O‘opu
Liberty/Mexican molly	*Poecilia spp.*	
Milkfish	*Chanos chanos*	‘Awa
Mosquitofish	*Gambusia affinis*	I‘a makika
Mozambique tilapia	*Oreochromis mossambicus*	
Redbelly tilapia	*Tilapia zilii*	
Striped mullet	*Mugil cephalus*	‘Ama ‘ama
Tilapia	*Oreochromis macrochir*	
Invertebrates		
American cockroach	*Periplaneta americana*	
Anthomyiid fly	*Clunio littoralis*	
Asian swallowtail butterfly	*Papilio xuthus*	
Asian tiger mosquito	*Aedes albopictus*	
Banana skipper	*Erionota thrax*	
Bigheaded ant	*Pheidole megacephala*	
Bilobed looper moth	*Megalographa biloba*	
Black field earwig	*Nala lividipes*	
Black saddlebags	*Tramea lacerata*	
Black witch	*Ascalapha odorata*	
Blackburn’s sphinx moth	*Manduca blackburni*	‘Ōka‘i ‘aiea
Brine fly	*Ephydra gracilis*	
Cabbage white	*Pieris rapae*	
Caddisfly	*Cheumatopsyche pettiti*	
Carpenter ant	*Camponotus variegatus*	
Chinese rose beetle	*Adoretus sinicus*	
Click beetle	*Cardiophorus stolatus*	
Click beetle	*Conoderus exsul*	
Cockroach egg parasitoid	*Evania appendigaster*	
Comperia wasp	*Comperia merceti*	
Crane fly	*Styringomyia didyma*	
Crayfish	*Procambarus clarkii*	‘Ōpae pake
Darner dragonfly	*Anax junius*	
Drone fly	*Eristalis tenax*	
Dung beetle	*Aphodius lividus*	
Ficus blister gall wasp	*Josephiella microcarpae*	
Fiery skipper butterfly	*Hylephila phyleus*	
Fire ant	*Solenopsis geminata*	

Common Name	Scientific Name	Hawaiian Name
Fly	*Anthrax koshunensis*	
Formosan subterranean termite	*Coptotermes formosanus*	
Fragile forktail	*Ischnura posita*	
German cockroach	*Blattella germanica*	
Globe skimmer	*Pantala flavescens*	
Grass bagworm	*Brachycyttarus griseus*	
Grass shrimp	*Neocaridina denticulate sinensis*	
Grasshopper	*Atractomorpha cynensis*	
Green darner	*Anax junius*	
Greenbugs aphid parastoid	*Lysiphlebus testaceipes*	
Ground beetle	*Stenolophus quinquepustulatus*	
Guava moth	*Ophiusa disjungens*	
Hawaiian blue butterfly	*Udara blackburni*	Koa pulelehua
Hawaiian midge	*Chironomus hawaiiensis*	
Hawaiian pelagic water strider	*Halobates hawaiiensis*	
Hawaiian prawn	*Macrobrachium grandimanus*	‘Ōpae oeha‘a
Hawaiian red shrimp	*Halocaradiana rubra*	‘Ōpae‘ula
Hover fly	*Eristalinus aeneus*	
Hover fly	*Ornidia obesa*	
Hover fly	*Syritta orientalis*	
Mealybug ladybird	*Cryptolaemus montrouzieri*	
Mexican leaf-roller	*Amorbia emigratella*	
Monarch butterfly	*Danaus plexippus*	
Midge	*Chironomus esakii*	
Milkweed aphid	*Aphis nerii*	
Oriental cockroach	*Blatta orientalis*	
Oriental latrine fly	*Chrysomya megacephala*	
Painted lady	*Vanessa cardui*	
Papuana ant	*Solenopsis papuana Emery*	
Passion butterfly	*Agraulis vanillae*	
Peablue butterfly	*Lampides boeticus*	
Powderpost beetle	*Amphicerus cornutus*	
Rambur's forktail	*Ischnura ramburii*	
Red admiral	*Vanessa atalanta*	
Red-black false blister beetle	*Ananca bicolor*	
Riparian earwig	*Labidura riparia*	
Roseate skimmer	*Orthemis ferruginea*	
Rove beetle	*Philonthus sp.*	
Salt marsh water boatmen	*Trichocorixa reticulata*	
Sevenspotted lady beetle	*Coccinella septempunctata*	
Skimmer dragonfly	*Orthemis ferruginea*	
Seed bug	*Ligyrocoris litigiosus*	
Soldier beetle	*Caccodes oceaniae*	
Sonoran carpenter bee	*Xylocopa sonorina*	

Common Name	Scientific Name	Hawaiian Name
Southern house mosquito	*Culex quinquefasciatus*	
Spotted-winged midge	*Polypedilum nubifer*	
Stable fly	*Stomoxys calcitrans*	
Syrphid fly	*Eristalinus arvorum*	
Vermilion saddlebags	*Tramea abdominalis*	
Water scavenger beetle	*Tropisternus sp.*	
Wasp mimic	*Taeniaptera angulata*	
Western honey bee	*Apis mellifera*	
Western pygmy blue butterfly	*Brephidium exilis*	
Mammals		
Black rat	*Rattus rattus*	ʻIole
Cat	*Felis catus*	Pōpoki
Dog	*Canis familiaris*	ʻĪlio
Hawaiian monk seal	*Monachus schauinslandi*	ʻĪlio-holo-i-ka-uaua
House mouse	*Mus musculus*	ʻIole
Polynesian rat	*Rattus exulans*	ʻIole
Small Indian mongoose	*Herpestes auropunctatus*	Manakuke
Reptiles and Amphibians		
Brahminy blind snake	*Ramphotyphlops braminus*	
Cane toad	*Bufo marinus*	
Common house gecko	*Hemidactylus frenatus*	Moʻo ʻalā
Green anole lizard	*Anolis carolinensis porcatus*	
Green turtle	*Chelonia mydas*	Honu
Hawksbill sea turtle	*Eretmochelys imbricate*	Honu ʻea
Red-eared slider	*Chrysemys scripta elegans*	
Hawaiian Birds		
Black-crowned night-heron	*Nycticorax nycticorax hoactli*	ʻAukuʻu
Hawaiian coot	*Fulica alai*	ʻAlae keʻokeʻo
Hawaiian duck	*Anas wyvilliana*	Koloa maoli
Hawaiian goose	*Branta sandvicensis*	Nēnē
Hawaiian stilt	*Himantopus mexicanus knudseni*	Aeʻo
Short-eared owl	*Asio flammeus sandwichensis*	Pueo
Migratory Birds		
Grebes		
Eared grebe	*Podiceps nigricollis*	
Pied-billed grebe	*Podilymbus podiceps*	
Herons		
Cattle egret	*Bubulcus ibis*	
Great blue heron	*Ardea herodias*	
Great egret	*Ardea alba*	
Snowy egret	*Egretta thula*	
Ibises		
White-faced ibis	*Plegadis chihi*	

Common Name	Scientific Name	Hawaiian Name
Geese and Ducks		
American wigeon	*Anas Americana*	
Blue-winged teal	*Anas discors*	
Brant	*Branta bernicla*	
Bufflehead	*Bucephala albeola*	
Cackling goose	*Branta hutchinsii*	
Canada goose	*Branta canadensis*	
Canvasback	*Aythya valisineria*	
Cinnamon teal	*Anas cyanoptera*	
Common goldeneye	*Bucephala clangula*	
Common merganser	*Mergus merganser*	
Eurasian wigeon	*Anas penelope*	
Fulvous whistling duck	*Dendrocygna bicolor*	
Gadwall	*Anas strepera*	
Garganey	*Anas querquedula*	
Greater scaup	*Aythya marila*	
Greater white-fronted goose	*Anser albifrons*	
Green-winged teal	*Anas crecca*	
Lesser scaup	*Aythya affinis*	
Mallard	*Anas platyrhynchos*	
Northern pintail	*Anas acuta*	Koloa māpu
Northern shoveler	*Anas clypeata*	Koloa mohā
Red-breasted merganser	*Mergus serrator*	
Redhead	*Aythya Americana*	
Ring-necked duck	*Aythya collaris*	
Snow goose	*Chen caerulescens*	
Tufted duck	*Aythya fuligula*	
Tundra swan	*Cygnus columbianus*	
Stilts		
American avocet	*Recurvirostra americana*	
Shorebirds		
Baird’s sandpiper	*Calidris bairdii*	
Black-bellied plover	*Pluvialis squatarola*	
Bristle-thighed curlew	*Numenius tahitiensis*	Kioea
Common snipe	*Gallinago gallinago*	
Curlew sandpiper	*Calidris ferruginea*	
Dunlin	*Calidris alpina*	
Greater yellowlegs	*Tringa melanoleuca*	
Killdeer	*Charadrius vociferus*	
Least sandpiper	*Calidris minutilla*	
Lesser yellowlegs	*Tringa flavipes*	
Long-billed dowitcher	*Limnodromus scolopaceus*	
Marbled godwit	*Limosa fedoa*	
Pacific golden plover	*Pluvialis fulva*	Kōlea
Pectoral sandpiper	*Calidris melanotos*	

Common Name	Scientific Name	Hawaiian Name
Red knot	*Calidris canutus*	
Red-necked stint	*Calidris ruficollis*	
Ruddy turnstone	*Arenaria interpres*	‘Akekeke
Ruff	*Philomachus pugnax*	
Sanderling	*Calidris alba*	Hunakai
Semipalmated plover	*Charadrius semipalmatus*	
Sharp-tailed sandpiper	*Calidris acuminata*	
Short-billed dowitcher	*Limnodromus griseus*	
Spotted sandpiper	*Actitis macularia*	
Wandering tattler	*Heteroscelus incanus*	‘Ūlilī
Western sandpiper	*Calidris mauri*	
Wilson’s phalarope	*Phalaropus tricolor*	
Whimbrel	*Numenius phaeopus*	
Gulls		
Bonaparte’s gull	*Larus philadelphia*	
California gull	*Larus californicus*	
Common black-headed gull	*Larus ridibundus*	
Franklin’s gull	*Larus pipixcan*	
Herring gull	*Larus argentatus*	
Glaucous-winged gull	*Larus glaucescens*	
Laughing gull	*Larus atricilla*	
Ring-billed gull	*Larus delawarensis*	
Terns		
Arctic tern	*Sterna paradisaea*	
Black tern	*Chlidonias niger*	
Caspian tern	*Sterna caspia*	
Common tern	*Sterna hirundo*	
Gull-billed tern	*Sterna nilotica*	
Least tern	*Sterna antillarum*	
Raptors		
Barn owl	*Tyto alba*	
Hawaiian short-eared owl	*Asio flammeus sandwichensis*	Pueo
Northern harrier	*Circus cyaneus*	
Osprey	*Pandion haliaetus*	
Peregrine falcon	*Falco peregrinus*	
Gallinaceous Birds		
Black francolin	*Francolinus francolinus*	
Gray francolin	*Francolinus pondicerianus*	
Ring-necked pheasant	*Phasianus colchicus*	
Migratory seabirds		
Bulwer’s petrel	*Bulweria bulwerii*	‘Ou
Black noddy	*Anous minutes melanogenys*	Noio
Blue-gray noddy	*Procelsterna cerulean saxatilis*	
Brown noddy	*Anous stolidus pileatus*	Noio kōhā
Great frigatebird	*Fregata minor palmerstoni*	‘Iwa

Common Name	Scientific Name	Hawaiian Name
Lesser frigatebird	*Fregata ariel*	
Red-footed booby	*Sula sula rubripes*	‘Ā
Wedge-tailed shearwater	*Puffinus pacificus*	‘Ua‘u kani
Nonnative Passerines		
African silverbill	*Lonchura cantans*	
Chestnut munia	*Lonchura atricapilla*	
Common myna	*Acridotheres tristis*	
House finch	*Carpodacus mexicanus*	
House sparrow	*Passer domesticus*	
Japanese white-eye	*Zosterops japonicas*	
Java sparrow	*Padda oryzivora*	
Mourning dove	*Zenaida macroura*	
Northern mockingbird	*Mimus polyglottos*	
Northern cardinal	*Cardinalis cardinalis*	
Nutmeg manikin	*Lonchura punctulata*	
Orange-cheeked waxbill	*Estrilda melpoda*	
Red avadavat	*Amandava amandava*	
Red-crested cardinal	*Paroaria coronate*	
Rock dove	*Columba livia*	
Spotted dove	*Streptopelia chinensis*	
Zebra dove	*Geopelia striata*	

Plant Species		
Australian saltbush	*Atriplex semibacatta*	
Barnyard grass	*Echinochloa crus-galli*	
Beach morning glory	*Ipomoea pes-caprae*	Pōhuehue
Beach naupaka	*Scaevola sericea*	Naupaka kahakai
Beach vitex	*Vitex rotundifolia*	‘Uhaloa
Bermuda grass	*Cynodon dactyron*	Manienie
Buffel grass	*Cenchrus ciliaris*	
California bulrush	*Schoenoplectus californicus*	‘Aka‘akai
California fan palm	*Washington robusta*	
California grass	*Brachiaria mutica*	
Coast sandalwood	*Santalum ellipticum*	Ihiahialo‘e
False sandalwood	*Myoporum sandwicense*	Naio
Guinea grass	*Panicum maximum*	
Hawai'i desert-thorn	*Lycium sandwicense*	‘Ohelo kai
Hawaiian cotton	*Gossypium tomentosum*	Mao
Hibiscus	*Hibiscus tiliaceus*	Hau
Hilo grass	*Paspalum conjugatum*	
Ironwood	*Casuarina equisetifolia*	
Koa haole	*Leucana leucocephala*	Koa haole
Lead tree	*Cordia subcordata*	Kou
Marsh fleabane	*Pluchea* x *fosbergii*	
Marsh fleabane	*Pluchea indica*	

Common Name	Scientific Name	Hawaiian Name
Marsh fleabane	*Pluchea carolinensis*	
Mesquite	*Prosopis pallida*	Kiawe
Pickleweed	*Batis maritima*	‘Akulikuli kai
Primrose willow	*Ludwigia octovalvis*	
Purple nutsedge	*Cyperus rotundus*	
Salt grass	*Distichlis spicata*	
Saltmarsh bulrush, makai sedge	*Bolboschoenus maritimus*	Kaluhā
Screw pine	*Pandanus tectorius*	Hala
Sea purslane	*Sesuvium portulacastrum*	‘Akulikuli
Seashore paspalum	*Paspalum vaginatum*	
Seashore rushgrass	*Sporobolus virginicus*	‘Aki’aki
Seaside heliotrope	*Heliotropium curassavicum*	Kīpūkai
Smooth flatsedge	*Cyperus laevigatus*	Makaloa
Spikerush, bent spikerush	*Eleocharis geniculata*	
Spiny amaranth	*Amaranthus spinosus*	Pakai kuku
Sprangletop	*Leptochloa fusca*	
Swollen fingergrass	*Chloris barbata*	
Tamarisk	*Tamarisk aphylla*	
Tree tobacco	*Nicotiana glauca*	
Uhaloa	*Waltheria indica*	‘Uhaloa
Wild millet, jungle-rice	*Echinochloa colona*	
Yellow ilima	*Sida fallax*	‘Ilima

Molokini Islet Species

Common Name	Scientific Name	Hawaiian Name
Invertebrates (2006)		
American cockroach	*Periplaneta americana*	
Beet webworm	*Spoladea recurvalis*	
Bigheaded ant	*Pheidole megacephala*	
Black house ant	*Ochetellus glaber*	
Black cockroach wasp	*Dolichurus stantoni*	
Dark comb-footed spider	*Steatoda grossa*	
Garden spider	*Argiope appensa*	
Grass webworm	*Herpetogramma licarsisalis*	
Guava moth	*Ophiusa disjungens*	
Hawaiian carpenter ant	*Camponotus variegates*	
House fly	*Musca domestica*	
Jumping plant louse	*Heteropsylla cubana*	
Keyhole wasp	*Pachodynerus nasidens*	
Koa haole seed weevil	*Araecerus levipennis*	
Long-legged fly	*Chrysosoma globiferum*	
Narrow-winged mantis	*Tenodera angustipennis*	
Orange-spotted ladybird	*Orcus australasiae*	
Paperfish	*Ctenolepisma longicaudatum*	
Sonoran carpenter bee	*Xylocopa sonorina*	
Thrip	*Acrotelsa hawaiiensis*	
Woodlouse spider	*Dysdera crocota*	
Seabirds		
Bulwer’s petrel	*Bulweria bulwerii*	‘Ou
Black noddy	*Anous minutes melanogenys*	Noio
Brown noddy	*Anous stolidus pileatus*	Noio kōhā
Great frigatebird	*Fregata minor palmerstoni*	‘Iwa
Red-footed booby	*Sula sula rubripes*	‘Ā
Wedge-tailed shearwater	*Puffinus pacificus*	‘Ua‘u kani

Plants (2005)		
Alena	*Boerhavia herbstii*	Alena
Alena	*Boerhavia repens*	Alena
Australian saltbush	*Atriplex semibaccata*	
Beach wiregrass	*Dactyoloctenium aegyptium*	
Bristly foxtail	*Setaria verticillata*	
Buffel grass	*Cenchrus ciliaris*	
Bur clover	*Medicago polymorpha*	
Cheeseweed	*Malva parviflora*	
Coastal nehe	*Lipochaeta lavarum*	Nehe
Coat buttons	*Tridax procumbens*	
Common sowthistle	*Sonchus oleraceus*	Pualele
Cow pea	*Macroptilium lathyroides*	

Common Name	Scientific Name	Hawaiian Name
Feather fingergrass	*Chloris virgata*	
Fuzzy rattlepod	*Crotalaria incana*	
Goatweed	*Ageratum conyzoides*	
Golden crown-beard	*Verbesina encelioides*	
Golden fern	*Pityrogramma austroamericana*	
Hairy abutilon	*Abutilon grandifolium*	
Hairy horseweed	*Conyza bonariensis*	
Hairy morning glory	*Merremia aegyptia*	
Hairy spurge	*Chamaesyce hirta*	
Hawai'i desert-thorn	*Lycium sandwicense*	‘Ohelo kai
Henry's crabgrass	*Digitaria ciliaris*	
Ihi	*Portulaca molokiniensis*	‘Ihi
Indian fig	*Opuntia ficus-indica*	Panini
Jamaican feverplant	*Tribulus cistoides*	Nohu
Kaunaoa	*Cuscuta sandwichiana*	Kauna‘oa
Koa haole	*Leucaena leucocephala*	Koa haole
Lambs quarters	*Chenopodium murale*	
Lantana	*Lantana camara*	
Maui panic grass	*Panicum pellitum*	Kaioio
Morning glory	*Jacquemontia ovalifolia sandwicensis*	Pā‘uohi‘iaka
Panicum	*Panicum faurei latius*	
Pickleweed	*Sesuvium portulacastrum*	‘Akulikuli
Pigweed	*Portulaca oleracea*	
Pili grass	*Heteropogon contortus*	
Polycarpon	*Polycarpon tetraphyllum*	
Portulaca	*Portulaca pilosa*	
Prickly lettuce	*Lactuca sativa*	
Prickly poppy	*Argemone glauca*	Pua kala
Purple cudweed	*Gamochaeta pupurea*	
Purslane	*Portulaca villosa*	Po‘e, ‘ihi
Radiate fingergrass	*Chloris radiata*	
Salt heliotrope	*Heliotropium curassavicum*	Nena
Saltbush	*Atriplex suberecta*	
Sandburr	*Cenchrus echinatus*	
Scarlet pimpernel	*Anagallis arvensis*	
Sourbush	*Pluchea carolinensis*	
Spanish clover	*Desmodium sandwicense*	
Spanish needles	*Bidens pilosa*	
Swinecress	*Coronopus didymus*	
Swollen fingergrass	*Chloris barbata*	
Sword fern	*Nephrolepis multiflora*	
Torrid panicgrass	*Panicum torridum*	Ka kona kona
Tree tobacco	*Nicotiana glauca*	

Common Name	Scientific Name	Hawaiian Name
Triangleleaf lipfern	*Doryopteris decipiens*	‘Iwa‘iwa
Uhaloa	*Waltheria indica*	‘Uhaloa
Yellow ilima	*Sida fallax*	‘Ilima
Yellow wood sorrel	*Oxalis corniculata*	

Appendix B. Compatibility Determinations and Appropriate Use Findings

B.1 Introduction

The Compatibility Determinations (CD) developed during the CCP planning process evaluate uses projected to occur at the Keālia Pond NWR over the next 15 years. The evaluation of funds needed for management and implementation of each use also assumes implementation as described in Chapter 2.

B.1.1 Uses Evaluated At This Time

The following CD are included in this CCP.

Table B-1. Summary of Compatibility Determinations.

Refuge Use	Page	Compatible?	Year Due for Reevaluation
Wildlife Observation, Photography, and Interpretation	B-5	Yes	2026
Environmental Education	B-11	Yes	2026
Research, Scientific Collecting, and Surveys	B-17	Yes	2021
Kiawe Tree Harvesting	B-27	Yes	2021

B.1.2 Compatibility – Legal and Historical Context

Compatibility is a tool refuge managers use to ensure that recreational and other uses do not interfere with wildlife conservation, the primary focus of refuges. Compatibility is not new to the Refuge System and dates back to 1918 as a concept. As policy, it has been used since 1962. The Refuge Recreation Act of 1962 directed the Secretary of the Interior to allow only those public uses of Refuge lands that were "compatible with the primary purposes for which the area was established."

Legally, Refuges outside of Alaska are closed to all public uses until officially opened. Regulations require that adequate funds be available for administration and protection of refuges before opening them to any public uses. However, wildlife-dependent recreational uses (hunting, fishing, wildlife observation and photography, environmental education, and interpretation) are to receive enhanced consideration and cannot be rejected simply for lack of funding resources unless the refuge has made a concerted effort to seek out funds from all potential partners. Once found compatible, wildlife-dependent recreational uses are deemed the priority public uses at the refuge. If a proposed use is found not compatible, the refuge manager is legally precluded from approving it. Economic uses that are conducted by or authorized by the refuge also require CD.

Under compatibility policy, uses are defined as recreational, economic/commercial, or management use of a refuge by the public or a non-Refuge System entity. Uses generally providing an economic return (even if conducted for the purposes of habitat management) are also subject to CD. The Service does not prepare CD for uses when the Service does not have jurisdiction. For example, the Service may have limited jurisdiction over Refuge areas where property rights are vested by others; where legally binding agreements exist; or where there are treaty rights held by tribes. In addition, aircraft overflights, emergency actions, some activities on navigable waters, and activities by other Federal agencies on "overlay Refuges" are exempt from the compatibility review process.

New compatibility regulations were adopted by the Service in October 2000. The regulations require that a use must be compatible with both the Refuge System mission and the purpose(s) of the individual Refuge. This standard helps to ensure consistency in application across the Refuge System. The Administration Act also requires that CD be in writing and that the public have an opportunity to comment on all use evaluations.

The Refuge System mission emphasizes that the needs of fish, wildlife, and plants must be of primary consideration. The Administration Act defined a compatible use as one that ". . . in the sound professional judgment of the Director, will not materially interfere with or detract from the fulfillment of the mission of the System or the purposes of the Refuge." Sound professional judgment is defined under the Administration Act as ". . . a finding, determination, or decision, that is consistent with principles of sound fish and wildlife management and administration, available science and resources . . ." Compatibility for wildlife-dependent uses may depend on the level or extent of a use.

Court interpretations of the compatibility standard have found that compatibility is a biological standard and cannot be used to balance or weigh economic, political, or recreational interests against the primary purpose of the refuge (*Defenders of Wildlife* v. *Andrus*).

The Service recognizes that CD are complex. For this reason, refuge managers are required to consider "principles of sound fish and wildlife management" and "best available science" in making these determinations (House of Representatives Report 105-106). Evaluations of the existing uses on the Keālia Pond NWR are based on the professional judgment of Refuge and planning personnel including observations of Refuge uses and reviews of relevant scientific literature.

B.1.3 Appropriate Use Findings

The Appropriate Refuge Uses policy outlines the process that the Service uses to determine when general public uses on refuges may be considered. Priority public uses previously defined as wildlife-dependent uses (hunting, fishing, wildlife observation and photography and EE and interpretation) under the Administration Act are generally exempt from appropriate use review. Other exempt uses include situations where the Service does not have adequate jurisdiction to control the activity and refuge management activities. In essence, the Appropriate Refuge Use policy, 603 FW 1 (2006), provides refuge managers with a consistent procedure to first screen and then document decisions concerning a public use. When a use is determined to be appropriate, a refuge manager must then decide if the use is compatible before allowing it on a refuge. The policy also requires review of existing public uses. During the CCP process, the refuge manager evaluated all existing and proposed refuge uses at Keālia Pond NWR using the guidelines and criteria as outlined in the appropriate use policy.

Using this process, and as documented on the following pages, the refuge manager determined the following uses appropriate: "Research, Scientific Collecting, and Surveys" and "Kiawe Tree Harvesting."

B.1.4 References

Compatibility regulations, adopted by the Service in October 2000: http://Refuges.fws.gov/policymakers/nwrpolicies.html

Defenders of Wildlife v. *Andrus* (Ruby Lake Refuge I). 11 Envtl. Rptr. Case 2098 (D.D.C. 1978), p. 873.

Fish and Wildlife Service. 2011. Keālia Pond National Wildlife Refuge: *Draft Comprehensive Conservation Plan and Environmental Assessment.*

House of Representatives Report 105-106 http://refuges.fws.gov/policyMakers/mandates/HR1420/part1.html

B.2 Compatibility Determination for Wildlife Observation, Photography, and Interpretation

Refuge Name(s): Keālia Pond National Wildlife Refuge

County and State: Maui County, Hawai‘i

Establishing and Acquisition Authority(ies):

Keālia Pond NWR was established in 1992 under the authority of the:

- Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 742a – 742j)
- Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544)

Refuge Purpose(s):

"…to conserve (A) fish and wildlife which, are listed as endangered or threatened species… or (B) Plants …" 16 U.S.C. 1534, Endangered Species Act of 1973.

National Wildlife Refuge System Mission:

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (Administration Act).

Description of Use(s):

The National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee), as amended by the National Wildlife Refuge System Improvement Act of 1997 identifies wildlife observation and photography among wildlife-dependent public uses which, when compatible with the purpose(s) of the refuge, are priority public uses and receive special consideration in planning for and management of the Refuge System.

Wildlife observation, photography and interpretation are non-consumptive, wildlife-dependent public uses with similar elements and so are considered together in this CD. Keālia Pond NWR is open to the public 5 days a week (closed on weekends), excluding Federal holidays. Public use activities take place at two areas on the Refuge, the Kanuimanu Ponds and the Keālia Coastal Boardwalk, with the goal of minimizing wildlife disturbance throughout the wetlands. The majority of use is self-guided. The Refuge has improved the public use facilities at these locations and the new visitor center will provide more formal learning opportunities and enhance their experience on the trails.

Most of the wildlife observation, photography, and interpretation activities occur at the Kanuimanu Ponds. The 20 acres of constructed ponds are remnant of the previous aquaculture facility that was in full operation before the Refuge was established. The five ponds comprising this area are interconnected with levees that serve as the hiking trail. These earthen levees have been widened and compacted sufficiently to allow access for wheelchairs for most of the route. Wheelchairs, defined as a device specifically designed to be used indoors and outdoors by a person with a disability, are the only motorized vehicles permitted on the trails. Pets are not allowed on the Refuge because of the openness of the area and close proximity to waterbirds.

The Kanuimanu Ponds area is flat and open with no trees along the levees. Vegetation is limited to ground cover and grasses, mostly for waterbird use and access, and maintenance reasons. A visitor shelter is planned for future construction; this three-sided structure will be placed in the footprint of the previous office trailer next to the eight-stall parking lot.

The Keālia Coastal Boardwalk is accessible from N. Kīhei Rd.; however, entry and exit into the parking area is only when traveling from Mā‘alaea (west side) to Kīhei (east side). This configuration allows safe sight distance when entering and exiting the lot due to the road’s alignment and adjacent curves. The Boardwalk gates are opened at 6:00 a.m. and closed at 7:00 p.m. throughout the year (including weekends).

The 2,200-foot long elevated Boardwalk is for pedestrians to access the sensitive coastal habitat without impacting (trampling) the dunes for the purpose of wildlife observation and photography. Wildlife viewing (bird watching) activity is best during winter months when the coastal flats are flooded and with future capability of maintaining water on the flats, the opportunities would be year-round. This highly visible facility is well used for wildlife observation; however, the trail is also used by beach walkers since the three Boardwalk ramps were intended to provide a loop trail. In general, all Boardwalk users, whether intentionally observing wildlife or not, have the opportunity to learn about the wetlands and wildlife from the interpretive panels placed along the length. Since the opening of the Boardwalk in September 2009, there has been an average of 15-20 people per day. The Boardwalk is intended for pedestrian traffic only, excluding pets, bicycles, skateboards, and bikes. The Boardwalk was constructed for access by persons with disabilities and is the best place on the Refuge for wheelchairs because of the smoother surface on the decking (compared with earthen levees).

The new headquarters/visitor center (HQ/VC) at Keālia Pond NWR will be staffed by trained volunteers for direct contact with visitors that will enhance their wildlife observation and interpretation experiences. In addition, the exhibit hall has interpretive panels to introduce visitors to the wetland and the resources for their outdoor observations.

Availability of Resources:

Category and Itemization	**One-time $**	**Annual $/yr**
Administration and management:	$0	$800
Maintenance:	$0	$5,400
Monitoring costs:	$0	$3,600
Special equipment, facilities, or improvements:	$0	$0
Offsetting revenues:	$0	$0

The Refuge has sufficient budget and staff to manage this use. Wildlife observation, photography, and interpretation on the Refuge require minimal resources because the public is on their own; however, indirectly, resources in the form of facilities maintenance and wetland restoration to maintain viewing opportunities do exist. The HQ/VC is intended to prepare visitors with the basic ecology and biology of the Refuge to supplement their experience on the trails.

Anticipated Impacts of the Use(s):
There are different types of human-wildlife conflicts (direct or indirect; human-caused or wildlife-caused) that occur when people are in nature. Public use activities at Keālia Pond NWR are designed to eliminate direct conflicts (e.g., harassment, direct mortality) and minimize indirect conflicts (disturbance as defined by a change in the wildlife's behavior), as a rule. Wildlife observation and photography is identified as a priority use because of the importance of sharing what is being protected and opportunities to increase visitor awareness of, appreciation for, and stewardship towards the natural resources. A balance needs to be attained in order for human activities to coexist with waterbird needs. This can be accomplished by minimizing activities and designing public use facilities that allow birds to engage in their natural behaviors.

Human activities on unconfined trails may result in direct effects on wildlife through harassment, a form of disturbance that can cause physiological effects or varying levels of behavioral modifications (Smith and Hunt 1995). Studies have shown that the severity of the effects depends upon the distance to the disturbance and its duration, frequency, predictability, and visibility to wildlife (Knight and Cole 1991). The variables found to have the greatest influence on wildlife behavior are: a) the distance from the animal to the disturbance, b) duration of the disturbance, and c) the amount and kind of vegetative cover. In addition, the type of movement by people elicits different responses; for examples, birds show a greater flight response from a human moving quickly and unpredictably (erratic) than to humans moving slowly following a distinct path. Excessive human noises, especially with erratic behavior, are also a factor in bird disturbance by humans.

Keālia Pond NWR has two areas where the public engages in wildlife observation and photography: the Kanuimanu Ponds and the Keālia Coastal Boardwalk.

Short-term impacts: Keālia Pond NWR has been open to the public for approximately 17 years during which time the staff has observed and monitored public use and waterbird behavior to formalize general rules and conditions for public access onto the Kanuimanu Pond levees. Based on this history, the Refuge will continue offering wildlife observation and photography opportunities because the short-term impacts are offset by minimizing or eliminating human disturbance. Activities are limited to pedestrian access only. Vehicles and bikes are not allowed on the levees or Boardwalk and pets (even on leashes) are not permitted. The presence of people observing or photographing wildlife has potential to cause short-term disturbances to wildlife. However, a majority of the visitors are in small groups (1-5) that create minimal disturbance of birds. Large tours or groups are typically birdwatchers that are goal-oriented and intent on minimal disturbance. Large non-wildlife-dependent activity groups are not the norm; however, if excessive disturbance is observed, the Refuge would mitigate through group education and interpretation. The staff will continue to monitor public use of the Refuge, identify when birds are most susceptible to human disturbance, and implement measures to eliminate and/or minimize the human activities for the benefit of endangered waterbirds.

Long-term impacts: Short-term impacts can have cumulative effects on waterbirds. During nesting season, trails are closed to public access to eliminate disturbance to waterbirds incubating eggs and rearing young. In the past, this closure has occurred during ‘alae ke‘oke‘o nesting period (January-February); however, this is not necessary every year, due to the location of their nests in emergent vegetation in the Main Pond hidden from view. During brood rearing, the young have the capability of swimming into the vegetation away from people. In contrast, closures are more typical during ae‘o nesting season (May-June) because of the location of their nests on the ground (adjacent to water), low tolerance to disturbance, and the chicks' limited ability to escape. In general, visitors' responses to these closures appear to be acceptable, especially since the bird observations are still available from the parking area or areas adjacent to the Boardwalk.

Wildlife disturbances can also be minimized when planning the restoration of wetlands. The Kanuimanu Ponds is the primary area for public use; however, this was only by convenience: the ponds were pre-existing as aquaculture ponds before the Refuge was established. When the ponds were restored, one of the primary objectives was to enhance habitat for endangered waterbirds; the use was not expected to create prime nesting habitat more so than foraging habitat because the area was open to the public. Instead, the ponds were designed to attract a diversity of waterbirds throughout the year for wildlife observation and photography. The vegetation along the slope and in the ponds in addition to combining small ponds into larger ponds created habitat away from trails for waterbirds to seek shelter, if necessary. This type of planning is expected to minimize short- and long-term effects to waterbirds.

Refuge staff will continue to monitor public use activities and evaluate potential disturbances in future planning and design of public use facilities. Future planning will also include methods to provide a high-quality experience to the public (e.g., bird observation or photo blinds). With the opening of a visitor center and the expected increase in public use, attention to this balance between waterbird use and public use will be essential to retain a quality wildlife observation and photography program.

Cumulative impacts: The level and type of use from activities described in this CD is not expected to result in any significant cumulative impacts.

Public Review and Comment:

Public review and comments were solicited in conjunction with release of the draft Keālia Pond NWR Draft CCP/ EA (2011) in order to comply with the National Environmental Policy Act and Service policy. This CD was released as integral part of the CCP and received the same level of public review and comments as the CCP, in accordance with Service planning policy.

Determination: (check one below)

___ Use is Not Compatible

_✓_ Use is Compatible With Following Stipulations

Stipulations Necessary to Ensure Compatibility:

- Visitors are required to stay on trails and designated paths throughout the year;
- Use is restricted to daylight hours only; and
- Pets are not allowed.
- Regulations will be available to the public through a Refuge brochure and interpretive panels;
- Directional, informational, and interpretive signs will be available and maintained to help keep visitors on the trails and help educate the public on minimizing wildlife and habitat disturbances;
- Human use levels will be monitored; and
- Trails will be temporarily closed during waterbird nesting season, if necessary, to eliminate disturbance.

Justification:

Wildlife observation, photography, and interpretation are three of the six wildlife-dependent recreational uses of the Refuge System identified in the Administration Act as legitimate and appropriate priority general public uses. They receive enhanced consideration in the CCP process, and are considered priority public uses when determined compatible. Although these activities can result in disturbance to wildlife, these activities would occur on a small percentage of Refuge acres. There is a sufficient amount of undisturbed habitat available to Refuge wildlife for escape and cover, and wildlife populations will find sufficient food resources and resting places. The relatively limited number of individual plants and animals expected to be adversely affected will not cause wildlife populations to materially decline, the physiological condition and production of refuge species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted. Thus, allowing wildlife observation, photography, and interpretation to occur under the stipulations described above will not materially detract or interfere with the purposes for which the Refuge was established or the Refuge System mission. Wildlife observation, photography, and interpretation programs complement the Refuge purpose, vision, and goals, and help fulfill the mission of the Refuge System.

Mandatory Reevaluation Date:

September 2026 Mandatory 15-year reevaluation date (for wildlife-dependent public uses)

__________ Mandatory 10-year reevaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

✓ Environmental Assessment and Finding of No Significant Impact

____ Environmental Impact Statement and Record of Decision

Refuge Determination:

Prepared by:

Refuge Planner,
Hawaiian and Pacific Islands NWRC

Laura Beauregard 9-20-11
(Signature) (Date)

Project Leader,
Maui National Wildlife Refuge Complex
Approval:

09-20-11
(Signature) (Date)

Concurrence:

Project Leader,
Hawaiian and Pacific Islands NWRC

Barry W. Stieglitz 9/22/11
(Signature) (Date)

Regional Chief,
National Wildlife Refuge System:

9/28/11
(Signature) (Date)

B.3 Compatibility Determination for Environmental Education

Refuge Name(s): Keālia Pond National Wildlife Refuge

County and State: Maui County, Hawai‘i

Establishing and Acquisition Authority(ies):

Keālia Pond NWR was established in 1992 under the authority of the:

- Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 742a – 742j)
- Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544)

Refuge Purpose(s):

"…to conserve (A) fish and wildlife which, are listed as endangered or threatened species… or (B) Plants …" 16 U.S.C. 1534, Endangered Species Act of 1973.

National Wildlife Refuge System Mission:

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (Administration Act).

Description of Use(s):

The National Wildlife Refuge System Administration Act of 1966 (16 U.S.C. 668dd-668ee), as amended by the National Wildlife Refuge System Improvement Act of 1997 identifies environmental education (EE) and interpretation among wildlife-dependent public uses which, when compatible with the purpose(s) of the refuge, are priority public uses and receive special consideration in planning for and management of the National Wildlife Refuge System.

Environmental education is a non-consumptive, wildlife-dependent public use. Environmental education programs at Keālia Pond NWR are currently conducted by nongovernmental organizations (Hawai‘i Nature Center, Maui Digital Bus) under a Special Use Permit. All outdoor classes are held at the Kanuimanu Ponds and are coordinated to not impact the Refuge's management programs (e.g., monthly bird censuses, maintenance). Hawai‘i Nature Center's 3rd grade wetland curriculum is held January-February each year. This time period is preferred because the ponds have water, vegetation, and high bird use for their observations and hands-on explorations. The Maui Digital Bus conducts their program throughout the year and is dependent on teachers' inquiries. Both programs have been successful in reaching a high number (1,500-2,000 students) and diversity of Maui's school children, and engages them in activities emphasizing the value of wetlands, endangered species, and ecological concepts (food chains, waterbird adaptations, invertebrate life cycles) all of which include hands-on activities. The Refuge's role for these programs is to provide the site where a variety of waterbird species are present and active learning is available in an outdoor setting.

Availability of Resources:

Category and Itemization	One-time $	Annual $/yr
Administration and management:	$0	$1,000
Maintenance:	$0	$900
Materials:	$0	$1,000
Special equipment, facilities, or improvements:	$0	$1,000
Offsetting revenues:	$0	$

Minimal costs of EE will be covered by Refuge visitor services funding provided in the annual Refuge budget.

Anticipated Impacts of the Use(s):

Short-term impacts: Under the current program, the number of school groups and students visiting the Refuge may vary from year to year but this variation is already considered in the guidelines and structure established for the program. The primary impacts come from temporary disturbance to individual animals (primarily birds) due to the presence and activity of the students as they are guided around the wetlands. The animals may flush, swim away, or seek cover and hide in vegetation. These impacts are mitigated by restricting the days, maximum number of students, and routes that EE activities take place. This allows the students to participate in the EE experience while causing temporary disturbance over the smallest area and to the fewest birds.

This program has been in place for more than 12 years and has not had a noticeable impact on bird populations using the Refuge.

Long-term impacts: The current, ongoing EE program covered by this CD will not cause any significant long-term impacts. The EE program is expected to increase with the development of a formal program designed to meet DOE requirements; however, a thorough evaluation of the impacts to existing resources and capability of the site to withstand additional groups will be reviewed in a Visitor Services Plan within 5 years. With the park ranger staff position to oversee public use facilities, wildlife-dependent activities, and new VC, we will likely attract more teachers and other educators to the site. Alternative sites such as the Keālia Coastal Boardwalk will also be evaluated as a potential EE site, thereby relieving the Kanuimanu Ponds for other wildlife-dependent activities.

Cumulative impacts: This EE program has been conducted in the current manner for more than 12 years and no cumulative impacts to wildlife resources on the Refuge have been observed or are anticipated.

Public Review and Comment:

Public review and comments were solicited in conjunction with release of the Draft CCP/EA (2011) in order to comply with the NEPA and Service policy.

Determination: (check one below)

___ Use is Not Compatible

_✓_ Use is Compatible with Following Stipulations

Stipulations Necessary to Ensure Compatibility:

User stipulations:

- Groups are required to stay on trails and designated paths throughout the year.
- Use is restricted to daylight hours only.
- Groups are limited to a certain number of students and teachers.

Administrative stipulations:

- Specific regulations and allowances are outlined in the Special Use Permits.
- Refuge-specific requirements are put in place to direct groups to staging areas and routes that do not impede normal refuge operations and are safe for students.
- Use levels will be monitored
- Trails will be temporarily closed during waterbird nesting season, if necessary, to eliminate disturbance.
- Refuge staff periodically participates with the group to ensure compliance with Refuge's conditions and accuracy of information is maintained.

Justification:
Environmental education is one of the six wildlife-dependent recreational uses of the Refuge System as stated in the Administration Act. Environmental education receives enhanced consideration in the CCP process, and is considered a priority public use when determined compatible. By limiting the size of groups, providing structured activities, and providing closed areas for wildlife away from human disturbance, this program would limit disturbances to wildlife. There is a sufficient amount of undisturbed habitat available to Refuge wildlife for escape and cover, and wildlife populations will find sufficient food resources and resting places. The relatively limited number of individual plants and animals expected to be adversely affected will not cause wildlife populations to materially decline, the physiological condition and production of refuge species will not be impaired, their behavior and normal activity patterns will not be altered dramatically, and their overall welfare will not be negatively impacted. Thus, allowing EE to occur under the stipulations described above will not materially detract or interfere with the purpose for which the Refuge was established or the Refuge System mission. Environmental education contributes to the mission of the Refuge System by providing wildlife-related educational benefits to visitors. Environmental education programs on Refuge lands are inherently valuable to the Service because they will enhance the public's knowledge of the Refuge and its resources, and expand the number of visitors who engage in the Refuge's conservation mission.

Mandatory Reevaluation Date: (provide month and year for "allowed" uses only)

September
2026_____ Mandatory 15-year reevaluation date (for wildlife-dependent public uses)
_________ Mandatory 10-year reevaluation date (for uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

_✓_ Environmental Assessment and Finding of No Significant Impact

____ Environmental Impact Statement and Record of Decision

Refuge Determination:

Prepared by:

Refuge Planner,
Hawaiian and Pacific Islands NWRC

Laura Beauregard 9-20-11
(Signature) (Date)

Project Leader,
Maui National Wildlife Refuge Complex
Approval:

Glynnis Nakai 09-20-11
(Signature) (Date)

Concurrence:

Project Leader,
Hawaiian and Pacific Islands NWRC

Barry W. Stieglitz 9/22/11
(Signature) (Date)

Regional Chief,
National Wildlife Refuge System:

Robert J. West 9/27/11
(Signature) (Date)

B.4 Compatibility Determination for Research, Scientific Collecting, and Surveys

CD Terminology:

Research: Planned, organized, and systematic investigation of a scientific nature.
Scientific collecting: Gathering of Refuge natural resources or cultural artifacts for scientific purposes.
Surveys: Scientific inventory or monitoring.

Refuge Name(s): Keālia Pond National Wildlife Refuge

County and State: Maui County, Hawaiʻi

Establishing and Acquisition Authority(ies):

Keālia Pond NWR was established in 1992 under the authority of the:

- Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 742a – 742j)
- Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544)

Refuge Purpose(s):

"…to conserve (A) fish and wildlife which, are listed as endangered or threatened species… or (B) Plants …" 16 U.S.C. 1534, Endangered Species Act of 1973.

National Wildlife Refuge System Mission:

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (Administration Act).

Description of Use(s):

We receive periodic requests from non-Service entities (e.g., universities, State agencies, other Federal agencies, nongovernmental organizations) to conduct research, scientific collecting, and surveys on Refuge lands. These project requests can involve a wide range of natural and cultural resources as well as public use management issues, including basic absence/presence surveys, collection of new species for identification, habitat use and life-history requirements for specific species/species groups, practical methods for habitat restoration, extent and severity of environmental contaminants, techniques to control or eradicate pest species, effects of climate change on environmental conditions and associated habitat/wildlife response, identification and analyses of paleontological specimens, modeling wildlife populations, and assessing response of habitat/wildlife to disturbance from public uses. Projects may be species-specific, Refuge-specific, or evaluate the relative contribution of the Refuge lands to larger landscapes (e.g., eco-region, region, flyway, national, international) issues and trends.

The Service's research and management and Appropriate Refuge Uses (603 FW1.10D(4)) policies indicate priority for scientific investigatory studies that contribute to the enhancement, protection, use, preservation, and management of native wildlife populations and their habitat as well as their natural diversity. Projects that contribute to refuge-specific needs for resource and/or wilderness management goals and objectives, where applicable, would be given a higher priority over other requests.

Availability of Resources:

Refuge staff responsibilities for projects by non-Service entities will primarily be limited to the following: review of proposals, prepare Special Use Permits (SUP) and other compliance documents (e.g., Section 7 of the ESA, Section 106 of the National Historic Preservation Act), and monitor project implementation to ensure that impacts and conflicts remain within acceptable levels (compatibility) over time. Additional administrative support, logistical and operational support may also be provided depending on each specific request. Estimated costs for one-time (e.g., prepare SUP) and annually recurring tasks by Refuge staff and other Service employees will be determined for each project. Sufficient funding in the general operating budget of the Refuge must be available to cover expenses for these projects. The terms and conditions for funding and staff support necessary to administer each project on the Refuge will be clearly stated in the SUP.

The Refuge has the following staffing and funding to administratively support and monitor research that is currently taking place on the Refuge (see table below). Any substantial increase in the number of projects would create a need for additional resources to oversee the administration and monitoring of the investigators and their projects. Any substantial additional costs above those itemized below may result in finding a project not compatible unless expenses are offset by the investigator(s), sponsoring agency, or organization.

Category and Itemization	**One-time $**	**Annual $/yr**
Administration and management	$0	$2,000
Maintenance	$0	$0
Monitoring	$0	$3,900
Special equipment, facilities, or improvement	$0	$0
Offsetting revenues	$0	$0

Itemized costs in the table above are current estimates calculated using 7 percent of the base cost for a GS-11 Refuge Biologist and 3 percent of the base cost for a GS-12 Refuge Manager.

Anticipated Impacts of the Use:

Use of the Refuge(s) to conduct research, scientific collecting, and surveys will generally provide information that would benefit fish, wildlife, plants, and their habitats. Scientific findings gained through these projects provide important information regarding life-history needs of species and species groups as well as identify or refine management actions to achieve resource management objectives in Refuge management plans (especially CCPs). Reducing uncertainty regarding wildlife and habitat responses to management actions in order to achieve desired outcomes reflected in resource management objectives is essential for adaptive management in accordance with 522 DM 1. If project methods impact or conflict with Refuge-specific resources, priority wildlife-dependent public uses, other high-priority research, and Refuge habitat and wildlife management programs, then it must be clearly demonstrated that the scientific findings will contribute to resource management and that the project cannot be conducted off-Refuge for the project to be compatible. The investigator(s) must identify methods/strategies in advance required to eliminate or minimize the potential impact(s) and conflict(s). If unacceptable impacts cannot be avoided, then the project will not be compatible.

Impacts would be project- and site-specific, where they will vary depending upon nature and scope of the field work. Data collection techniques will generally have minimal animal mortality or disturbance, habitat destruction, no introduction of contaminants, or no introduction of nonnative species. In contrast, projects involving the collection of biotic samples (plants or animals) or requiring intensive ground-based data or sample collection will have short-term impacts. To reduce impacts, the minimum number of samples (e.g., water, soils, vegetative litter, plants, macroinvertebrates, and vertebrates) will be collected for identification and/or experimentation and statistical analysis. Where possible, researchers would coordinate and share collections to reduce sampling needed for multiple projects. Investigator(s) obtaining required State and Federal collecting permits will also ensure minimal impacts to fish, wildlife, plants, and their habitats. If, after incorporating the above strategies, the project results in long-term or cumulative effects, it will not be deemed compatible. A Section 7 consultation under the ESA will be required for activities that may affect a federally listed species and/or critical habitat. Only projects that have no effect or will result in not likely to adversely affect determinations will be considered compatible.

Spread of pest plants and/or pathogens is possible from ground disturbance and/or transportation of project equipment and personnel, but it will be minimized or eliminated by requiring proper cleaning of investigator equipment and clothing as well as quarantine methods, where necessary. If after all practical measures are taken, an unacceptable spread of pest species is anticipated to occur, then the project will be found not compatible without a restoration or mitigation plan. Localized and temporary effects may occur from vegetation trampling, collecting of soil and plant samples, or trapping and handling of wildlife. Impacts may also occur from infrastructure necessary to support a project (e.g., permanent transects or plot markers, exclosure devices, monitoring equipment, solar panels to power unattended monitoring equipment). Some level of disturbance is expected with these projects, especially if investigator(s) enter areas closed to the public and collect samples or handle wildlife. However, wildlife disturbance (including altered behavior) will usually be localized and temporary in nature. Where long-term or cumulative unacceptable effects cannot be avoided, the project will not be found compatible.

At least 6 months before initiation of field work (unless an exception is made by prior approval of the Refuge Manager), project investigator(s) must submit a detailed proposal. Project proposals will be reviewed by Refuge staff and others, as needed, to assess the potential impacts (short-term, long-term, and cumulative) relative to benefits of the investigation to Refuge management issues and understanding of natural systems. This assessment will form the primary basis for allowing or denying a specific project. Projects that result in unacceptable Refuge impacts will not be found compatible. If allowed and found compatible after approval, all projects also will be assessed during implementation to ensure impacts and conflicts remain within acceptable levels. If the proposal is approved, the Refuge Manager will issue a SUP(s) with required stipulations (terms and conditions) of the project to avoid and/or minimize potential impacts to Refuge resources as well as conflicts with other public-use activities and Refuge field management operations. After approval, projects also are monitored during implementation to ensure impacts and conflicts remain within acceptable levels based upon documented stipulations. Projects that are not covered by the CCP will require additional NEPA documentation.

Public Review and Comment:

Public review and comments were solicited in conjunction with release of the Draft CCP/EA (2011) in order to comply with the NEPA and Service policy.

Determination: (check one below)

____ The use is not compatible.

_✓_ The use is compatible with the following stipulations.

Stipulations Necessary to Ensure Compatibility:

Each project will require an SUP. Annual or other short-term SUPs are preferred; however, some permits will be a longer period, if needed, to allow completion of the project. All SUPs will have a definite termination date. Permit renewals will be subject to Refuge Manager review and approval based on timely submission of and content in progress reports, compliance with SUP stipulations, and required permits. Other stipulations and provisions would include the following:

- Projects will adhere to scientifically defensible protocols for data collection, where available and applicable.
- Investigators must possess appropriate and comply with conditions of State and Federal permits for their projects.
- If unacceptable impacts to natural resources or conflicts arise or are documented by the Refuge staff, then the Refuge Manager can suspend, modify conditions of, or terminate an on-going project already permitted by SUP(s) on a Refuge.
- Progress reports are required at least annually for multiple-year projects.
- Final reports are due 1 year after completion of the project unless negotiated otherwise with the Refuge Manager.
- Continuation of existing projects will require approval by the Refuge Manager.
- The Refuge staff will be given the opportunity to review draft manuscript(s) from the project before being submitted to a scientific journal(s) for consideration of publication.
- The Refuge staff will be provided with copies (including, but not limited to: reprints, videos, and electronic media) of all publications resulting from a Refuge project.
- The Refuge staff will be provided with copies of raw data (electronic database format) at the conclusion of the project.
- Upon completion of the project or annually, all equipment and markers unless required for long-term projects must be removed and sites must restored to the Refuge Manager's satisfaction. Conditions for clean-up and removal of equipment and physical markers will be stipulated in the SUP(s).
- All samples collected on Refuge lands are the property of the Service even while in the possession of the investigator(s). Any future work with previously collected samples not clearly identified in the project proposal will require submission of a subsequent proposal for review and approval. In addition, a new SUP will be required for additional project work. For samples or specimens to be stored at other facilities (e.g., museums), a memorandum of understanding will be necessary.
- Sampling equipment as well as investigator(s) clothing and vehicles (e.g., all-terrain vehicles, boats) will be thoroughly cleaned (free of dirt and plant material) before being allowed for use on Refuge lands and/or waters to prevent the introduction and/or spread of pests.

- The Service, specific Refuge unit, names of Refuge staff and other Service personnel who supported or contributed to the project will be appropriately cited and acknowledged in all written and oral presentations resulting from projects on Refuge lands.
- At any time, Refuge staff may accompany investigator(s) in the field.
- Investigator(s) and support staff will follow all Refuge-specific regulations for access and travel on the Refuge.

Justification:

Research, scientific collecting, and surveys on Refuge lands are inherently valuable to the Service because they will expand scientific information available for resource management decisions. In addition, only projects that directly or indirectly contribute to the enhancement, protection, use, preservation, and management of Refuge wildlife populations and their habitats generally will be authorized on Refuge lands. In many cases, if it were not for the Refuge staff providing access to Refuge lands and waters along with some support, the research project would likely not occur and less scientific information would be available to the Service to aid in managing and conserving resources. By allowing the use to occur under the stipulations described above, it is anticipated that wildlife species that could be disturbed during the use would find sufficient food resources and resting places so their abundance and use will not be measurably lessened on the Refuge. Additionally, it is anticipated that monitoring, as needed, will prevent unacceptable or irreversible impacts to fish, wildlife, plants, and their habitats. The combination of stipulations identified above and conditions included in any SUP(s) will ensure that proposed projects contribute to the enhancement, protection, conservation, and management of native wildlife populations and their habitats on the Refuge. As a result, these projects will not materially interfere with or detract from fulfilling Refuge purpose(s); contributing to the mission of the Service and Refuge System; and maintaining the biological integrity, diversity, and environmental health of the Refuge.

Mandatory Re-evaluation Date: (provide month and year for “allowed” uses only)

________ Mandatory 15-year re-evaluation date (wildlife-dependent public uses)

September
____2021 Mandatory 10-year re-evaluation date (uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion and Environmental Action Statement

_✓_ Environmental Assessment and Finding of No Significant Impact

____ Environmental Impact Statement and Record of Decision

Refuge Determination:

Prepared by:

Refuge Planner,
Hawaiian and Pacific Islands NWRC

Laura Beauregard 9-20-11
(Signature) (Date)

Project Leader,
Maui National Wildlife Refuge Complex
Approval:

Glynnis Nakai 09-20-11
(Signature) (Date)

Concurrence:

Project Leader,
Hawaiian and Pacific Islands NWRC

Barry W. Stieglitz 9/22/11
(Signature) (Date)

Regional Chief,
National Wildlife Refuge System:

Rob S. West 9/28/11
(Signature) (Date)

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Keālia Pond National Wildlife Refuge

Use: Research, Scientific Collecting, and Surveys

This form is not required for wildlife-dependent recreational uses; take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.
Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No __

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence. Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: Glynnis Nakai Date: 09-20-11

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use. If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence. If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: Barry W. Stieglitz Date: 9/22/11

FWS Form 3-2319

A compatibility determination is required before the use may be allowed. **02/06**

Attachment 1: Appropriate Uses Justification

Date: **May 5, 2011**

Refuge: Keālia Pond National Wildlife Refuge (Refuge)

Project: Research, Scientific Collecting, and Surveys

Summary: The Refuge receives requests to conduct scientific research on Refuge lands and waters. Research applicants must submit a proposal that would outline: (1) objectives of the study; (2) justification for the study; (3) detailed methodology and schedule; (4) potential impacts on Refuge wildlife and/or habitat, including disturbance (short-term and long-term), injury, or mortality; (5) personnel required; (6) costs to Refuge, if any; and (7) end products (i.e., reports, publications). Research proposals would be reviewed by Refuge staff, Regional Office Branch of Refuge Biology, and others as appropriate prior to the Refuge issuing a SUP. Projects will not be open-ended, and, at a minimum, will be reviewed annually.

For each of the findings listed on FWS Form 3-2319, a justification has been provided below:

a. Do we have jurisdiction over the use?

Some or all of the proposed activities would take place within Refuge boundaries. The Refuge has jurisdiction over those research projects that are sited within Refuge boundaries.

b. Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?

Proposed research activities should comply with all applicable laws and regulations. Any restrictions or qualifications that are required to comply with law and regulations would be specified in the SUP. The State DLNR was invited on two occasions to participate on core planning teams, but declined due to insufficient staffing. However, as this Appropriate Refuge Use Justification does not propose a significant deviation from the status quo, and no comments on this topic were received from the State during the comment period, we believe additional coordination is not necessary.

c. Is the use consistent with applicable Executive orders and Department and Service policies?

Through the review of individual projects, the Refuge would ensure that they are consistent with applicable policies, especially Research on Service Lands Policy (803 FW 1).

d. Is the use consistent with public safety?

Through individual project review, the Refuge will ensure that each project is consistent with public safety. If necessary, stipulations to ensure public safety will be included in the project's SUP.

e. Is the use consistent with goals and objectives in an approved management plan or other document?

Research activities are approved in instances where they can provide meaningful data that may contribute to Refuge management and public appreciation of natural resources.

f. Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?

Earlier documented analysis has approved the use and touted the benefits of research, scientific collecting, and surveys on national wildlife refuges.

g. Is the use manageable within available budget and staff?

The Refuge receives <10 requests per year for this activity, and it is manageable with available budget and staff.

h. Will this be manageable in the future within existing resources?

The proposed activity at current levels would be manageable in the future with the existing resources.

i. Does the use contribute to the public's understanding and appreciation of the Refuge's natural or cultural resources, or is the use beneficial to the Refuge's natural or cultural resources?

The proposed use is beneficial to the Refuge's natural and cultural resources because the types of research projects approved are those that have the distinct likelihood to help achieve Refuge purposes by providing information useful for the management of trust resources and may contribute to the public's understanding and appreciation of natural and/or cultural resources.

j. Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?

The Refuge will ensure that the research activities will not impair existing or future wildlife-dependent recreational use of the Refuge during individual project review, prior to issuing a SUP for the project.

B.5 Compatibility Determination for Kiawe Tree Harvesting

Refuge Name(s): Keālia Pond National Wildlife Refuge

County and State: Maui County, Hawai‘i

Establishing and Acquisition Authority(ies):

Keālia Pond NWR was established in 1992 under the authority of the:
- Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 742a – 742j)
- Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1544)

Refuge Purpose(s):

"…to conserve (A) fish and wildlife which, are listed as endangered or threatened species… or (B) Plants …" 16 U.S.C. 1534, Endangered Species Act of 1973.

National Wildlife Refuge System Mission:

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (Administration Act).

Description of Use(s):

The forested area at Keālia Pond NWR is predominantly kiawe trees (mesquite) – a nonnative species which is advantageous as a buffer around the wetland but is host to cattle egret colonies, particularly along the north edge of the wetlands. The Refuge has occasionally (0-1 annually) received requests to cut kiawe for firewood and fence posts to accomplish specific community events (Kīhei Canoe Club, Halau Maui Nui o Kama) and projects (The Nature Conservancy, Kamehameha Schools, East Maui Watershed Partnership).

Kiawe removal areas are predefined and delineated by Refuge staff. A typical project would cover 4 acres with the removal of 20 trees to be used for 40 fence posts. Unused woody debris may be mulched. Stumps are treated with glyphosate to keep them from re-sprouting. All kiawe debris material that has not been finely mulched, including excess branches, must be removed at the user's expense and taken off-Refuge to the green waste site.

Although the wood was not sold, it represents a commodity with market value, therefore, by definition removing the wood is a commercial use. By regulation (50 CFR 29.1, we can only allow commercial uses to occur if the use contributes to achieving Refuge purposes. The activity of removing kiawe is for the benefit of the wetland and waterbirds by removing pest plant species and reducing predation and disturbances by nonnative cattle egrets. Kiawe removal at targeted locations is also necessary for native forest restoration. In the past, a couple of groups known to manage natural areas were given the opportunity to take wood when they assisted Refuge staff as a volunteer. This volunteer effort was only allowed in a predefined area that the Refuge was already clearing to open up the perimeter of a permanent pond.

Availability of Resources:

Category and Itemization	One-time $	Annual $/yr
Administration and management:	$0	$800
Maintenance:	$0	$0
Monitoring costs:	$0	$0
Special equipment, facilities, or improvements:	$0	$0
Offsetting revenues:	$0	$0

The Refuge has sufficient budget and staff to manage this use.

Anticipated Impacts of the Use(s):

Short-term impacts:
Removal of cattle egrets' roost and colonies provides only short-term impacts because other kiawe trees are available; however, the Refuge targets areas adjacent to wetlands to minimize disturbance and predation on endangered Hawaiian waterbirds. Allowing clubs to harvest and remove kiawe reduces the Refuge cost to pay to have the wood hauled to a green waste facility.

Long-term impacts:
We will see a net reduction of kiawe over time. The long-term impacts would be a minor decrease in the number of cattle egrets present on the Refuge, thereby reducing egret predation on waterbird chicks. Removal of kiawe is necessary for native planting reforestation efforts.

Cumulative impacts: The level and type of use from activities described in this CD is not expected to result in any significant cumulative impacts as the amount of wood removed is negligible compared to the total forested area.
.

Public Review and Comment:
The period of public review began (Month) 2011 and ended (Month) 2011.

Public review and comments were solicited in conjunction with release of the Draft CCP/EA (2011) in order to comply with the NEPA and Service policy.

Determination: (check one below)

___ Use is Not Compatible

_✓_ Use is Compatible With Following Stipulations

Stipulations Necessary to Ensure Compatibility:

User stipulations:

- Submit formal written request with documentation on the purposes for kiawe wood;
- Use is restricted to daylight hours when Refuge staff are present;
- Pets are not allowed;
- User is limited to areas predefined and delineated by Refuge staff;

- All kiawe debris material, including excess branches, must be removed at the user's expense and taken off-Refuge to the green waste site;
- Equipment is limited to a chain saw (user supplied) which is in safe operating condition and all personal protective equipment must be worn (hard hat with safety shield, chaps, gloves, etc.);
- Refuge staff will inspect site and kiawe load being removed upon user departure;
- Access to site off entrance road or parking area is on foot only; and
- User will arrive with vehicle, equipment, and clothing free of any soil, seeds, or invertebrates to prevent introduction of pest species to the Refuge.

Administrative stipulations:

- Regulations will be provided in writing and verbally reviewed with the user before initiating work;
- Permit will be specific to the individual (primary point of contact that must be present) and will cover no more than 3 workers for a set period of time;
- Kiawe removal will only be in areas where the Refuge is performing restoration, typically adjacent to wetlands;
- Kiawe harvesting is limited to the months from September-November;
- The Refuge has the right to disapprove a request if the intent is for sale purposes; and
- The Refuge has the right to terminate an already approved user/permitee if: rules and regulations are not followed; safety is impaired due to carelessness; waterbird impacts are greater than expected; safety of Refuge staff, visitors, or volunteers are in jeopardy;

Justification:
Kiawe trees are a pest plants on the Refuge that provide breeding and roosting habitat for the nonnative cattle egret. Cattle egrets have been known prey on chicks of all endangered waterbird species occurring on the Refuge. Kiawe overshadows native plants and deep taproots use all available water. Dense kiawe thickets have replaced native plants in the coastal dry forest at Keālia Pond NWR.

Harvesting of kiawe trees will achieve an indirect predator control strategy for cattle egrets identified under Objective 1.1 and enhance shrub land habitat as identified in Objective 2.1 of the CCP. This management action will remove an existing cattle egret rookery adjacent to Kanuimanu ponds and may be used to control future rookeries in other stands of kiawe trees on the Refuge. Partnering with nongovernmental, nonprofit, conservation-oriented organizations to remove the trees and process the wood for use on other conservation projects supports environmental sustainability and promotes the recovery of endangered Hawaiian waterbirds. By allowing the use to occur under the stipulations described above, it is anticipated that adverse impacts to wildlife species can be avoided by timing the harvesting activities when birds are not using the area. Monitoring will prevent unacceptable or irreversible impacts to fish, wildlife, plants, and their habitats. As a result, not only does this kiawe tree harvesting activity not materially interfere with or detract from fulfilling the Refuge purpose, it contributes to achieving CCP goals by removing a pest plant species from the habitat and reducing the habitat for another pest species.

Mandatory Reevaluation Date: (provide month and year for "allowed" uses only)

_________Mandatory 15-year reevaluation date (for wildlife-dependent public uses)

September
_____2021Mandatory 10-year reevaluation date (for all uses other than wildlife-dependent public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

____ Categorical Exclusion without Environmental Action Statement

____ Categorical Exclusion and Environmental Action Statement

_✓__ Environmental Assessment and Finding of No Significant Impact

____ Environmental Impact Statement and Record of Decision

Refuge Determination:

Prepared by:

Refuge Planner,
Hawaiian and Pacific Islands NWRC

Laura Beauregard 9-20-11
(Signature) (Date)

Project Leader,
Maui National Wildlife Refuge Complex
Approval:

Glynnis Nakai 09-20-11
(Signature) (Date)

Concurrence:

Project Leader,
Hawaiian and Pacific Islands NWRC

Barry W. Stieglitz 9/22/11
(Signature) (Date)

Regional Chief,
National Wildlife Refuge System:

[illegible] West 9/20/11
(Signature) (Date)

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name. Keālia Pond National Wildlife Refuge

Use: Kiawe Tree Harvesting

This form is not required for wildlife-dependent recreational uses; take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No __

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence. Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ Appropriate ✓

Refuge Manager: Glynnis Nakai Date: 09-20-11

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use. If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence. If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: Barry W. Stieglitz Date: 9/22/11

FWS Form 3-2319

A compatibility determination is required before the use may be allowed. **02/06**

Attachment 1: Appropriate Uses Justification

Date: **May 5, 2011**

Refuge: Keālia Pond National Wildlife Refuge (Refuge)

Project: Kiawe tree harvesting

Summary: The Refuge has received requests to cut kiawe for firewood and fence posts for specific community events (Kīhei Canoe Club, Halau Maui Nui o Kama), projects (The Nature Conservancy, Kamehameha Schools, East Maui Watershed Partnership).

Kiawe are nonnative species that serve as a buffer protecting wetlands from upper land use activities; an area where surface water flows from streams filter suspended sediment and slows down water before entering the Main Pond; perching structure for pueo; and cattle egret roost and colonies. Providing habitat for cattle egrets is the primary negative impact of kiawe along the wetland boundaries and a management need that the Refuge has been addressing within the last 2-3 years.

One effort to control cattle egrets at the Refuge is to remove trees where birds are roosting and nesting. These areas are easy to identify because of the large colonies that form. Chemical and mechanical treatment has shown to be an effective method to impact a large number of birds, especially areas adjacent to wetlands where endangered waterbird nesting occurs. Accessibility to these areas is difficult due to the density and moist soil conditions; therefore, the Refuge attempts to remove trees using chainsaws.

Another management objective strategy includes the removal of kiawe to allow for protection of native plant species. Reforestation to a natural native lowland forest will require the removal of nonnative kiawe. If natural resource groups are in need of kiawe for fence posts or Hawaiian cultural practices then it may be possible to permit these specific users to harvest kiawe so long as the areas are in coordination with the Refuge's management objectives and the removal benefits endangered waterbirds (minimize predation and disturbances by cattle egrets).

For each of the findings listed on FWS Form 3-2319, a justification has been provided below:

a. Do we have jurisdiction over the use?

All of the proposed activity would take place within Refuge boundaries. The Refuge only has jurisdiction over those projects that are sited within Refuge boundaries.

b. Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?

Proposed kiawe tree harvesting activities must comply with all applicable laws and regulations. Any restrictions or qualifications that are required to comply with law and regulations would be specified in the SUP.

c. Is the use consistent with applicable Executive orders and Department and Service policies?

Yes. It follows the waterbird recovery plan by minimizing predation by cattle egrets by eliminating roost sites.

d. Is the use consistent with public safety?

Through individual project review, the Refuge will ensure that each project is consistent with public safety. Stipulations to ensure public safety will be included in the project's SUP.

e. Is the use consistent with goals and objectives in an approved management plan or other document?

Kiawe removal will only be permitted if the activity is in conjunction or in assistance with the Refuge's habitat management plan and protection of endangered Hawaiian waterbirds and restoration of a native plant community. This activity is intended as a management tool.

f. Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?

This is the first time the use has been proposed for formal review.

g. Is the use manageable within available budget and staff?

The Refuge receives 0-1 request per year for this activity, and it is manageable with available budget and staff.

h. Will this be manageable in the future within existing resources?

The proposed activity at current levels would be manageable in the future with the existing resources.

i. Does the use contribute to the public's understanding and appreciation of the Refuge's natural or cultural resources, or is the use beneficial to the Refuge's natural or cultural resources?

The proposed use is beneficial to the Refuge's natural and cultural resources and may contribute to the public's understanding and appreciation of natural and/or cultural resources.

j. Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?

The Refuge will ensure that the kiawe tree harvesting activities will not impair existing or future wildlife-dependent recreational use of the Refuge during individual project review, prior to issuing a SUP for the project.

Appendix C. Plan Implementation and Costs

C.1 Administration

Keālia Pond NWR is administered as part of the Maui National Wildlife Refuge Complex (Complex) which also includes the Kakahaiʻa NWR on the south coast of Molokaʻi. The Service is in the process of establishing Molokini as a Refuge unit of the Keālia Pond NWR that will also have oversight from the Complex office located at Keālia Pond NWR.

C.2 Staffing

All staff positions share responsibilities and duties for two refuges, in addition to the Molokini Unit, once established; e.g., no staff is assigned or performs duties only on specific refuges within the Complex. Due to projected Complex-wide workload, priorities, and logistics, this arrangement is expected to continue. However, when more personnel are funded (e.g., a Maintenance Worker or Equipment Operator), staff may be assigned more specific duties on individual refuges.

The Service National Staffing Model (NSM) generated eight positions for the Complex with seven stationed at Keālia Pond NWR, although only four have been funded. The Hawaiian and Pacific Islands NWR Complex in Honolulu has temporarily re-assigned its outdoor recreation planner position to operate the VC until such time as the Refuge receives funding for a permanent visitor services manager. This position is shown on the following table as current staff. Additional staffing would provide increased capacity to conduct biological inventory, monitoring, and research; increased visitor opportunities; EE and interpretation of Refuge resources; collaborative efforts with other government agencies and nongovernmental organizations; and more pest species control for the benefit of endangered waterbirds.

As the new VC was unplanned when the NSM was finalized, increased staffing with specific responsibilities in the visitor, volunteer, and education programs, and maintaining the new facility is necessary to provide quality customer service and ensure safe conditions for visitors. Molokini responsibilities are not included in the NSM until such time as it is officially established as an overlay refuge. Therefore, the three additional positions over the NSM-justified eight positions are intended to reflect the additional workload for the VC and Molokini Unit.

Current and Necessary Permanent Full-time Staffing for Maui NWR Complex

Staff Position	Salary Rating	Identified in NSM	Current	HQ/VC
Project Leader	GS-12	✓	✓	
Deputy Project Leader	GS-9/11	✓		
Wildlife Biologist	GS-11	✓	✓	
Biological Science Technician	GS-5/7			
Visitor Services Manager	GS-7/9/11	✓	✓	✓
Refuge Ranger	GS-5/7			✓
Administrative Support Assistant	GS-7	✓	✓	
Maintenance Worker (Habitat & Facilities)	WG-8	✓	✓	
Maintenance Worker (Facilities)	WG-7/8			✓
Equipment Operator	WG-6/7	✓		
Law Enforcement Officer	GS-7/9			✓

C.3 Refuge Funding and Budget Requests

Successful implementation of the CCP relies on our ability to secure funding, personnel, infrastructure, and other resources to accomplish the actions identified. Full implementation of the actions and strategies in this CCP will incur costs including staffing, construction projects, and individual resource program expansions. In addition to annual budget allocations, funding can be received through special funding sources and programs geared toward specific resource issues/needs. Examples include grants or project-specific funding for endangered species, pest species control, wetlands, coastal habitats, climate change, and Service initiatives.

Currently there are two sources of funding that will enable the Keālia Pond NWR to carry out its plans under the CCP, including additional staff; these sources includes the Refuge Operating Needs System (RONS) and Service Asset Maintenance Management System (SAMMS) for repair/renovation of existing facilities. The RONS and SAMMS systems will be updated with new/additional projects that are approved under this CCP.

Project	Cost Estimate
Develop, plan, and implement visitor services, education, and volunteer programs	$ 117,598
Control invasive cattle egret predation on endangered waterbirds	$ 130,000
Restore emergent wetlands and mudflats on the southeast side of Kanuimanu Ponds	$ 171,573
Implement waterbird recovery actions (Biological Technician)	$ 77,615
Erect predator fence to protect endangered Hawaiian waterbirds	$ 750,000
Restore natural groundwater-fed ponds in forested habitat	$ 115,000
Restore east mudflats for endangered waterbirds	$ 38,578
Install pump and water distribution system at Mā‘alaea Flats	$ 75,000
Restore east mudflats for endangered Hawaiian waterbirds	$ 39,073
Implement Visitor Services, Education, and Volunteer Programs (Refuge Ranger)	$ 77,615
Provide Visitor, Resource, and Facility Protection (Law Enforcement Officer)	$ 150,000
Construct well, pump, and water distribution system on north edge of marsh	$75,000
Construct water control structure and pumping capability at Keālia Pond outlet	$ 350,000
Construct long-term water source to restore 60 acres of coastal wetlands at Mā‘alaea Flats	$ 75,000
Construct new shop/maintenance facility	$ 600,000

This list does not include facilities (e.g., public roads, parking areas, boardwalks, etc.) that will be identified in the Visitor Services Plan

C.4 Step-down Plans

The CCP is one of several plans necessary for Refuge management. The CCP provides guidance in the form of goals, objectives, and strategies for several Refuge program areas but may lack some of the specifics needed for implementation. Stepdown management plans will be developed for individual program areas within approximately 6 years after CCP completion. Step-down plans, where feasible, will be prepared to cover all Refuges in the Complex. All step-down plans require appropriate NEPA compliance and implementation may require additional permits. Stepdown plans for the Refuge follow in the table below. Project-specific plans, with appropriate NEPA compliance, may be prepared outside of these step-down plans.

Stepdown Management Plan Status

Completed	**Date**
• Habitat Management Plan	2011 (CCP meets requirements for HMP)
• Integrated Pest Management Plan	2011 (Prepared concurrently with CCP, Appendix E)
• Fire Management Plan	2004 (Appendix G)
• Occupational Safety and Health Plan	2009
Scheduled	
• Inventory and Monitoring Plan	Initiated by 2013
• Visitor Services Plan	Initiated by 2013
• Land Protection Plan	Initiated by 2013
Studies Identified in CCP Strategies	
• Topographical mapping of Māʻalaea Flat	2012
• Comprehensive Water Resources Assessment	2012
• ʻŌkaʻi ʻaiea (Blackburn Sphinx Moth): population, mapping, and habitat	2012
• Geomorphological Assessment	2012-2014
• Climate Change Monitoring Plan	Initiated in 2011
• Biological and Botanical Assessment of Molokini Islet	2013-2015
• ʻUaʻu kani population model for Molokini Islet to identify carrying capacity and dispersal to Maui	2013-2015
• Breeding phenology of ʻou on Molokini Islet	2013-2015

Appendix D. Wilderness Review for Keālia Pond NWR

General Information on Wilderness Reviews

Wilderness review is the process used to determine whether or not to recommend lands or waters in the Refuge System to Congress for designation as wilderness. Planning policy for the Refuge System (602 FW 3) mandates conducting wilderness reviews every 15 years through the CCP process.

The wilderness review process has three phases: inventory, study, and recommendation. After first identifying lands and waters that meet the minimum criteria for wilderness, the resulting wilderness study areas (WSA) are further evaluated to determine if they merit recommendation from the Service to the Secretary of the Interior for inclusion in the National Wilderness Preservation System (NWPS). Areas recommended for designation are managed to maintain wilderness character in accordance with management goals, objectives, and strategies outlined in the final CCP until Congress makes a decision or the CCP is amended to modify or remove the wilderness proposal. A brief discussion of wilderness inventory, study, and recommendation follows.

Wilderness Inventory
The wilderness inventory consists of identifying areas that minimally meet the requirements for wilderness as defined in the Wilderness Act of 1964 (Wilderness Act). Wilderness is defined as an area which:

- Has at least 5,000 acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition, or be capable of restoration to wilderness character through appropriate management at the time of review, or be a roadless island;
- Generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;
- Has outstanding opportunities for solitude or a primitive and unconfined type of recreation; and
- May also contain ecological, geological, or other features of scientific, educational, scenic, or historic value. These features and values, though desirable, are not necessary for an area to qualify as a wilderness.

Wilderness Study
During the study phase, lands and waters qualifying for wilderness as a result of the inventory are studied to analyze values (ecological, recreational, cultural, spiritual), resources (wildlife, water, vegetation, minerals, soils), and uses (habitat management, public use) within the area. The findings of the study help determine whether to recommend the area for designation as wilderness.

Wilderness Recommendation
Once a wilderness study determines that a WSA meets the requirements for inclusion in the NWPS, a wilderness study report that presents the results of the wilderness review, accompanied by a Legislative Environmental Impact Statement (LEIS), is prepared. The wilderness study report and LEIS that support wilderness designation are then transmitted through the Secretary of the Interior to the President of the United States, and ultimately to the Congress for approval.

The following section summarizes the inventory phase of the wilderness review for Keālia Pond NWR and the proposed Molokini Unit.

Wilderness Inventory

The wilderness inventory is a broad look at the planning area to identify WSAs. These WSAs are roadless areas within refuge boundaries, including submerged lands and their associated water column, that meet the minimum criteria for wilderness identified in Sect. 2. (c) of the Wilderness Act. A WSA must meet the minimum size criteria (or be a roadless island), appear natural, and provide outstanding opportunities for solitude or primitive recreation. Other supplemental values are evaluated, but not required.

Evaluation of Size Criteria for Roadless Areas, Roadless Islands, and Submergent Lands and Associated Water Column

Identification of roadless areas, roadless islands, and submerged lands and associated water column, required gathering land status maps, land use and road inventory data, satellite imagery, aerial photographs, and personal observations of areas within refuge boundaries. “Roadless” refers to the absence of improved roads suitable and maintained for public travel by means of motorized vehicles primarily intended for highway use.

Inventory units meet the size criteria for a WSA if any one of the following standards applies:

- An area with over 5,000 contiguous ac. State and private lands are not included in making this acreage determination.
- A roadless island of any size. A roadless island is defined as an area surrounded by permanent waters or that is markedly distinguished from the surrounding lands by topographical or ecological features.
- An area of less than 5,000 contiguous Federal acres that is of sufficient size as to make practicable its preservation and use in an unimpaired condition, and of a size suitable for wilderness management.
- An area of less than 5,000 contiguous Federal acres that is contiguous with a designated wilderness, recommended wilderness, or area under wilderness review by another Federal wilderness managing agency such as the Forest Service, National Park Service, or Bureau of Land Management.

Keālia Pond NWR, is a highly modified 691-acre parcel of land located on the island of Maui and does not meet the size criteria. It is also bounded and bisected by State-owned and Refuge-owned roadways maintained for travel by passenger vehicles.

The Molokini Unit, a roadless islet (19 acres proposed as an overlay refuge), meets the roadless island criteria for a WSA.

Evaluation of the Naturalness Criteria

A WSA must meet the naturalness criteria. Section 2.(c) of the Wilderness Act defines wilderness as an area that “…generally appears to have been affected primarily by the forces of nature with the imprint of man’s work substantially unnoticeable.” The area must appear natural to the average visitor rather than “pristine.” The presence of ecologically accurate, historical landscape conditions is not required. An area may include some manmade features and human impacts provided they are substantially unnoticeable in the unit as a whole. Human-caused hazards, such as the presence of unexploded ordnance from military activity, and the physical impacts of refuge management facilities and activities are also considered in the evaluation of the naturalness criteria. An area may not be considered unnatural in appearance solely on the basis of "sights and sounds" of human impacts and activities outside the boundary of the unit. The cumulative effects of these factors were considered in the evaluation of naturalness for each wilderness inventory unit.

In the wilderness inventory, specific manmade features and other human impacts need to be identified that affect the overall apparent naturalness of the tract. The following factors were primary considerations in evaluating the naturalness of the Refuge:

- Administrative and storage containers, greenhouse;
- Well pumps, earthen dikes, exposed water lines, water control structures; and
- Gates, parking lots, and roadways.

Keālia Pond NWR is bounded and bisected by State-owned and Refuge-owned roadways maintained for travel by passenger vehicles. This inventory unit contains numerous earthen dikes, ditches, roadways, buildings, and water control structures and does not meet the naturalness criteria.

Public access to the Molokini Unit has been limited since the early 1900s due to the sensitivity of burrowing seabird nest sites. Therefore, seabird habitat is intact and nesting birds have been successful. Nonetheless, a navigation aid beacon, an active and permanent U.S. Aids to Navigation System erected from a cement foundation on top of the islet, has a strong visual presence on the islet. The Molokini Unit does not meet the minimum naturalness criteria for a WSA.

<u>Evaluation of Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation</u>
In addition to meeting the size and naturalness criteria, a WSA must provide outstanding opportunities for solitude or primitive recreation. The area does not have to possess outstanding opportunities for both solitude and primitive and unconfined recreation, and does not need to have outstanding opportunities on every acre. Further, an area does not have to be open to public use and access to qualify under these criteria. Congress has designated a number of wilderness areas in the NWPS that are closed to public access to protect ecological resource values.

Opportunities for solitude refers to the ability of a visitor to be alone and secluded from other visitors in the area. Primitive and unconfined recreation means nonmotorized, dispersed outdoor recreation activities that do not require developed facilities or mechanical transport. These primitive recreation activities may provide opportunities to experience challenge and risk, self-reliance, and adventure.

These two opportunity "elements" are not well defined by the Wilderness Act but in most cases can be expected to occur together. However, an outstanding opportunity for solitude may be present in an area offering only limited primitive recreation potential. Conversely, an area may be so attractive for recreation use that experiencing solitude is not an option.

These inventory units do not offer opportunities for solitude or primitive and unconfined recreation. Daily management activities at Keālia Pond NWR occur, including road maintenance, mowing and disking of fields, and manipulation of water control structures. Recreational and educational activities are only conducted in group settings, and only allowed as staff-guided activities.

Although the Molokini Unit is free from human habitation, the marine environment surrounding the islet, managed by the Hawai‘i Department of Land and Natural Resources as the Molokini Shoal

Marine Life Conservation District, is one of the most popular diving and snorkeling sites in the Hawaiian Islands. The constant presence of people and marine vessels around the inventory unit therefore does not allow for an individual to experience solitude within the overlay refuge. The Molokini Unit is and will remain closed to public access to protect the fragile nests of burrowing seabirds. However, given the lack of development on the island, opportunities for primitive and unconfined recreation are theoretically possible. The Molokini Unit does not meet the minimum criteria for solitude for a WSA, however it does meet the minimum criteria for primitive and unconfined recreation.

Evaluation of Supplemental Values

Supplemental values are defined by the Wilderness Act as "ecological, geological, or other features of scientific, educational, scenic, or historic value." Based upon the findings of the required components for WSA designation, supplemental values were not evaluated.

Findings

The inventory units of Keālia Pond NWR and the proposed Molokini Unit do not meet the minimum criteria for consideration as WSA (see Table D.1).

Table D.1 Wilderness Inventory Summary

Keālia Pond NWR (691 acres)	
Required Components	
(1) Has at least 5,000 ac of land or is of sufficient size to make practicable its preservation and use in an unconfined condition, or is a roadless island.	No. Does not contain 5,000 acres, is not a roadless island, and is not practicable to manage as a wilderness.
(2) Generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable.	No. Landscape is highly modified and actively managed.
(3a) Has outstanding opportunities for solitude.	No. Refuge is actively and regularly managed.
(3b) Has outstanding opportunities for a primitive and unconfined type of recreation.	No. Recreation is highly regulated and requires staff presence.
Other Components	
(4) Contains ecological, geological or other features of scientific, educational, scenic, or historic value.	Not evaluated.
Summary	
Parcel qualifies as a wilderness study area (meets criteria 1, 2 & 3a or 3b).	No.
Molokini Unit (19 acres)	
Required Components	
(1) Has at least 5,000 ac of land or is of sufficient size to make practicable its preservation and use in an unconfined condition, or is a roadless island.	Yes. It is a roadless island.
(2) Generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable.	No. Contains a permanent aids to navigation beacon, highly visible within the tiny islet.
(3a) Has outstanding opportunities for solitude.	No. Marine vessel and human presence around the islet is heavy.
(3b) Has outstanding opportunities for a primitive and unconfined type of recreation.	Yes. Unit is not currently open to the public, however opportunities are present.
Other Components	
(4) Contains ecological, geological or other features of scientific, educational, scenic, or historic value.	Not evaluated.
Summary	
Parcel qualifies as a wilderness study area (meets criteria 1, 2 & 3a or 3b).	No.

Appendix E. Integrated Pest Management Program, Keālia Pond NWR

1.0 Background

Integrated Pest Management is an interdisciplinary approach utilizing methods to prevent, eliminate, contain, and/or control pest species in concert with other management activities on Refuge lands and waters to achieve wildlife and habitat management goals and objectives. The IPM is also a scientifically based, adaptive management process where available scientific information and best professional judgment of the Refuge staff as well as other resource experts would be used to identify and implement appropriate management strategies that can be modified and/or changed over time to ensure effective, site-specific management of pest species to achieve desired outcomes. In accordance with 43 CFR 46.145, adaptive management would be particularly relevant where long-term impacts may be uncertain and future monitoring would be needed to make adjustments in subsequent implementation decisions. After a tolerable pest population (threshold) is determined considering achievement of Refuge resource objectives and the ecology of pest species, one or more methods, or combinations thereof, are selected that are feasible, efficacious, and most protective of nontarget resources, including native species (fish, wildlife, and plants), and Service personnel, Service authorized agents, volunteers, and the public. Staff time and available funding will be considered when determining feasibility/practicality of various treatments.

Our IPM techniques to address pests are presented as CCP strategies prescriptions (see Section 2.0 of this CCP) in an adaptive management context to achieve Refuge resource objectives. In order to satisfy requirements for IPM planning as identified in the Director's Memo (dated September 9, 2004) entitled *Integrated Pest Management Plans and Pesticide Use Proposals: Updates, Guidance, and an Online Database*, the following elements of an IPM program have been incorporated into this CCP:

- Habitat and/or wildlife objectives that identify pest species and appropriate thresholds to indicate the need for and successful implementation of IPM techniques; and
- Monitoring before and/or after treatment to assess progress toward achieving objectives including pest thresholds.

Where pesticides would be necessary to address pests, this Appendix provides a structured procedure to evaluate potential effects of proposed uses involving ground-based applications to Refuge biological resources and environmental quality. Only pesticide uses that likely would cause minor, temporary, or localized effects to Refuge biological resources and environmental quality with appropriate best management practices (BMPs), where necessary, would be allowed for use on the Refuge.

This Appendix does not describe the more detailed process to evaluate potential effects associated with aerial applications of pesticides. Moreover, it does not address effects of mosquito control with pesticides (larvicides, pupacides, or adulticides) based upon identified human health threats and presence of disease-carrying mosquitoes in sufficient numbers from monitoring conducted on a Refuge. However, the basic framework to assess potential effects to Refuge biological resources and environmental quality from aerial application of pesticides or use of insecticides for mosquito management would be similar to the process described in this Appendix for ground-based treatments of other pesticides.

2.0 Pest Management Laws and Policies

In accordance with 517 DM and 569 FW 1(Integrated Pest Management), plant, invertebrate, and vertebrate pests on units of the National Wildlife Refuge System can be controlled to assure balanced wildlife and fish populations in support of refuge-specific wildlife and habitat management objectives. Pest control on Federal (Refuge) lands and waters also is authorized under the following legal mandates:

- National Wildlife Refuge System Administration Act of 1966, as amended (16 USC 668dd-668ee);
- Plant Protection Act of 2000 (7 USC 7701 *et seq*.);
- Noxious Weed Control and Eradication Act of 2004 (7 USC 7781-7786, Subtitle E);
- Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (7 USC 136-136y);
- National Invasive Species Act of 1996 (16 USC 4701);
- Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (16 USC 4701);
- Food Quality Protection Act of 1996 (7 USC 136);
- Executive Order 13148, Section 601(a);
- Executive Order 13112; and
- Animal Damage Control Act of 1931 (7 USC 426-426c, 46 Stat. 1468).

Pests are defined as "…living organisms that may interfere with the site-specific purposes, operations, or management objectives or that jeopardize human health or safety" from Department policy 517 DM 1 (Integrated Pest Management Policy). Similarly, 569 FW 1 defines pests as "…invasive plants and introduced or native organisms that may interfere with achieving our management goals and objectives on or off our lands, or that jeopardize human health or safety." 517 DM 1 also defines an invasive species as "a species that is nonnative to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health." Throughout the remainder of this CCP, the terms pest and invasive species are used interchangeably because both can prevent/impede achievement of Refuge wildlife and habitat objectives and/or degrade environmental quality.

In general, control of pests (vertebrate or invertebrate) on the Refuge would conserve and protect the nation's fish, wildlife, and plant resources as well as maintain environmental quality. From 569 FW 1, animal or plant species, which are considered pests, may be managed if the following criteria are met:

- Threat to human health and well-being or private property, the acceptable level of damage by the pest has been exceeded, or State or local government has designated the pest as noxious;
- Detrimental to resource objectives as specified in a Refuge resource management plan (e.g., comprehensive conservation plan, habitat management plan), if available; and
- Control would not conflict with attainment of resource objectives or the purposes for which the Refuge was established.

The specific justifications for pest management activities on the Refuge are the following:

- Protect human health and well-being;
- Prevent substantial damage to important to Refuge resources;
- Protect newly introduced or re-establish native species;
- Control nonnative (exotic) species in order to support existence for populations of native species;
- Prevent damage to private property; and

- Provide the public with quality, compatible wildlife-dependent recreational opportunities.

In accordance with Service policy 620 FW 1 (Habitat Management Plans), there are additional management directives regarding invasive species found on the Refuge:

- "We are prohibited by Executive Order, law, and policy from authorizing, funding, or carrying out actions that are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere."
- "Manage invasive species to improve or stabilize biotic communities to minimize unacceptable change to ecosystem structure and function and prevent new and expanded infestations of invasive species. Conduct Refuge habitat management activities to prevent, control, or eradicate invasive species..."

Animal species damaging/destroying Federal property and/or detrimental to the management program of a Refuge may be controlled as described in 50 CFR 31.14 (Official Animal Control Operations)**.**

Trespass and feral animals also may be controlled on Refuge lands. Based upon 50 CFR 28.43 (Destruction of Dogs and Cats), dogs and cats running at large on a national wildlife refuge and observed in the act of killing, injuring, harassing or molesting humans or wildlife may be disposed of in the interest of public safety and protection of the wildlife.

Feral animals should be disposed by the most humane method(s) available and in accordance with relevant Service directives (including Executive Order 11643). Disposed wildlife specimens may be donated or loaned to public institutions. Donation or loans of resident wildlife species will only be made after securing State approval (50 CFR 30.11 [Donation and Loan of Wildlife Specimens]**).** Surplus wildlife specimens may be sold alive or butchered, dressed and processed subject to Federal and State laws and regulations (50 CFR 30.12 [Sale of Wildlife Specimens]**).**

3.0 Strategies

To fully embrace IPM as identified in 569 FW 1, the following strategies, where applicable, would be carefully considered on the Refuge for each pest species:

Prevention. This would be the most effective and least expensive long-term management option for pests. It encompasses methods to prevent new introductions or the spread of the established pests to un-infested areas. It requires identifying potential routes of invasion to reduce the likelihood of infestation. Hazard Analysis and Critical Control Points (HACCP) planning can be used determine if current management activities on a Refuge may introduce and/or spread invasive species in order to identify appropriate BMPs for prevention.

Prevention may include source reduction, using pathogen-free or weed-free seeds or fill; exclusion methods (e.g., barriers) and/or sanitation methods (e.g., wash stations) to prevent re-introductions by various mechanisms including vehicles and personnel. Because invasive species are frequently the first to establish newly disturbed sites, prevention would require a reporting mechanism for early detection of new pest occurrences with quick response to eliminate any new satellite pest populations. Prevention would require consideration of the scale and scope of land management activities that may promote pest establishment within un-infested areas or promote reproduction and spread of existing populations. Along with preventing initial introduction, prevention would involve halting the spread of existing infestations to new sites (Mullin et al. 2000). The primary reason of prevention would be to keep pest-free lands or waters from becoming infested. Executive Order 11312 emphasizes the priority for prevention with respect to managing pests.

The following would be methods to prevent the introduction and/or spread of pests on Refuge lands:

- Before beginning ground-disturbing activities (e.g., disking, scraping), inventory and prioritize pest infestations in project operating areas and along access routes. Refuge staff would identify pest species on site or within reasonably expected potential invasion vicinity. Where possible, Refuge staff would begin project activities in less infested areas before working in areas with high infestation to minimize dispersal of pests.
- Refuge staff will establish staging areas in the treated area to prevent contaminating pest-free areas. They would avoid or minimize travel through pest-infested areas, or restrict to those periods when spread of seed or propagules of invasive plants would be least likely.
- Refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned of pests. Where possible, Refuge staff would clean equipment before entering lands at on-Refuge approved cleaning site(s). This practice does not pertain to vehicles traveling frequently in and out of the project area that will remain on roadways. Seeds and plant parts of pest plants would need to be collected, where practical. Refuge staff would remove mud, dirt, and plant parts from project equipment before moving it into a project area.
- Refuge staff would clean all equipment, before leaving the project site, if operating in areas infested with pests. Refuge staff would determine the need for, and when appropriate, identify sanitation sites where equipment can be cleaned.
- Refuge staffs, their authorized agents, and Refuge volunteers would, where possible, inspect, remove, and properly dispose of seed and parts of invasive plants found on their clothing and equipment. Proper disposal means bagging the seeds and plant parts and then properly discarding of them (e.g., incinerating).
- Refuge staff would evaluate options, including closure, to restrict the traffic on sites with on-going restoration of desired vegetation. Refuge staff would revegetate disturbed soil (except travel ways on surfaced projects) to optimize plant establishment for each specific site. Revegetation may include topsoil replacement, planting, seeding, fertilization, liming, and weed-free mulching as necessary. Refuge staff would use native material, where appropriate and feasible. Refuge staff would use certified weed-free or weed-seed-free hay or straw where certified materials are reasonably available.
- Refuge staff would provide information, training and appropriate pest identification materials to Refuge staffs, permit holders, and recreational visitors. Refuge staff would educate them about pest identification, biology, impacts, and effective prevention measures.
- Refuge staff would inspect borrow material for invasive plants prior to use and transport onto and/or within Refuge lands.
- Refuge staff would consider invasive plants in planning for road maintenance activities.
- Refuge staff would restrict off road travel to designated routes.

The following would be methods to prevent the introduction and/or spread of pests into Refuge waters:

- Refuge staff would inspect boats (including air boats), trailers, and other boating equipment and, where possible, remove any visible plants, animals, or mud before leaving any waters or boat launching facilities. Where possible, staff would drain water from motor, live well, bilge, and transom wells while on land before leaving the site.

If possible, Refuge staff would wash and dry boats, downriggers, anchors, nets, floors of boats, propellers, axles, trailers, and other boating equipment to kill pests not visible at the boat launch. These prevention methods to minimize/eliminate the introduction and/or spread of pests were taken verbatim or slightly modified from Appendix E of US Forest Service (2005).

- **Mechanical/Physical Methods.** These methods would remove and destroy, disrupt the growth of, or interfere with the reproduction of pest species. For plants species, these treatments can be accomplished by hand, hand tool (manual), power tools, or heavy equipment and include pulling, grubbing, digging, tilling/disking, cutting, swathing, grinding, sheering, girdling, mowing, and mulching of the pest plants.

  For animal species, Service employees or their authorized agents could use mechanical/physical methods (including trapping) to control pests as a refuge management activity. Based upon 50 CFR 31.2, trapping can be used on a refuge to reduce surplus wildlife populations for a "balanced conservation program" in accordance with Federal or State laws and regulations. In some cases, trapped animals would be relocated to off-refuge sites with prior approval from the State.

  Each of these tools would be efficacious to some degree and applicable to specific situations. In general, mechanical controls can effectively control annual and biennial pest plants. However, to control perennial plants, the root system has to be destroyed or it would resprout and continue to grow and develop. Mechanical controls are typically not capable of destroying a perennial plants root system. Although some mechanical tools (e.g., disking, plowing) may damage root systems, they may stimulate regrowth producing a denser plant population that may aid in the spread depending upon the target species. In addition, steep terrain and soil conditions would be major factors that can limit the use of many mechanical control methods.

  Some mechanical control methods (e.g., mowing), which would be used in combination with herbicides, can be a very effective technique to control perennial species. For example, mowing perennial plants followed sequentially by treating the plant regrowth with a systemic herbicide often would improve the efficacy of the herbicide compared to herbicide treatment only.

- **Cultural Methods.** These methods would involve manipulating habitat to increase pest mortality by reducing its suitability to the pest. Cultural methods would include water-level manipulation, , prescribed burning (facilitate revegetation, increase herbicide efficacy, and remove litter to assist in emergence of desirable species), planting or seeding desirable species to shade or out-compete invasive plants, applying fertilizer to enhance desirable vegetation, irrigation, and other habitat alterations.

- **Biological Control Agents.** Classical biological control would involve the deliberate introduction and management of natural enemies (parasites, predators, grazing animals or pathogens) to reduce pest populations. Many of the most ecologically or economically damaging pest species in the United States originated in foreign countries. These newly introduced pests, which are free from natural enemies found in their country or region of origin, may have a competitive advantage over cultivated and native species. This competitive advantage often allows introduced species to flourish, and they may cause widespread economic damage to crops or out compete and displace native vegetation. Once the introduced pest species population reaches a certain level, traditional methods of pest management may be cost prohibitive or impractical. Biological controls typically are used when these pest populations have become so widespread that eradication or effective control would be difficult or no longer practical.

Biological control has advantages as well as disadvantages. Benefits would include reducing pesticide usage, host specificity for target pests, long-term self-perpetuating control, low cost/acre, capacity for searching and locating hosts, synchronizing biological control agents to hosts' life cycles, and the unlikelihood that hosts will develop resistance to agents. Disadvantages would include the following: limited availability of agents from their native lands, the dependence of control on target species density, slow rate at which control occurs, biotype matching, the difficulty and expense of conflicts over control of the target pest, and host specificity when host populations are low.

A reduction in target species populations from biological controls is typically a slow process, and efficacy can be highly variable. It may not work well in a particular area although it does work well in other areas. Biological control agents would require specific environmental conditions to survive over time. Some of these conditions are understood; whereas, others are only partially understood or not at all.

Biological control agents would not eradicate a target pest. When using biological control agents, residual levels of the target pest typically are expected; the agent population level or survival would be dependent upon the density of its host. After the pest population decreases, the population of the biological control agent would decrease correspondingly. This is a natural cycle. Some pest populations (e.g., invasive plants) would tend to persist for several years after a biological control agent becomes established due to seed reserves in the soil, inefficiencies in the agents search behavior, and the natural lag in population buildup of the agent.

The full range of pest groups potentially found on refuge lands and waters would include diseases, invertebrates (insects, mollusks), vertebrates and invasive plants (most common group). Often it is assumed that biological control would address many if not most of these pest problems. Introduced species without desirable close relatives in the United States would generally be selected as biological controls. Natural enemies that are restricted to one or a few closely related plants in their country of origin are targeted as biological controls (Center et al. 1997, Hasan and Ayres 1990).

The Hawai‘i Department of Agriculture (HDOA) has a highly successful bio-control program for the erythrina gall wasp which has resulted in the rebounding of the native wiliwili trees. In June 2010, HDOA began another biological control program that releases a tiny parasitic insect to control the stinging Nettle Caterpillar. The release of Brazilian scale to slow the growth rate and spread of strawberry guava has recently been proposed to give Hawai‘i's native plants a chance for survival, protect the ability of the forests to provide water, and provide better protection for agricultural crops from the fruit flies that breed in the overabundance of strawberry guava fruit. Due to the success of HDOA's biocontrol programs, the State has become a leader in the world on the use of biological control to fight invasive pests.

Refuge staff would ensure introduced agents are approved by the applicable authorities. Except for a small number of formulated biological control products registered by USEPA under FIFRA, most biological control agents are regulated by the U.S. Department of Agriculture (USDA)-Animal Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPQ). State departments of agriculture and, in some cases, county agricultural commissioners or weed districts, have additional approval authority.

Federal permits (USDA-APHIS-PPQ Form 526) are required to import biocontrol agents from another State. Form 526 may be obtained by writing:

USDA-APHIS-PPQ
Biological Assessment and Taxonomic Support
4700 River Road, Unit 113
Riverdale, MD 20737

or

through the internet at URL address:
http://www.aphis.usda.gov/ppq/permits/bioligical/weedbio.html.

The Service strongly supports the development, and legal and responsible use of appropriate, safe, and effective biological control agents for nuisance and nonindigenous or pest species.

State and county agriculture departments may also be sources for biological control agents or they may have information about where biological control agents may be obtained. Commercial sources should have an Application and Permit to Move Live Plant Pests and Noxious Weeds (USDA-PPQ Form 226 USDA-APHIS-PPQ, Biological Assessment and Taxonomic Support, 4700 River Road, Unit 113, Riverdale, MD 20737) to release specific biological control agents in a State and/or county. Furthermore, certification regarding the biological control agent's identity (genus, specific epithet, sub-species and variety) and purity (e.g., parasite free, pathogen free, and biotic and abiotic contaminants) should be specified in purchase orders.

Biological control agents are subject to 569 FW 1. In addition, Refuge staff would follow the International Code of Best Practice for Classical Biological Control of Weeds (http://sric.ucdavis.edu/exotic /exotic.htm) as ratified by delegates to the X International Symposium on Biological Control of Weeds, Bozeman, MT, July 9, 1999. This code identifies the following:

- Release only approved biological control agents,
- Use the most effective agents,
- Document releases, and
- Monitor for impact to the target pest, nontarget species and the environment.

Biological control agents formulated as pesticide products and registered by the USEPA (e.g., *Bti*) are also subject to PUP review and approval (see below).

A record of all releases would be maintained with date(s), location(s), and environmental conditions of the release site(s); the identity, quantity, and condition of the biological control agents released; and other relevant data and comments such as weather conditions. Systematic monitoring to determine the establishment and effectiveness of the release is also recommended.

NEPA documents regarding biological and other environmental effects of biological control agents prepared by another Federal agency, where the scope is relevant to evaluation of releases on Refuge lands, would be reviewed. Possible source agencies for such NEPA documents include the Bureau of Land Management (BLM), U.S. Forest Service, National Park Service, U.S. Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s) from the review. Incorporating by reference (43 CFR 46.135) is a technique used to avoid redundancies in analysis. It also can reduce the bulk of a Service NEPA document, which only must identify the documents that are incorporated by reference. In addition, relevant portions must be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

- **Pesticides.** The selective use of pesticides would be based upon pest ecology (including mode of reproduction), the size and distribution of its populations, site-specific conditions (e.g., soils, topography), known efficacy under similar site conditions, and the capability to utilize best management practices (BMPs) to reduce/eliminate potential effects to nontarget species, sensitive habitats, and potential to contaminate surface and groundwater. All pesticide usage (pesticide, target species, application rate, and method of application) would comply with the applicable Federal (FIFRA) and State regulations pertaining to pesticide use, safety, storage, disposal, and reporting. Before pesticides can be used to eradicate, control, or contain pests on Refuge lands and waters, pesticide use proposals (PUPs) would be prepared and approved in accordance with 569 FW 1. PUP records would provide a detailed, time-, site-, and target-specific description of the proposed use of pesticides on Refuge. All PUPs would be created, approved or disapproved, and stored in the Pesticide Use Proposal System (PUPS), which is a centralized database only accessible on the Service's intranet (https://systems.fws.gov/pups). Only Service employees would be authorized to access PUP records for a Refuge in this database.

  Application equipment would be selected to provide site-specific delivery to target pests while minimizing/eliminating direct or indirect (e.g., drift) exposure to nontarget areas and degradation of surface and groundwater quality. Where possible, target-specific equipment (e.g., backpack sprayer, wiper) would be used to treat target pests. Other target-specific equipment to apply pesticides would include soaked wicks or paint brushes for wiping vegetation and lances, hatchets, or syringes for direct injection into stems. Granular pesticides may be applied using seeders or other specialized dispensers. In contrast, aerial spraying (e.g., fixed wing or helicopter) would only be used where access is difficult (remoteness) and/or the size/distribution of infestations precludes practical use of ground-based methods.

  Because repeated use of one pesticide may allow resistant organisms to survive and reproduce, multiple pesticides with variable modes of action would be considered for treatments on Refuge lands and waters. If there is only one pesticide available to control a pest species its use will be balanced against the potential for species resistance. Indiscriminate use of a pesticide may result pest resistance and no effective control in the future. This is especially important if multiple applications within years and/or over a growing season likely would be necessary for habitat maintenance and restoration activities to achieve resource objectives. Integrated chemical and nonchemical controls also are highly effective, where practical, because pesticide resistant organisms can be removed from the site.

Cost may not be the primary factor in selecting a pesticide for use on the Refuge. If the least expensive pesticide would potentially harm natural resources or people, then a different product would be selected, if available. The most efficacious pesticide available with the least potential to degrade environment quality (soils, surface water, and groundwater) as well as least potential effect to native species and communities of fish, wildlife, plants, and their habitats would be acceptable for use on Refuge lands in the context of an IPM approach.

- **Habitat restoration/maintenance.** Restoration and/or proper maintenance of Refuge habitats associated with achieving wildlife and habitat objectives would be essential for long-term prevention, eradication, or control (at or below threshold levels) of pests. Promoting desirable plant communities through the manipulation of species composition, plant density, and growth rate is an essential component of invasive plant management (Masters et al. 1996, Masters and Shelly 2001, Brooks et al. 2004). The following three components of succession could be manipulated through habitat maintenance and restoration: site availability, species availability, and species performance (Cox and Anderson 2004). Although a single method (e.g., herbicide treatment) may eliminate or suppress pest species in the short term, the resulting gaps and bare soil create niches that are conducive to further invasion by the species and/or other invasive plants, including species that may be even more harmful than the target species. On degraded sites where desirable species are absent or in low abundance, revegetation with native/desirable grasses, forbs, and legumes may be necessary to direct and accelerate plant community recovery, and achieve site-specific objectives in a reasonable time frame. The selection of appropriate species for revegetation would be dependent on a number of factors including resource objectives and site-specific, abiotic factors (e.g., soil texture, soil moisture, precipitation/temperature regimes, and shade conditions). Seed availability and cost, ease of establishment, seed production, and competitive ability also would be important considerations.

- **Predator Control.** The predator management plan for Keālia Pond NWR is implemented to reduce depredation of endangered waterbirds. Control measures would include indirect, non-lethal and lethal techniques in addition to prevention and direct control measures that would have minimal effects on the human environment.

  Indirect Measures at Keālia Pond NWR will include installation of a perimeter predator proof fence (Alternative C). In the absence of this fence, dense vegetation will remain to discourage visitors from disturbing endangered waterbirds and nesting areas will be temporarily closed to access. Cattle egret roost trees will be mechanically removed or treated with herbicides.

  Most cats and dogs will be removed by cage traps and transported to an animal shelter. Other predators (mongooses, rats) would be controlled by cage traps or humane lethal means. Control measures will minimize loss of non-target native wildlife. Except for nuisance alien species, all uninjured non-target species captured will be released near the site of capture or at a suitable location at the discretion of Refuge staff.

  Most of Keālia Pond NWR is closed to the public and posted. In public access areas (Kanuimanu Ponds, Keālia Coastal Boardwalk), most predator control measures will be conducted during the aeʻo nesting season and areas with active nests will also be closed. Rodenticides will be placed in tamper-resistant bait boxes and the area signed. Herbicide treatment of cattle egret roost trees will occur in closed areas of the Refuge. Egret control by firearms will occur when the Refuge is closed to the public.

Direct Measures include a range of predator management equipment and methods . The preferred control method will be cage traps for dogs and cats. Mongooses and rodents will be controlled by a combination of cage traps, lethal traps, and rodenticides. Direct control of cattle egrets would be with firearms. In rare instances, a Timms™ kill trap (a type of snap trap) or padded leghold trap would be used on cats that avoid cage traps. All cage traps will be checked every 48 hours or less. Except for continuous trapping (year-round) near the HQ/VC, trapping will occur seasonally just prior to the ae‘o nesting season through the end of the breeding/chick rearing period (April-September). Spot trapping may occur when signs of depredation of endangered species are observed outside the nesting season. Predator monitoring will occur throughout the year by direct observations, tracks, tracking tunnels, and trail cameras. Cage trapped dogs and cats will be transported to a local animal shelter. Any cage trapped birds will be released at the trap site. Live trapped mongooses will the euthanized using approved humane methods.

4.0 Priorities for Treatments

The magnitude (number, distribution, and sizes of infestations) for pest problems is too extensive and beyond the available capital resources to effectively address during any single field season. To manage pests in Refuge, it would be essential to prioritize treatment of infestations. Highest priority treatments would be focused on early detection and rapid response to eliminate infestations of new pests, if possible. This would be especially important for aggressive pests potentially impacting species, species groups, communities, and/or habitats associated Refuge purpose(s), System resources of concern (federally listed species, migratory birds, selected marine mammals, and interjurisdictional fish), and native species for maintaining/restoring biological integrity, diversity, and environmental health.

The next priority would be treating established pests that appear in one or more previously uninfested areas. Moody and Mack (1988) demonstrated through modeling that small, new outbreaks of invasive plants eventually would infest an area larger than the established, source population. They also found that control efforts focusing on the large, main infestation rather than the new, small satellites reduced the chances of overall success. The lowest priority would be treating large infestations (sometimes monotypic stands) of well-established pests. In this case, initial efforts would focus upon containment of the perimeter followed by work to control/eradicate the established infested area. If containment and/or control of a large infestation is not effective, then efforts would focus upon halting pest reproduction or managing source populations. Maxwell et al. (2009) found treating fewer populations that are sources represents an effective long-term strategy to reduce of total number of invasive populations and decreasing meta-population growth rates.

Although State listed noxious weeds would always of high priority for management, other pest species known to cause substantial ecological impact would also be considered. For example, short-spined kiawe may not be listed by a State as noxious, but it can greatly alter fire regimes in the coastal dryland shrub habitat resulting in large monotypic stands that displace native bunch grasses, forbs, and shrubs. Pest control would likely require a multi-year commitment from Refuge staff. Essential to the long-term success of pest management would be pre- and post-treatment monitoring, assessment of the successes and failures of treatments, and development of new approaches when proposed methods do not achieve desired outcomes.

5.0 Best Management Practices (BMPs)

BMPs can minimize or eliminate possible effects associated with pesticide usage to nontarget species and/or sensitive habitats as well as degradation of water quality from drift, surface runoff, or leaching. Based upon the Department of the Interior Pesticide Use Policy (517 DM 1) and the Service Pest Management Policy and Responsibilities (30 AM 12), the use of applicable BMPs (where feasible) also would likely ensure that pesticide uses may not adversely affect federally listed species and/or their critical habitats through determinations made using the process described in 50 CFR part 402.

The following are BMPs pertaining to mixing/handling and applying pesticides for all ground-based treatments of pesticides, which would be considered and utilized, where feasible, based upon target- and site-specific factors and time-specific environmental conditions. Although not listed below, the most important BMP to eliminate/reduce potential impacts to nontarget resources would be an IPM approach to prevent, control, eradicate, and contain pests.

5.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks would not be left unattended during filling.
- All pesticide containers would be triple rinsed and the rinsate would be used as water in the sprayer tank and applied to treatment areas.
- All pesticide spray equipment would be properly cleaned. Where possible, rinsate would be used as part of the make-up water in the sprayer tank and applied to treatment areas.
- Refuge staff would empty, triple rinsed pesticide containers that can be recycled at local herbicide container collections.
- All unused pesticides would be properly discarded at a local “safe send” collection.
- Pesticides and pesticide containers would be lawfully stored, handled, and disposed of in accordance with the label and in a manner safeguarding human health, fish, and wildlife and prevent soil and water contamination.
- Refuge staff would consider the water quality parameters (e.g., pH, hardness) that are important to ensure greatest efficacy where specified on the pesticide label.
- All pesticide spills would be addressed immediately using procedures identified in Refuge spill respond plan.

5.2 Applying Pesticides

- Pesticide treatments would only be conducted by or under the supervision of Service personnel and non-Service applicators with the appropriate, State or BLM certification to safely and effectively conduct these activities on Refuge lands and waters.
- Refuge staff would comply with all Federal, State, and local pesticide use laws and regulations as well as Service pesticide-related policies. For example, Refuge staff would use application equipment and apply rates for the specific pest(s) identified on the pesticide label as required under FIFRA.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators would review the labels, MSDSs, and Pesticide Use Proposal (PUPs) for each pesticide, determining the target pest, appropriate mix rate(s), PPE, and other requirements listed on the pesticide label.
- A 1’ no-spray buffer from the water’s edge would be used, where applicable, and it does not detrimentally influence effective control of pest species.

- Use low impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, Thinvert system application) rather than broadcast foliar application (e.g., boom sprayer, other larger tank wand applications), where practical.
- Use low volume rather than high volume foliar applications where low impact methods above are not feasible or practical, to maximize herbicide effectiveness and ensure correct and uniform application rates.
- Applicators would use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators would use the largest droplet size that results in uniform coverage.
- Applicators would use drift reduction technologies such as low-drift nozzles, where possible.
- Where possible, spraying would occur during low (average<7mph and preferably 3-5 mph) and consistent direction wind conditions with moderate temperatures (typically <85 ^{o}F).
- Where possible, applicators would avoid spraying during inversion conditions (often associated with calm and very low wind conditions) that can cause large-scale herbicide drift to nontarget areas.
- Equipment would be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.
- Spray applications would be made at the lowest height for uniform coverage of target pests to minimize/eliminate potential drift.
- If windy conditions frequently occur during afternoons, spraying (especially boom treatments) would typically be conducted during early morning hours.
- Spray applications would not be conducted on days with >30% forecast for rain within 6 hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) to minimize/eliminate potential runoff.
- Where possible, applicators would use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Where possible, applicators would use a nontoxic dye to aid in identifying target area treated as well as potential over spray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, the application would be stopped until repairs can be made to the sprayer.
- For pesticide uses associated with facilities management, buffers, as appropriate, would be used to protect sensitive habitats, especially wetlands and other aquatic habitats.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones may be identified to protect sensitive areas downwind of applications. Refuge staff would only apply adjacent to sensitive areas when the wind is blowing the opposite direction.
- Applicators would utilize scouting for early detection of pests to eliminate unnecessary pesticide applications.
- Refuge staff would consider timing of application so native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Rinsate from cleaning spray equipment after application would be recaptured and reused or applied to an appropriate pest plant infestation.
- Application equipment (e.g., sprayer, ATV, tractor) would be thoroughly cleaned and PPE would be removed/disposed of on-site by applicators after treatments to eliminate the potential spread of pests to un-infested areas.

6.0 Safety

6.1 Personal Protective Equipment

All applicators would wear the specific personal protective equipment (PPE) identified on the pesticide label. The appropriate PPE will be worn at all times during handling, mixing, and applying. PPE can include the following: disposable (e.g., Tyvek) or laundered coveralls; gloves (latex, rubber, or nitrile); rubber boots; and/or an NIOSH-approved respirator. Because exposure to concentrated product is usually greatest during mixing, extra care should be taken while preparing pesticide solutions. Persons mixing these solutions can be best protected if they wear long gloves, an apron, footwear, and a face shield.

Coveralls and other protective clothing used during an application would be laundered separately from other laundry items. Transporting, storing, handling, mixing and disposing of pesticide containers will be consistent with label requirements, USEPA and OSHA requirements, and Service policy.

If a respirator is necessary for a pesticide use, then the following requirements would be met in accordance with Service safety policy: a written Respirator Program, fit testing, physical examination (including pulmonary function and blood work for contaminants), and proper storage of the respirator.

6.2 Notification

The restricted entry interval (REI) is the time period required after the application at which point someone may safely enter a treated area without PPE. Refuge staff, authorized management agents of the Service, volunteers, and members of the public who could be in or near a pesticide treated area within the stated re-entry time period on the label would be notified about treatment areas. Posting would occur at any site where individuals might inadvertently become exposed to a pesticide during other activities on the Refuge. Where required by the label and/or State-specific regulations, sites would also be posted on its perimeter and at other likely locations of entry. Refuge staff would also notify appropriate private property owners of an intended application, including any private individuals have requested notification. Special efforts would be made to contact nearby individuals who are beekeepers or who have expressed chemical sensitivities.

6.3 Medical Surveillance

Medical surveillance may be required for Service personnel and approved volunteers who mix, apply, and/or monitor use of pesticides (see 242 FW 7 [Pesticide Users] and 242 FW 4 [Medical Surveillance]). In accordance with 242 FW 7.12A, Service personnel would be medically monitoring if 1 or more of the following criteria is met: exposed or may be exposed to concentrations at or above the published permissible exposure limits or threshold limit values (see 242 FW 4); use pesticides in a manner considered "frequent pesticide use"; or use pesticides in a manner that requires a respirator (see 242 FW 14 for respirator use requirements). In 242 FW7.7A, **"Frequent Pesticide Use"** means when a person applying pesticide handles, mixes, or applies pesticides, with a Health Hazard rating of 3 or higher, for 8 or more hours in any week or 16 or more hours in any 30-day period." Under some circumstances, individuals may be medically monitored who use pesticides infrequently, experience an acute exposure (sudden, short term), or use pesticides with a health hazard ranking of 1 or 2. This decision would consider the individual's health and fitness level, the pesticide's specific health risks, and the potential risks from other pesticide-related activities. Refuge cooperators and other authorized agents (e.g., State and County employees) would be responsible for their own medical monitoring needs and costs.

Standard examinations (at Refuge expense) of appropriate Refuge staff would be provided by the nearest certified occupational health and safety physician as determined by Federal Occupational Health.

6.4 Certification and Supervision of Pesticide Applicators

Appropriate Refuge staff or approved volunteers handling, mixing, and/or applying or directly supervising others engaged in pesticide use activities would be trained and State or federally licensed to apply pesticides to Refuge lands or waters. In accordance with 242 FW7.18A and 569 FW 1, certification is required to apply restricted use pesticides based upon USEPA regulations. For safety reasons, all individuals participating in pest management activities with general use pesticides also are encouraged to attend appropriate training or acquire pesticide applicator certification. The certification requirement would be for a commercial or private applicator depending upon the State. New staff unfamiliar with proper procedures for storing, mixing, handling, applying, and disposing of herbicides and containers would receive orientation and training before handling or using any products. Documentation of training would be kept in the files at the Refuge office.

6.5 Record Keeping

Labels and material safety data sheets

Pesticide labels and material safety data sheets (MSDSs) would be maintained at the Refuge shop and laminated copies in the mixing area. These documents also would be carried by field applicators, where possible. A written reference (e.g., note pad, chalk board, dry erase board) for each tank to be mixed would be kept in the mixing area for quick reference while mixing is in progress. In addition, approved PUPs stored in the PUPS database typically contain website links (URLs) to pesticide labels and MSDSs.

Pesticide use proposals (PUPs)

A PUP would be prepared for each proposed pesticide use associated with annual pest management on Refuge lands and waters. A PUP would include specific information about the proposed pesticide use including the common and chemical names of the pesticide(s), target pest species, size and location of treatment site(s), application rate(s) and method(s), and federally listed species determinations, where applicable.

In accordance with 30 AM 12 and 7 RM 14, PUPs would be required for the following:

- Uses of pesticides on lands and facilities owned or managed by the Service, including properties managed by Service personnel as a result of the Food Security Act of 1985;
- Service projects by non-Service personnel on Service owned or controlled lands and facilities and other pest management activities that would be conducted by Service personnel; and
- Where the Service would be responsible or provides funds for pest management identified in protective covenants, easements, contracts, or agreements off Service lands.

In accordance with Service guidelines (Director's memo [December 12, 2007]), Refuge staff may receive up to 5-year approvals for Washington Office and field reviewed proposed pesticide uses based upon meeting identified criteria including an approved IPM plan, where necessary (see http://www.fws.gov/contaminants/Issues/IPM.cfm). For a refuge, an IPM plan (requirements described herein) can be completed independently or in association with a CCP or HMP if IPM strategies and potential environmental effects are adequately addressed within appropriate NEPA documentation.

PUPs would be created, approved or disapproved, and stored as records in the Pesticide Use Proposal System (PUPS), which is centralized database on the Service's intranet (https://systems.fws.gov/pups). Only Service employees can access PUP records in this database.

Pesticide usage
In accordance with 569 FW 1, the Refuge Project Leader would be required to maintain records of all pesticides annually applied on lands or waters under Refuge jurisdiction. This would encompass pesticides applied by other Federal agencies, State and county governments, nongovernment applicators including cooperators and their pest management service providers with Service permission. For clarification, pesticide means all insecticides, insect and plant growth regulators, dessicants, herbicides, fungicides, rodenticides, acaricides, nematicides, fumigants, avicides, and piscicides.

The following usage information can be reported for approved PUPs in the PUPS database:
- Pesticide trade name(s)
- Active ingredient(s)
- Total acres treated
- Total amount of pesticides used (lbs or gallons)
- Total amount of active ingredient(s) used (lbs)
- Target pest(s)
- Efficacy (% control)

To determine whether treatments are efficacious (eradicating, controlling, or containing the target pest) and achieving resource objectives, habitat and/or wildlife response would be monitored both pre- and post-treatment, where possible. Considering available annual funding and staffing, appropriate monitoring data regarding characteristics (attributes) of pest infestations (e.g., area, perimeter, degree of infestation-density, % cover, density) as well as habitat and/or wildlife response to treatments may be collected and stored in a relational database (e.g., Refuge Habitat Management Database), preferably a geo-referenced data management system (e.g., Refuge Lands GIS [RLGIS]) to facilitate data analyses and subsequent reporting. In accordance with adaptive management, data analysis and interpretation would allow treatments to be modified or changed over time, as necessary, to achieve resource objectives considering site-specific conditions in conjunction with habitat and/or wildlife responses. Monitoring could also identify short- and long-term impacts to natural resources and environmental quality associated with IPM treatments in accordance with adaptive management principles identified in 43 CFR 46.145.

7.0 Evaluating Pesticide Use Proposals

Pesticides would only be used on Refuge lands for habitat management as well as facilities maintenance after approval of a PUP. In general, proposed pesticide uses on Refuge lands would only be approved where there would likely be minor, temporary, or localized effects to fish and wildlife species as well as minimal potential to degrade environmental quality. Potential effects to listed and nonlisted species would be evaluated with quantitative ecological risk assessments and other screening measures. Potential effects to environmental quality would be based upon pesticide characteristics of environmental fate (water solubility, soil mobility, soil persistence, and volatilization) and other quantitative screening tools. Ecological risk assessments as well as characteristics of environmental fate and potential to degrade environmental quality for pesticides would be documented in Chemical Profiles (see Section 7.6). These profiles would include threshold values for quantitative measures of ecological risk assessments and screening tools for environmental fate that represent minimal potential effects to species and environmental quality. In general, only pesticide uses with appropriate BMPs (see Section 5.0) for habitat management and facilities maintenance on Refuge lands that would potentially have minor, temporary, or localized effects on Refuge biological and environmental quality (threshold values not exceeded) would be approved.

7.1 Overview of Ecological Risk Assessment

An ecological risk assessment process would be used to evaluate potential adverse effects to biological resources as a result of a pesticide(s) proposed for use on Refuge lands. It is an established quantitative and qualitative methodology for comparing and prioritizing risks of pesticides and conveying an estimate of the potential risk for an adverse effect. This quantitative methodology provides an efficient mechanism to integrate best available scientific information regarding hazard, patterns of use (exposure), and dose-response relationships in a manner that is useful for ecological risk decision-making. It would provide an effective way to evaluate potential effects where there is missing or unavailable scientific information (data gaps) to address reasonable, foreseeable adverse effects in the field as required under 40 CFR Part 1502.22. Protocols for ecological risk assessment of pesticide uses on the Refuge were developed through research and established by the US Environmental Protection Agency (USEPA).

Table E.1. Ecotoxicity tests used to evaluate potential effects to birds, fish, and mammals to establish toxicity endpoints for risk quotient calculations.

Species Group	Exposure	Measurement endpoint
Bird	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[1]
Fish	Acute	Median Lethal Concentration (LC_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[2]
Mammal	Acute	Oral Lethal Dose (LD_{50})
	Chronic	No Observed Effect Concentration (NOEC) or No Observed Adverse Effect Concentration (NOAEC)[3]

[1]Measurement endpoints typically include a variety of reproductive parameters (e.g., number of eggs, number of offspring, eggshell thickness, and number of cracked eggs).
[2]Measurement endpoints for early life stage/life cycle typically include embryo hatch rates, time to hatch, growth, and time to swim-up.
[3]Measurement endpoints include maternal toxicity, teratogenic effects or developmental anomalies, evidence of mutagenicity or genotoxicity, and interference with cellular mechanisms such as DNA synthesis and DNA repair.

The toxicological data used in ecological risk assessments are typically results of standardized laboratory studies provided by pesticide registrants to the USEPA to meet regulatory requirements under the Federal Insecticide, Fungicide and Rodenticide Act of 1996 (FIFRA). These studies assess the acute (lethality) and chronic (reproductive) effects associated with short- and long-term exposure to pesticides on representative species of birds, mammals, freshwater fish, aquatic invertebrates, and terrestrial and aquatic plants. Other effects data publicly available would also be utilized for risk assessment protocols described herein. Toxicity endpoint and environmental fate data are available from a variety of resources.

7.2 Determining Ecological Risk to Fish and Wildlife

The potential for pesticides used on the Refuge to cause direct adverse effects to fish and wildlife would be evaluated using USEPA's Ecological Risk Assessment Process (USEPA 2004). This deterministic approach, which is based upon a two-phase process involving estimation of environmental concentrations and then characterization of risk, would be used for ecological risk assessments. This method integrates exposure estimates (estimated environmental concentration [EEC] and toxicological endpoints [e.g., LC_{50} and oral LD_{50}]) to evaluate the potential for adverse effects to species groups (birds, mammals, and fish) representative of legal mandates for managing units of the NWRS. This integration is achieved through risk quotients (RQs) calculated by dividing the EEC by acute and chronic toxicity values selected from standardized toxicological endpoints or published effect (Table E.1).

$$RQ = EEC/Toxicological\ Endpoint$$

The level of risk associated with direct effects of pesticide use would be characterized by comparing calculated RQs to the appropriate Level of Concern (LOC) established by USEPA (1998 [Table 2]). The LOC represents a quantitative threshold value for screening potential adverse effects to fish and wildlife resources associated with pesticide use. The following are four exposure-species group scenarios that would be used to characterize ecological risk to fish and wildlife on the Refuge: acute-listed species, acute-nonlisted species, chronic-listed species, and chronic-nonlisted species.

Acute risk would indicate the potential for mortality associated with short-term dietary exposure to pesticides immediately after an application. For characterization of acute risks, median values from LC_{50} and LD_{50} tests would be used as toxicological endpoints for RQ calculations. In contrast, chronic risks would indicate the potential for adverse effects associated with long-term dietary exposure to pesticides from a single application or multiple applications over time (within a season and over years). For characterization of chronic risks, the no observed concentration (NOAEC) or no observed effect concentration (NOEC) for reproduction would be used as toxicological endpoints for RQ calculations. Where available, the NOAEC would be preferred over a NOEC value.

Listed species are those federally designated as threatened, endangered, or proposed in accordance with the Endangered Species Act of 1973 (16 USC 1531-1544, 87 Stat. 884, as amended-Public Law 93-205). For listed species, potential adverse effects would be assessed at the individual level because loss of individuals from a population could detrimentally impact a species. In contrast, risks to nonlisted species would consider effects at the population level. A RQ<LOC would indicate the proposed pesticide use "may affect, not likely to adversely effect" individuals (listed species) and it would not pose an unacceptable risk for adverse effects to populations (nonlisted species) for each taxonomic group (Table E.2). In contrast, a RQ>LOC would indicate a "may affect, likely to adversely affect" for listed species and it would also pose unacceptable ecological risk for adverse effects to nonlisted species.

Table E.2. Presumption of unacceptable risk for birds, fish, and mammals (US EPA 1998).

Risk Presumption		Level of Concern	
		Listed Species	Nonlisted Species
Acute	Birds	0.1	0.5
	Fish	0.05	0.5
	Mammals	0.1	0.5
Chronic	Birds	1.0	1.0
	Fish	1.0	1.0
	Mammals	1.0	1.0

Environmental exposure

Following release into the environment through application, pesticides would experience several different routes of environmental fate. Pesticides which would be sprayed can move through the air (e.g., particle or vapor drift) and may eventually end up in other parts of the environment such as nontarget vegetation, soil, or water. Pesticides applied directly to the soil may be washed off the soil into nearby bodies of surface water (e.g., surface runoff) or may percolate through the soil to lower soil layers and groundwater (e.g., leaching) (Baker and Miller 1999, Pope et. al. 1999, Butler et. al. 1998, Ramsay et. al. 1995, EXTOXNET 1993*a*). Pesticides which would be injected into the soil may also be subject to the latter two fates. The aforementioned possibilities are by no means complete, but it does indicate movement of pesticides in the environment is very complex with transfers occurring continually among different environmental compartments. In some cases, these exchanges occur not only between areas that are close together, but it also may involve transportation of pesticides over long distances (Barry 2004, Woods 2004).

Terrestrial exposure

The estimated environmental concentration (ECC) for exposure to terrestrial wildlife would be quantified using an USEPA screening-level approach (USEPA 2004). This screening-level approach is not affected by product formulation because it evaluates pesticide active ingredient(s). This approach would vary depending upon the proposed pesticide application method: spray or granular.

Terrestrial-spray application

For spray applications, exposure would be determined using the Kanaga nomogram method (USEPA 2005*a*, USEPA 2004, Pfleeger et al. 1996) through the USEPA's Terrestrial Residue Exposure model (T-REX) version 1.2.3 (USEPA 2005*b*). To estimate the maximum (initial) pesticide residue on short grass (<8"m tall) as a general food item category for terrestrial vertebrate species, T-REX input variables would include the following from the pesticide label: maximum pesticide application rate (pounds active ingredient [acid equivalent]/acre) and pesticide half-life (days) in soil. Although there are other food item categories (tall grasses; broadleaf plants and small insects; and fruits, pods, seeds and large insects), short grass was selected because it would yield maximum EECs (240 ppm per lb ai/acre) for worse-case risk assessments. Short grass is not representative of forage for carnivorous species (e.g., raptors), but it would characterize the maximum potential exposure through the diet of avian and mammalian prey items. Consequently, this approach would provide a conservative screening tool for pesticides that do not biomagnify.

For RQ calculations in T-REX, the model would require the weight of surrogate species and Mineau scaling factors (Mineau et. al. 1996). Body weights of bobwhite quail and mallard are included in T-REX by default, but body weights of other organisms (Table E.3) would be entered manually. The

Mineau scaling factor accounts for small-bodied bird species that may be more sensitive to pesticide exposure than would be predicted only by body weight. Mineau scaling factors would be entered manually with values ranging from 1 to 1.55 that are unique to a particular pesticide or group of pesticides. If specific information to select a scaling factor is not available, then a value of 1.15 would be used as a default. Alternatively, zero would be entered if it is known that body weight does not influence toxicity of pesticide(s) being assessed. The upper bound estimate output from the T-REX Kanaga nomogram would be used as an EEC for calculation of RQs. This approach would yield a conservative estimate of ecological risk.

Table E.3. Average body weight of selected terrestrial wildlife species frequently used in research to establish toxicological endpoints (Dunning 1984).

Species	Body Weight (kg)
Mammal (15 g)	0.015
House sparrow	0.0277
Mammal (35 g)	0.035
Starling	0.0823
Red-winged blackbird	0.0526
Common grackle	0.114
Japanese quail	0.178
Bobwhite quail	0.178
Rat	0.200
Rock dove (aka pigeon)	0.542
Mammal (1000 g)	1.000
Mallard	1.082
Ring-necked pheasant	1.135

Terrestrial – granular application

Granular pesticide formulations and pesticide-treated seed would pose a unique route of exposure for avian and mammalian species. The pesticide is applied in discrete units which birds or mammals might ingest accidentally with food items or intentionally as in the case of some bird species actively seeking and picking up gravel or grit to aid digestion or seed as a food source. Granules may also be consumed by wildlife foraging on earthworms, slugs or other soft-bodied soil organisms to which the granules may adhere.

Terrestrial wildlife RQs for granular formulations or seed treatments would be calculated by dividing the maximum milligrams of active ingredient (ai) exposed (e.g., EEC) on the surface of an area equal to 1 square foot by the appropriate LD_{50} value multiplied by the surrogate's body weight (Table 3). An adjustment to surface area calculations would be made for broadcast, banded, and in-furrow applications. An adjustment also would be made for applications with and without incorporation of the granules. Without incorporation, it would be assumed that 100% of the granules remain on the soil surface available to foraging birds and mammals. Press wheels push granules flat with the soil surface, but they are not incorporated into the soil. If granules are incorporated in the soil during band or T-band applications or after broadcast applications, it would be assumed only 15% of the applied granules remain available to wildlife. It would be assumed that only 1% of the granules are available on the soil surface following in-furrow applications.

EECs for pesticides applied in granular form and as seed treatments would be determined considering potential ingestion rates of avian or mammalian species (e.g., 10-30% body weight/day).

This would provide an estimate of maximum exposure that may occur as a result of granule or seed treatment spills such as those that commonly occur at end rows during application and planting. The availability of granules and seed treatments to terrestrial vertebrates would also be considered by calculating the loading per unit area (LD_{50}/ft^2) for comparison to USEPA Level of Concerns (USEPA 1998). The T-REX version 1.2.3 (USEPA 2005*b*) contains a submodel which automates Kanaga exposure calculations for granular pesticides and treated seed.

The following formulas will be used to calculate EECs depending upon the type of granular pesticide application:

• In-furrow applications assume a typical value of 1% granules, bait, or seed remain unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}580\ mg/lbs)(1\%\ exposed))] / \{[(43{,}560\ ft.^2/acre)/(row\ spacing\ (ft.))] / (row\ spacing\ (ft.)\}$$

or

$$mg\ a.i./ft^2 = [(lbs\ product/1000\ ft.\ row)(\%\ a.i.)(1000\ ft\ row)(453{,}580\ mg/lb.)(1\%\ exposed)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

• Incorporated banded treatments assume that 15% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/1000\ row\ ft.)(\%\ a.i.)(453{,}580\ mg/lb.)(1\text{-}\%\ incorporated)] / (1{,}000\ ft.)(band\ width\ (ft.))$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

• Broadcast treatment without incorporation assumes 100% of granules, bait, seeds are unincorporated.

$$mg\ a.i./ft.^2 = [(lbs.\ product/acre)(\%\ a.i.)(453{,}590\ mg/lb.)] / (43{,}560\ ft.^2/acre)$$

$$EEC = [(mg\ a.i./ft.^2)(\%\ of\ pesticide\ biologically\ available)]$$

Where:

• *% of pesticide biologically available = 100% without species specific ingestion rates*

• *Conversion for calculating mg a.i./ft.*^{2} *using ounces: 453,580 mg/lb. /16 = 28,349 mg/oz.*

The following equation would used to calculate a RQ based on the EEC calculated by one of the above equations. The EEC would divided by the surrogate LD_{50} toxicological endpoint multiplied by the body weight (Table 3) of the surrogate.

$$RQ = EEC / [LD_{50}\ (mg/kg) * body\ weight\ (kg)]$$

As with other risk assessments, a RQ>LOC would be a presumption of unacceptable ecological risk. A RQ<LOC would be a presumption of acceptable risk with only minor, temporary, or localized effects to species.

Aquatic exposure

Exposures to aquatic habitats (e.g., wetlands, meadows, ephemeral pools, water delivery ditches) would be evaluated separately for ground-based pesticide treatments of habitats managed for fish and wildlife compared with cropland/facilities maintenance. The primary exposure pathway for aquatic organisms from any ground-based treatments likely would be particle drift during the pesticide application. However, different exposure scenarios would be necessary as a result of contrasting application equipment and techniques as well as pesticides used to control pests on agricultural lands and facilities maintenance (e.g., roadsides, parking lots, trails) compared with other managed habitats on the Refuge. In addition, pesticide applications may be done <25'of the high water mark of aquatic habitats for habitat management treatments; whereas, no-spray buffers (≥25') would be used for facilities maintenance treatments.

Table E.4. Estimated Environmental Concentrations (ppb) of pesticides in aquatic habitats (1' depth) immediately after direct application (Urban and Cook 1986).

Lbs/acre	EEC (ppb)
0.10	36.7
0.20	73.5
0.25	91.9
0.30	110.2
0.40	147.0
0.50	183.7
0.75	275.6
1.00	367.5
1.25	459.7
1.50	551.6
1.75	643.5
2.00	735.7
2.25	827.6
2.50	919.4
3.00	1103.5
4.00	1471.4
5.00	1839
6.00	2207
7.00	2575
8.00	2943
9.00	3311
10.00	3678

Habitat treatments

For the worst-case exposure scenario to nontarget aquatic habitats, EECs (Table E. 4) would be would be derived from Urban and Cook (1986) that assumes an intentional overspray to an entire, nontarget water body (1-foot depth) from a treatment <25' from the high water mark using the max application rate (acid basis [see above]). However, use of BMPs for applying pesticides (see Section 4.2) would likely minimize/eliminate potential drift to nontarget aquatic habitats during actual treatments. If there would be unacceptable (acute or chronic) risk to fish and wildlife with the simulated 100% overspray (RQ>LOC), then the proposed pesticide use may be disapproved or the PUP would be approved at a lower application rate to minimize/eliminate unacceptable risk to aquatic organisms (RQ=LOC).

Facilities maintenance treatments

Field drift studies conducted by the Spray Drift Task Force, which is a joint project of several agricultural chemical businesses, were used to develop a generic spray drift database. From this database, the AgDRIFT computer model was created to satisfy USEPA pesticide registration spray drift data requirements and as a scientific basis to evaluate off-target movement of pesticides from particle drift and assess potential effects of exposure to wildlife. Several versions of the computer model have been developed (i.e., v2.01 through v2.10). The Spray Drift Task Force AgDRIFT® model version 2.01 (SDTF 2003, AgDRIFT 2001) would be used to derive EECs resulting from drift of pesticides to Refuge aquatic resources from ground-based pesticide applications >25’ from the high water mark. The Spray Drift Task Force AgDRIFT model is publicly available at http://www.agdrift.com. At this website, click “AgDRIFT 2.0” and then click “Download Now” and follow the instructions to obtain the computer model.

The AgDRIFT model is composed of submodels called tiers. Tier I Ground submodel would be used to assess ground-based applications of pesticides. Tier outputs (EECs) would be calculated with AgDRIFT using the following input variables: max application rate (acid basis [see above]), low boom (20”), fine to medium droplet size, EPA-defined wetland, and a
≥25-foot distance (buffer) from treated area to water.

7.2.2 Use of information on effects of biological control agents, pesticides, degradates, and adjuvants

NEPA documents regarding biological and other environmental effects of biological control agents, pesticides, degradates, and adjuvants prepared by another Federal agency, where the scope would be relevant to evaluation of effects from pesticide uses on Refuge lands, would be reviewed. Possible source agencies for such NEPA documents would include the BLM , US Forest Service, National Park Service, US Department of Agriculture-Animal and Plant Health Inspection Service, and the military services. It might be appropriate to incorporate by reference parts or all of existing document(s). Incorporating by reference (40 CFR 1502.21) is a technique used to avoid redundancies in analysis. It also would reduce the bulk of a Service NEPA document, which only would identify the documents that are incorporated by reference. In addition, relevant portions would be summarized in the Service NEPA document to the extent necessary to provide the decision maker and public with an understanding of relevance of the referenced material to the current analysis.

In accordance with the requirements set forth in 43 CFR 46.135, the Service would specifically incorporate through reference ecological risk assessments prepared by the US Forest Service (http://www.fs.fed.us/r6/invasiveplant-eis/Risk-Assessments/Herbicides-Analyzed-InvPlant-EIS.htm) and BLM (http://www.blm.gov/wo/st/en/prog/more/veg_eis.html). These risk assessments and associated documentation also are available in total with the administrative record for the Final Environmental Impact Statement entitled *Pacific Northwest Region Invasive Plant Program – Preventing and Managing Invasive Plants* (US Forest Service 2005) and *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States Programmatic EIS (PEIS)* (BLM 2007). In accordance with 43 CFR 46.120(d), use of existing NEPA documents by supplementing, tiering to, incorporating by reference, or adopting previous NEPA environmental analyses would avoid redundancy and unnecessary paperwork.

As a basis for completing “Chemical Profiles” for approving or disapproving Refuge PUPs, ecological risk assessments for the following herbicide and adjuvant uses prepared by the US Forest Service would be incorporated by reference:
- 2,4-D
- Chlorosulfuron

- Clopyralid
- Dicamba
- Glyphosate
- Imazapic
- Imazapyr
- Metsulfuron methyl
- Picloram
- Sethoxydim
- Sulfometuron methyl
- Triclopyr
- Nonylphenol polyethylate (NPE) based surfactants

As a basis for completing "Chemical Profiles" for approving or disapproving Refuge PUPs, ecological risk assessments for the following herbicide uses as well as evaluation of risks associated with pesticide degradates and adjuvants prepared by the BLM would be incorporated by reference:

- Bromacil
- Chlorsulfuron
- Diflufenzopyr
- Diquat
- Diuron
- Fluridone
- Imazapic
- Overdrive (diflufenzopyr and dicamba)
- Sulfometuron methyl
- Tebuthiuron
- Pesticide degradates and adjuvants (*Appendix D – Evaluation of risks from degradates, polyoxyethylene-amine (POEA) and R-11, and endocrine disrupting chemicals*)

7.2.3 Assumptions for ecological risk assessments

There are a number of assumptions involved with the ecological risk assessment process for terrestrial and aquatic organisms associated with utilization of the USEPA 's (2004) process. These assumptions may be risk neutral or may lead to an over- or under-estimation of risk from pesticide exposure depending upon site-specific conditions. The following describes these assumptions, their application to the conditions typically encountered, and whether or not they may lead to recommendations that are risk neutral, underestimate, or overestimate ecological risk from potential pesticide exposure.

- Indirect effects would not be evaluated by ecological risk assessments. These effects include the mechanisms of indirect exposure to pesticides: consuming prey items (fish, birds, or small mammals), reductions in the availability of prey items, and disturbance associated with pesticide application activities.
- Exposure to a pesticide product can be assessed based upon the active ingredient. However, exposure to a chemical mixture (pesticide formulation) may result in effects that are similar or substantially different compared to only the active ingredient. Nontarget organisms may be exposed directly to the pesticide formulation or only various constituents of the formulation as they dissipate and partition in the environment. If toxicological information for both the active ingredient and formulated product are available, then data representing the greatest potential toxicity would be selected for use in the risk assessment process (USEPA 2004). As a result,

this conservative approach may lead to an overestimation of risk characterization from pesticide exposure.

- Because toxicity tests with listed or candidate species or closely related species are not available, data for surrogate species would be most often used for risk assessments. Specifically, bobwhite quail and mallard duck are the most frequently used surrogates for evaluating potential toxicity to federally listed avian species. Bluegill sunfish, rainbow trout, and fathead minnow are the most common surrogates for evaluating toxicity for freshwater fishes. However, sheep's head minnow can be an appropriate surrogate marine species for coastal environments. Rats and mice are the most common surrogates for evaluating toxicity for mammals. Interspecies sensitivity is a major source of uncertainty in pesticide assessments. As a result of this uncertainty, data is selected for the most sensitive species tested within a taxonomic group (birds, fish, and mammals) given the quality of the data is acceptable. If additional toxicity data for more species of organisms in a particular group are available, the selected data will not be limited to the species previously listed as common surrogates.
- The Kanaga nomogram outputs maximum EEC values that may be used to calculate an average daily concentration over a specified interval of time, which is referred to as a time-weighted-average (TWA). The maximum EEC would be selected as the exposure input for both acute and chronic risk assessments in the screening-level evaluations. The initial or maximum EEC derived from the Kanaga nomogram represents the maximum expected instantaneous or acute exposure to a pesticide. Acute toxicity endpoints are determined using a single exposure to a known pesticide concentration typically for 48 to 96 hours. This value is assumed to represent ecological risk from acute exposure to a pesticide. On the other hand, chronic risk to pesticide exposure is a function of pesticide concentration and duration of exposure to the pesticide. An organism's response to chronic pesticide exposure may result from either the concentration of the pesticide, length of exposure, or some combination of both factors. Standardized tests for chronic toxicity typically involve exposing an organism to several different pesticide concentrations for a specified length of time (days, weeks, months, years or generations). For example, avian reproduction tests include a 10-week exposure phase. Because a single length of time is used in the test, time response data is usually not available for inclusion into risk assessments. Without time response data it is difficult to determine the concentration which elicited a toxicological response.
- Using maximum EECs for chronic risk estimates may result in an overestimate of risk, particularly for compounds that dissipate rapidly. Conversely, using TWAs for chronic risk estimates may underestimate risk if it is the concentration rather than the duration of exposure that is primarily responsible for the observed adverse effect. The maximum EEC would be used for chronic risk assessments although it may result in an overestimate of risk. TWAs may be used for chronic risk assessments, but they will be applied judiciously considering the potential for an underestimate or overestimate of risk. For example, the number of days exposure exceeds a Level of Concern may influence the suitability of a pesticide use. The greater the number of days the EEC exceeds the Level of Concern translates into greater the ecological risk. This is a qualitative assessment, and is subject to reviewer's expertise in ecological risk assessment and tolerance for risk.
- The length of time used to calculate the TWA can have a substantial effect on the exposure estimates and there is no standard method for determining the appropriate duration for this estimate. The T-REX model assumes a 21-week exposure period, which is equivalent to avian reproductive studies designed to establish a steady-state concentration for bioaccumulative compounds. However, this does not necessarily define the true exposure duration needed to elicit a toxicological response. Pesticides, which do not bioaccumulate, may achieve a steady-state

concentration earlier than 21 weeks. The duration of time for calculating TWAs will require justification and it will not exceed the duration of exposure in the chronic toxicity test (approximately 70 days for the standard avian reproduction study). An alternative to using the duration of the chronic toxicity study is to base the TWA on the application interval. In this case, increasing the application interval would suppress both the estimated peak pesticide concentration and the TWA. Another alternative to using TWAs would be to consider the number of days that a chemical is predicted to exceed the LOC.

- Pesticide dissipation is assumed to be first-order in the absence of data suggesting alternative dissipation patterns such as bi-phasic. Field dissipation data would generally be the most pertinent for assessing exposure in terrestrial species that forage on vegetation. However, this data is often not available and it can be misleading particularly if the compound is prone to "wash-off". Soil half-life is the most common degradation data available. Dissipation or degradation data that would reflect the environmental conditions typical of Refuge lands would be utilized, if available.
- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column.
- Actual habitat requirements of any particular terrestrial species are not considered, and it is assumed that species exclusively and permanently occupy the treated area, or adjacent areas receiving pesticide at rates commensurate with the treatment rate. This assumption would produce a maximum estimate of exposure for risk characterization. This assumption would likely lead to an overestimation of exposure for species that do not permanently and exclusively occupy the treated area (USEPA 2004).
- Exposure through incidental ingestion of pesticide contaminated soil is not considered in the USEPA risk assessment protocols. Research suggests <15% of the diet can consist of incidentally ingested soil depending upon species and feeding strategy (Beyer et al. 1994). An assessment of pesticide concentrations in soil compared to food item categories in the Kanaga nomogram indicates incidental soil ingestion will not likely increase dietary exposure to pesticides. Inclusion of soil into the diet would effectively reduce the overall dietary concentration compared to the present assumption that the entire diet consists a contaminated food source (Fletcher et al. 1994). An exception to this may be soil-applied pesticides in which exposure from incidental ingestion of soil may increase. Potential for pesticide exposure under this assumption may be underestimated for soil-applied pesticides and overestimated for foliar-applied pesticides. The concentration of a pesticide in soil would likely be less than predicted on food items.
- Exposure through inhalation of pesticides is not considered in the USEPA risk assessment protocols. Such exposure may occur through three potential sources: spray material in droplet form at time of application, vapor phase with the pesticide volatilizing from treated surfaces, and airborne particulates (soil, vegetative matter, and pesticide dusts). The USEPA (1990) reported exposure from inhaling spray droplets at the time of application is not an appreciable route of exposure for birds. According to research on mallards and bobwhite quail, respirable particle size (particles reaching the lung) in birds is limited to maximum diameter of 2 to 5 microns. The spray droplet spectra covering the majority of pesticide application scenarios indicate that less than 1% of the applied material is within the respirable particle size. This route of exposure is further limited because the permissible spray drop size distribution for ground pesticide applications is restricted to ASAE medium or coarser drop size distribution.
- Inhalation of a pesticide in the vapor phase may be another source of exposure for some pesticides under certain conditions. This mechanism of exposure to pesticides occurs post application and it would pertain to those pesticides with a high vapor pressure. The USEPA is

currently evaluating protocols for modeling inhalation exposure from pesticides including near-field and near-ground air concentrations based upon equilibrium and kinetics-based models. Risk characterization for exposure with this mechanism is unavailable.

- The effect from exposure to dusts contaminated with the pesticide cannot be assessed generically as partitioning issues related to application site soils and chemical properties of the applied pesticides render the exposure potential from this route highly situation specific.
- Dermal exposure may occur through three potential sources: direct application of spray to terrestrial wildlife in the treated area or within the drift footprint, incidental contact with contaminated vegetation, or contact with contaminated water or soil. Interception of spray and incidental contact with treated substrates may pose risk to avian wildlife (Driver et al. 1991). However, available research related to wildlife dermal contact with pesticides is extremely limited, except dermal toxicity values are common for some mammals used as human surrogates (rats and mice). The USEPA is currently evaluating protocols for modeling dermal exposure. Risk characterization may be underestimated for this route of exposure, particularly with high risk pesticides such as some organophosphates or carbamate insecticides. If protocols are established by the USEPA for assessing dermal exposure to pesticides, they will be considered for incorporation into pesticide assessment protocols.
- Exposure to a pesticide may occur from consuming surface water, dew or other water on treated surfaces. Water soluble pesticides have potential to dissolve in surface runoff and puddles in a treated area may contain pesticide residues. Similarly, pesticides with lower organic carbon partitioning characteristics and higher solubility in water have a greater potential to dissolve in dew and other water associated with plant surfaces. Estimating the extent to which such pesticide loadings to drinking water occurs is complex and would depend upon the partitioning characteristics of the active ingredient, soils types in the treatment area, and the meteorology of the treatment area. In addition, the use of various water sources by wildlife is highly species-specific. Currently, risk characterization for this exposure mechanism is not available. The USEPA is actively developing protocols to quantify drinking water exposures from puddles and dew. If and when protocols are formally established by the USEPA for assessing exposure to pesticides through drinking water, these protocols will be incorporated into pesticide risk assessment protocols.
- Risk assessments are based upon the assumption that the entire treatment area would be subject to pesticide application at the rates specified on the label. In most cases, there is potential for uneven application of pesticides through such plausible incidents such as changes in calibration of application equipment, spillage, and localized releases at specific areas in or near the treated field that are associated with mixing and handling and application equipment as well as applicator skill. Inappropriate use of pesticides and the occurrence of spills represent a potential underestimate of risk. It is likely not an important factor for risk characterization. All pesticide applicators are required to be certified by the State in which they apply pesticides. Certification training includes the safe storage, transport, handling, and mixing of pesticides, equipment calibration and proper application with annual continuing education.
- The USEPA relies on Fletcher (1994) for setting the assumed pesticide residues in wildlife dietary items. The USEPA (2004) "believes that these residue assumptions reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify". Fletcher's (1994) research suggests that the pesticide active ingredient residue assumptions used by the USEPA represent a 95^{th} percentile estimate. However, research conducted by Pfleeger et al. (1996) indicates USEPA residue assumptions for short grass was not exceeded. Baehr and Habig (2000) compared USEPA residue assumptions with distributions of measured pesticide residues for the USEPA's UTAB database. Overall

residue selection level will tend to overestimate risk characterization. This is particularly evident when wildlife individuals are likely to have selected a variety of food items acquired from multiple locations. Some food items may be contaminated with pesticide residues whereas others are not contaminated. However, it is important to recognize differences in species feeding behavior. Some species may consume whole above-ground plant material, but others will preferentially select different plant structures. Also, species may preferentially select a food item although multiple food items may be present. Without species specific knowledge regarding foraging behavior characterizing ecological risk other than in general terms is not possible.

- Acute and chronic risk assessments rely on comparisons of wildlife dietary residues with LC_{50} or NOEC values expressed as concentrations of pesticides in laboratory feed. These comparisons assume that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy and assimilative efficiency differences between wildlife food items and laboratory feed. Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods are not accounting for a potentially important aspect of food requirements.
- There are several other assumptions that can affect nontarget species not considered in the risk assessment process. These include possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic and biotic factors) and behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse affects to nontarget species, but they are usually characterized in the published literature in only a general manner limiting their value in the risk assessment process.
- It is assumed that aquatic species exclusively and permanently occupy the water body being assessed. Actual habitat requirements of aquatic species are not considered. With the possible exception of scenarios where pesticides are directly applied to water, it is assumed that no habitat use considerations specific for any species would place the organisms in closer proximity to pesticide use sites. This assumption produces a maximum estimate of exposure or risk characterization. It would likely be realistic for many aquatic species that may be found in aquatic habitats within or in close proximity to treated terrestrial habitats. However, the spatial distribution of wildlife is usually not random because wildlife distributions are often related to habitat requirements of species. Clumped distributions of wildlife may result in an under- or over-estimation of risk depending upon where the initial pesticide concentration occurs relative to the species or species habitat.
- For species found in the water column, it would be assumed that the greatest bioavailable fraction of the pesticide active ingredient in surface waters is freely dissolved in the water column. Additional chemical exposure from materials associated with suspended solids or food items is not considered because partitioning onto sediments likely is minimal. Adsorption and bioconcentration occurs at lower levels for many newer pesticides compared with older more persistent bioaccumulative compounds. Pesticides with RQs close to the listed species level of concern, the potential for additional exposure from these routes may be a limitation of risk assessments, where potential pesticide exposure or risk may be underestimated.
- Mass transport losses of pesticide from a water body (except for losses by volatilization, degradation and sediment partitioning) would not be considered for ecological risk assessment. The water body would be assumed to capture all pesticide active ingredients entering as runoff, drift, and adsorbed to eroded soil particles. It would also be assumed that pesticide active

ingredient is not lost from the water body by overtopping or flow-through, nor is concentration reduced by dilution. In total, these assumptions would lead to a near maximum possible water-borne concentration. However, this assumption would not account for potential to concentrate pesticide through the evaporative loss. This limitation may have the greatest impact on water bodies with high surface-to-volume ratios such as ephemeral wetlands, where evaporative losses are accentuated and applied pesticides have low rates of degradation and volatilization.

- For acute risk assessments, there would be no averaging time for exposure. An instantaneous peak concentration would be assumed, where instantaneous exposure is sufficient in duration to elicit acute effects comparable to those observed over more protracted exposure periods (typically 48 to 96 hours) tested in the laboratory. In the absence of data regarding time-to-toxic event, analyses and latent responses to instantaneous exposure, risk would likely be overestimated.
- For chronic exposure risk assessments, the averaging times considered for exposure are commensurate with the duration of invertebrate life-cycle or fish-early life stage tests (e.g., 21-28 days and 56-60 days, respectively). Response profiles (time to effect and latency of effect) to pesticides likely vary widely with mode of action and species and should be evaluated on a case-by-case basis as available data allow. Nevertheless, because the USEPA relies on chronic exposure toxicity endpoints based on a finding of no observed effect, the potential for any latent toxicity effects or averaging time assumptions to alter the results of an acceptable chronic risk assessment prediction is limited. The extent to which duration of exposure from water-borne concentrations overestimate or underestimate actual exposure depends on several factors. These include the following: localized meteorological conditions, runoff characteristics of the watershed (e.g., soils, topography), the hydrological characteristics of receiving waters, environmental fate of the pesticide active ingredient, and the method of pesticide application. It should also be understood that chronic effects studies are performed using a method that holds water concentration in a steady state. This method is not likely to reflect conditions associated with pesticide runoff. Pesticide concentrations in the field increase and decrease in surface water on a cycle influenced by rainfall, pesticide use patterns, and degradation rates. As a result of the dependency of this assumption on several undefined variables, risk associated with chronic exposure may in some situations underestimate risk and overestimate risk in others.
- There are several other factors that can affect nontarget species not considered in the risk assessment process. These would include the following: possible additive or synergistic effects from applying two or more pesticides or additives in a single application, co-location of pesticides in the environment, cumulative effects from pesticides with the same mode of action, effects of multiple stressors (e.g., combination of pesticide exposure, adverse abiotic [not pesticides] and biotic factors), and sub-lethal effects such as behavioral changes induced by exposure to a pesticide. These factors may exist at some level contributing to adverse affects to nontarget species, but they are not routinely assessed by regulatory agencies. Therefore, information on the factors is not extensive limiting their value for the risk assessment process. As this type of information becomes available, it would be included, either quantitatively or qualitatively, in this risk assessment process.
- USEPA is required by the Food Quality Protection Act to assess the cumulative risks of pesticides that share common mechanisms of toxicity, or act the same within an organism. Currently, USEPA has identified four groups of pesticides that have a common mechanism of toxicity requiring cumulative risk assessments. These four groups are: the organophosphate insecticides, N-methyl carbamate insecticides, triazine herbicides, and chloroacetanilide herbicides.

7.3 Pesticide Mixtures and Degradates

Pesticide products are usually a formulation of several components generally categorized as active ingredients and inert or other ingredients. The term active ingredient is defined by the FIFRA as preventing, destroying, repelling, or mitigating the effects of a pest, or it is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. In accordance with FIFRA, the active ingredient(s) must be identified by name(s) on the pesticide label along with its relative composition expressed in percentage(s) by weight. In contrast, inert ingredient(s) are not intended to affect a target pest. Their role in the pesticide formulation is to act as a solvent (keep the active ingredient is a liquid phase), an emulsifying or suspending agent (keep the active ingredient from separating out of solution), or a carrier such as clay in which the active ingredient is impregnated on the clay particle in dry formulations. For example, if isopropyl alcohol would be used as a solvent in a pesticide formulation, then it would be considered an inert ingredient. FIFRA only requires that inert ingredients identified as hazardous and associated percent composition, and the total percentage of all inert ingredients must be declared on a product label. Inert ingredients that are not classified as hazardous are not required to be identified.

The USEPA (September 1997) issued Pesticide Regulation Notice 97-6 which encouraged manufacturers, formulators, producers, and registrants of pesticide products to voluntarily substitute the term "other ingredients" for "inert ingredients" in the ingredient statement. This change recognized that all components in a pesticide formulation potentially could elicit or contribute to an adverse effect on nontarget organisms and, therefore, are not necessarily inert. Whether referred to as "inerts" or "other ingredients," these constituents within a pesticide product have the potential to affect species or environmental quality. The USEPA categorizes regulated inert ingredients into the following four lists (http://www.epa.gov/opprd001/inerts/index.html):

- List 1 – Inert Ingredients of Toxicological Concern
- List 2 – Potentially Toxic Inert Ingredients
- List 3 – Inerts of Unknown Toxicity
- List 4 – Inerts of Minimal Toxicity

Several of the List 4 compounds are naturally-occurring earthen materials (e.g., clay materials, simple salts) that would not elicit toxicological response at applied concentrations. However, some of the inerts (particularly the List 3 compounds and unlisted compounds) may have moderate to high potential toxicity to aquatic species based on MSDSs or published data.

Comprehensively assessing potential effects to nontarget fish, wildlife, plants, and/or their habitats from pesticide use is a complex task. It would be preferable to assess the cumulative effects from exposure to the active ingredient, its degradates, and inert ingredients as well as other active ingredients in the spray mixture. However, it would only be feasible to conduct deterministic risk assessments for each component in the spray mixture singly. Limited scientific information is available regarding ecological effects (additive or synergistic) from chemical mixtures that typically rely upon broadly encompassing assumptions. For example, the US Forest Service (2005) found that mixtures of pesticides used in land (forest) management likely would not cause additive or synergistic effects to nontarget species based upon a review of scientific literature regarding toxicological effects and interactions of agricultural chemicals (ATSDR 2004). Moreover, information on inert ingredients, adjuvants, and degradates is often limited by the availability of and access to reliable toxicological data for these constituents.

Toxicological information regarding "other ingredients" may be available from sources such as the following:

- TOMES (a proprietary toxicological database including USEPA's IRIS, the Hazardous Substance Data Bank, the Registry of Toxic Effects of Chemical Substances [RTECS]).
- USEPA's ECOTOX database, which includes AQUIRE (a database containing scientific papers published on the toxic effects of chemicals to aquatic organisms).
- TOXLINE (a literature searching tool).
- Material Safety Data Sheets (MSDSs) from pesticide suppliers.
- Other sources such as the Farm Chemicals Handbook.

Because there is a lack of specific inert toxicological data, inert(s) in a pesticide may cause adverse ecological effects. However, inert ingredients typically represent only a small percentage of the pesticide spray mixture, and it would be assumed that negligible effects would be expected to result from inert ingredient(s).

Although the potential effects of degradates should be considered when selecting a pesticide, it is beyond the scope of this assessment process to consider all possible breakdown chemicals of the various product formulations containing an active ingredient. Degradates may be more or less mobile and more or less hazardous in the environment than their parent pesticides (Battaglin et al. 2003). Differences in environmental behavior (e.g., mobility) and toxicity between parent pesticides and degradates would make assessing potential degradate effects extremely difficult. For example, a less toxic and more mobile, bioaccumulative, or persistent degradate may have potentially greater effects on species and/or degrade environmental quality. The lack of data on the toxicity of degradates for many pesticides would represent a source of uncertainty for assessing risk.

An USEPA-approved label specifies whether a product can be mixed with one or more pesticides. Without product-specific toxicological data, it would not possible to quantify the potential effects of these mixtures. In addition, a quantitative analysis could only be conducted if reliable scientific information allowed a determination of whether the joint action of a mixture would be additive, synergistic, or antagonistic. Such information would not likely exist unless the mode of action would be common among the chemicals and receptors. Moreover, the composition of and exposure to mixtures would be highly site- and/or time-specific and, therefore, it would be nearly impossible to assess potential effects to species and environmental quality.

To minimize or eliminate potential negative effects associated with applying two or more pesticides as a mixture, the use would be conducted in accordance with the labeling requirements. Labels for two or more pesticides applied as a mixture should be completely reviewed, where products with the least potential for negative effects would be selected for use on the Refuge. This is especially relevant when a mixture would be applied in a manner that may already have the potential for an effect(s) associated with an individual pesticide (e.g., runoff to ponds in sandy watersheds). Use of a tank mix under these conditions would increase the level of uncertainty in terms of risk to species or potential to degrade environmental quality.

Adjuvants generally function to enhance or prolong the activity of pesticide. For terrestrial herbicides, adjuvants aid in the absorption into plant tissue. Adjuvant is a broad term that generally applies to surfactants, selected oils, anti-foaming agents, buffering compounds, drift control agents, compatibility agents, stickers, and spreaders. Adjuvants are not under the same registration requirements as pesticides and the USEPA does not register or approve the labeling of spray adjuvants. Individual pesticide labels identify types of adjuvants approved for use with it. In general, adjuvants compose a relatively small portion of the volume of pesticides applied. Selection of adjuvants with limited toxicity and low volumes would be recommended to reduce the potential for the adjuvant to influence the toxicity of the pesticide.

7.4 Determining Effects to Soil and Water Quality

The approval process for pesticide uses would consider potential to degrade water quality on and off Refuge lands. A pesticide can only affect water quality through movement away from the treatment site. After application, pesticide mobilization can be characterized by one or more of the following (Kerle et al. 1996):

- Attach (sorb) to soil, vegetation, or other surfaces and remain at or near the treated area;
- Attach to soil and move off-site through erosion from run-off or wind;
- Dissolve in water that can be subjected to run-off or leaching.

As an initial screening tool, selected chemical characteristics and rating criteria for a pesticide can be evaluated to assess potential to enter ground and/or surface waters. These would include the following: persistence, sorption coefficient (K_{oc}), groundwater ubiquity score (GUS), and solubility.

Persistence, which is expressed as half-life ($t_{½}$), represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially). Persistence in the soil can be categorized as the following: nonpersistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et. al. 1996). Half-life data is usually available for aquatic and terrestrial environments.

Another measure of pesticide persistence is dissipation time (DT_{50}). It represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, half-life describes the rate for degradation only. As for half-life, units of dissipation time are usually expressed in days. Field or foliar dissipation time is the preferred data for use to estimate pesticide concentrations in the environment. However, soil half-life is the most common persistence data cited in published literature. If field or foliar dissipation data is not available, soil half-life data may be used. The average or representative half-life value of most important degradation mechanism will be selected for quantitative analysis for both terrestrial and aquatic environments.

Mobility of a pesticide is a function of how strongly it is adsorbed to soil particles and organic matter, its solubility in water, and its persistence in the environment. Pesticides strongly adsorbed to soil particles, relatively insoluble in water, and not environmentally persistent would be less likely to move across the soil surface into surface waters or to leach through the soil profile and contaminate groundwater. Conversely, pesticides that are not strongly adsorbed to soil particles, are highly water soluble, and are persistent in the environment would have greater potential to move from the application site (off-site movement).

The degree of pesticide adsorption to soil particles and organic matter (Kerle et. al. 1996) is expressed as the soil adsorption coefficient (K_{oc}). The soil adsorption coefficient is measured as micrograms of pesticide per gram of soil (μg/g) that can range from near zero to the thousands. Pesticides with higher Koc values are strongly sorbed to soil and, therefore, would be less subject to movement.

Water solubility describes the amount of pesticide that will dissolve in a known quantity of water. The water solubility of a pesticide is expressed as milligrams of pesticide dissolved in a liter of water (mg/l or ppm). Pesticide with solubility <0.1 ppm are virtually insoluble in water, 100-1000 ppm are moderately soluble, and >10,000 ppm highly soluble (US Geological Survey 2000). As pesticide solubility increases, there would be greater potential for off-site movement.

The Groundwater Ubiquity Score (GUS) is a quantitative screening tool to estimate a pesticide's potential to move in the environment. It utilizes soil persistence and adsorption coefficients in the following formula.

$$GUS = \log_{10}(t_{½}) \times [4 - \log_{10}(K_{oc})]$$

The potential pesticide movement rating would be based upon its GUS value. Pesticides with a GUS <0.1 would considered to have an extremely low potential to move toward groundwater. Values of 1.0-2.0 would be low, 2.0-3.0 would be moderate, 3.0-4.0 would be high, and >4.0 would have a very high potential to move toward groundwater.
Water solubility describes the amount of pesticide dissolving in a specific quantity of water, where it is usually measured as mg/l or parts per million (ppm). Solubility is useful as a comparative measure because pesticides with higher values are more likely to move by run-off or leaching. GUS, water solubility, $t_{½}$, and K_{oc} values are available for selected pesticides from the OSU Extension Pesticide Properties Database at http://npic.orst.edu/ppdmove.htm. Many of the values in this database were derived from the SCS/ARS/CES Pesticide Properties Database for Environmental Decision Making (Wauchope et al. 1992).

Soil properties influence the fate of pesticides in the environment. The following six properties are mostly likely to affect pesticide degradation and the potential for pesticides to move off-site by leaching (vertical movement through the soil) or runoff (lateral movement across the soil surface).

- Permeability is the rate of water movement vertically through the soil. It is affected by soil texture and structure. Coarse textured soils (e.g., high sand content) have a larger pore size and they are generally more permeable than fine textured soils (i.e., high clay content). The more permeable soils would have a greater potential for pesticides to move vertically down through the soil profile. Soil permeability rates (inches/hour) are usually available in county soil survey reports.
- Soil texture describes the relative percentage of sand, silt, and clay. In general, greater clay content with smaller the pore size would lower the likelihood and rate water that would move through the soil profile. Clay also serves to adsorb (bind) pesticides to soil particles. Soils with high clay content would adsorb more pesticide than soils with relatively low clay content. In contrast, sandy soils with coarser texture and lower water holding capacity would have a greater potential for water to leach through them.
- Soil structure describes soil aggregation. Soils with a well developed soil structure have looser, more aggregated, structure that would be less likely to be compacted. Both characteristics would allow for less restricted flow of water through the soil profile resulting in greater infiltration.
- Organic matter would be the single most important factor affecting pesticide adsorption in soils. Many pesticides are adsorbed to organic matter which would reduce their rate of downward movement through the soil profile. Also, soils high in organic matter would tend to hold more water, which may make less water available for leaching.
- Soil moisture affects how fast water would move through the soil. If soils are already wet or saturated before rainfall or irrigation, excess moisture would runoff rather than infiltrate into the soil profile. Soil moisture also would influence microbial and chemical activity in soil, which effects pesticide degradation.

- Soil pH would influence chemical reactions that occur in the soil which in turn determines whether or not a pesticide will degrade, rate of degradation, and, in some instances, which degradation products are produced.

Based upon the aforementioned properties, soils most vulnerable to groundwater contamination would be sandy soils with low organic matter. In contrast, the least vulnerable soils would be well-drained clayey soils with high organic matter. Consequently, pesticides with the lowest potential for movement in conjunction with appropriate best management practices (see below) would be used in an IPM framework to treat pests while minimizing effects to nontarget biota and protecting environmental quality.

Along with soil properties, the potential for a pesticide to affect water quality through run-off and leaching would consider site-specific environmental and abiotic conditions including rainfall, water table conditions, and topography (Huddleston 1996).

- Water is necessary to separate pesticides from soil. This can occur in two basic ways. Pesticides that are soluble move easily with runoff water. Pesticide-laden soil particles can be dislodged and transported from the application site in runoff. The concentration of pesticides in the surface runoff would be greatest for the first runoff event following treatment. The rainfall intensity and route of water infiltration into soil, to a large extent, determine pesticide concentrations and losses in surface runoff. The timing of the rainfall after application also would have an effect. Rainfall interacts with pesticides at a shallow soil depth (¼ to ½ inch), which is called the mixing zone (Baker and Miller 1999). The pesticide/water mixture in the mixing zone would tend to leach down into the soil or runoff depending upon how quickly the soil surface becomes saturated and how rapidly water can infiltrate into the soil. Leaching would decrease the amount of pesticide available near the soil surface (mixing zone) to runoff during the initial rainfall event following application and subsequent rainfall events.
- Terrain slope would affect the potential for surface runoff and the intensity of runoff. Steeper slopes would have greater potential for runoff following a rainfall event. In contrast, soils that are relatively flat would have little potential for runoff, except during intense rainfall events. In addition, soils in lower areas would be more susceptible to leaching as a result of receiving excessive water from surrounding higher elevations.
- Depth to groundwater would be an important factor affecting the potential for pesticides to leach into groundwater. If the distance from the soil surface to the top of the water table is shallow, pesticides would have less distance to travel to reach groundwater. Shallower water tables that persist for longer periods would be more likely to experience groundwater contamination. Soil survey reports are available for individual counties. These reports provide data in tabular format regarding the water table depths and the months during which it is persists. In some situations, a hard pan exists above the water table that would prevent pesticide contamination from leaching.

7.5 Determining Effects to Air Quality

Pesticides may volatilize from soil and plant surfaces and move from the treated area into the atmosphere. The potential for a pesticide to volatilize is determined by the pesticide's vapor pressure which would be affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these numbers easier to compare, vapor pressure may be expressed in exponent form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with $I<10$ would have a low potential to volatilize; whereas, pesticides with $I>1{,}000$ would have a high potential to volatilize (Oregon State University 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database.

7.6 Preparing a Chemical Profile

The following instructions would be used by Service personnel to complete Chemical Profiles for pesticides. Specifically, profiles would be prepared for pesticide active ingredients (e.g., glyphosate, imazapic) that would be contained in one or more trade name products that are registered and labeled with USEPA. All information fields under each category (e.g., Toxicological Endpoints, Environmental Fate) would be completed for a Chemical Profile. If no information is available for a specific field, then "No data is available in references" would be recorded in the profile. Available scientific information would be used to complete Chemical Profiles. Each entry of scientific information would be shown with applicable references.

Completed Chemical Profiles would provide a structured decision-making process utilizing quantitative assessment/screening tools with threshold values (where appropriate) that would be used to evaluate potential biological and other environmental effects to Refuge resources. For ecological risk assessments presented in these profiles, the "worst-case scenario" would be evaluated to determine whether a pesticide could be approved for use considering the maximum single application rate specified on pesticide labels for habitat management and croplands/facilities maintenance treatments pertaining to Refuges. Where the "worst-case scenario" likely would only result in minor, temporary, and localized effects to listed and nonlisted species with appropriate BMPs (see Section 5.0), the proposed pesticide's use in a PUP would have a scientific basis for approval under any application rate specified on the label that is at or below rates evaluated in a Chemical Profile. In some cases, the Chemical Profile would include a lower application rate than the maximum labeled rate in order to protect Refuge resources. As necessary, Chemical Profiles would be periodically updated with new scientific information or as pesticides with the same active ingredient are proposed for use on the Refuge in PUPs.

Throughout this section, threshold values (to prevent or minimize potential biological and environmental effects) would be clearly identified for specific information presented in a completed Chemical Profile. Comparison with these threshold values provides an explicit scientific basis to approve or disapprove PUPs for habitat management and cropland/facilities maintenance on Refuge lands. In general, PUPs would be approved for pesticides with Chemical Profiles where there would be no exceedances of threshold values. However, BMPs are identified for some screening tools that would minimize/eliminate potential effects (exceedance of the threshold value) as a basis for approving PUPs.

Date: Service personnel would record the date when the Chemical Profile is completed or updated. Chemical Profiles (e.g., currently approved pesticide use patterns) would be periodically reviewed and updated, as necessary. The most recent review date would be recorded on a profile to document when it was last updated.

Trade Name(s): Service personnel would accurately and completely record the trade name(s) from the pesticide label, which includes a suffix that describes the formulation (e.g., WP, DG, EC, L, SP, I, II or 64). The suffix often distinguishes a specific product among several pesticides with the same active ingredient. Service personnel would record a trade name for each pesticide product with the same active ingredient.

Common chemical name(s): Service personnel would record the common name(s) listed on the pesticide label or material safety data sheet (MSDS) for an active ingredient. The common name of a pesticide is listed as the active ingredient on the title page of the product label immediately following the trade name, and the MSDS, Section 2: Composition/ Information on Ingredients. A Chemical Profile is completed for each active ingredient.

Pesticide Type: Service personnel would record the type of pesticide for an active ingredient as one of the following: herbicide, dessicant, fungicide, fumigant, growth regulator, insecticide, pisicide, or rodenticide.

EPA Registration Number(s): This number (EPA Reg. No.) appears on the title page of the label and MSDS, Section 1: Chemical Product and Company Description. It is not the EPA Establishment Number that is usually located near it. Service personnel would record the EPA Reg. No. for each trade name product with an active ingredient based upon PUPs.

Pesticide Class: Service personnel would list the general chemical class for the pesticide (active ingredient). For example, malathion is an organophosphate and carbaryl is a carbamate.

CAS (Chemical Abstract Service) Number: This number is often located in the second section (Composition/Information on Ingredients) of the MSDS. The MSDS table listing components usually contains this number immediately prior to or following the % composition.

Other Ingredients: From the most recent MSDS for the proposed pesticide product(s), Service personnel would include any chemicals in the pesticide formulation not listed as an active ingredient that are described as toxic or hazardous, or regulated under the Superfund Amendments and Reauthorization Act (SARA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Toxic Substances Control Act (TSCA), Occupational Safety and Health Administration (OSHA), State Right-to-Know, or other listed authorities. These are usually found in MSDS sections titled "Hazardous Identifications", "Exposure Control/Personal Protection", and "Regulatory Information". If concentrations of other ingredients are available for any compounds identified as toxic or hazardous, then Service personnel would record this information in the Chemical Profile by trade name. MSDS(s) may be obtained from the manufacturer, manufacturer's website or from an on-line database maintained by Crop Data Management Systems, Inc. (see list below).

Toxicological Endpoints

Toxicological endpoint data would be collected for acute and chronic tests with mammals, birds, and fish. Data would be recorded for species available in the scientific literature. If no data are found for a particular taxonomic group, then "No data available is references" would be recorded as the data entry. Throughout the Chemical Profile, references (including toxicological endpoint data) would be cited using parentheses (#) following the recorded data.

Mammalian LD_{50}: For test species in the scientific literature, Service personnel would record available data for oral lethal dose (LD_{50}) in mg/kg-bw (body weight) or ppm-bw. Most common test species in scientific literature are the rat and mouse. The lowest LD_{50} value found for a rat would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk to mammals (see Table 1 in Section 7.1).

Mammalian LC_{50}: For test species in the scientific literature, Service personnel would record available data for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species in scientific literature are the rat and mouse. The lowest LC_{50} value found for a rat would be used as a toxicological endpoint for diet-based RQ calculations to assess acute risk.

Mammalian Reproduction: For test species listed in the scientific literature, Service personnel would record the test results (e.g., Lowest Observed Effect Concentration [LOEC], Lowest Observed Effect Level [LOEL], No Observed Adverse Effect Level [NOAEL], No Observed Adverse Effect Concentration [NOAEC]) in mg/kg-bw or mg/kg-diet for reproductive test procedure(s) (e.g., generational studies [preferred], fertility, new born weight). Most common test species available in scientific literature are rats and mice. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for a rat would be used as a toxicological endpoint for RQ calculations to assess chronic risk.

Avian LD_{50}: For test species available in the scientific literature, Service personnel would record values for oral lethal dose (LD_{50}) in mg/kg-bw or ppm-bw. Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LD_{50} value found for an avian species would be used as a toxicological endpoint for dose-based RQ calculations to assess acute risk.

Avian LC_{50}: For test species available in the scientific literature, Service personnel would record values for dietary lethal concentration (LC_{50}) as reported (e.g., mg/kg-diet or ppm-diet). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest LC_{50} value found for an avian species would be used as a toxicological endpoint for dietary-based RQ calculations to assess acute risk.

Avian Reproduction: For test species available in the scientific literature, Service personnel would record test results (e.g., LOEC, LOEL, NOAEC, NOAEL) in mg/kg-bw or mg/kg-diet consumed for reproductive test procedure(s) (e.g., early life cycle, reproductive). Most common test species available in scientific literature are the bobwhite quail and mallard. The lowest NOEC, NOAEC, NOEL, or NOAEL test results found for an avian species would be used as a toxicological endpoint for RQ calculations to assess chronic risk.

Fish LC_{50}: For test freshwater or marine species listed in the scientific literature, Service personnel would record a LC_{50} in ppm or mg/L. Most common test species available in the scientific literature are the bluegill, rainbow trout, and fathead minnow (marine). Test results for many game species may also be available. The lowest LC_{50} value found for a freshwater fish species would be used as a toxicological endpoint for RQ calculations to assess acute risk.

Fish Early Life Stage (ELS)/Life Cycle: For test freshwater or marine species available in the scientific literature, Service personnel would record test results (e.g., LOEC, NOAEL, NOAEC, LOAEC) in ppm for test procedure(s) (e.g., early life cycle, life cycle). Most common test species available in the scientific literature are bluegill, rainbow trout, and fathead minnow. Test results for other game species may also be available. The lowest test value found for a fish species (preferably freshwater) would be used as a toxicological endpoint for RQ calculations to assess chronic risk.

Other: For test invertebrate as well as nonvascular and vascular plant species available in the scientific literature, Service personnel would record $LC_{50,}$ $LD_{50,}$ LOEC, LOEL, NOAEC, NOAEL, or EC_{50} (environmental concentration) values in ppm or mg/L. Most common test invertebrate species available in scientific literature are the honey bee and the water flea (*Daphnia magna*). Green algae (*Selenastrum capricornutum*) and pondweed (*Lemna minor*) are frequently available test species for aquatic nonvascular and vascular plants, respectively.

Ecological Incident Reports: After a site has been treated with pesticide(s), wildlife may be exposed to these chemical(s). When exposure is high relative to the toxicity of the pesticides, wildlife may be killed or visibly harmed (incapacitated). Such events are called ecological incidents. The USEPA maintains a database (Ecological Incident Information System) of ecological incidents. This database stores information extracted from incident reports submitted by various Federal and State agencies and nongovernment organizations. Information included in an incident report is date and location of the incident, type and magnitude of affects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and results of any chemical residue and cholinesterase activity analyses conducted during the investigation.
Incident reports can play an important role in evaluating the effects of pesticides by supplementing quantitative risk assessments. All incident reports for pesticide(s) with the active ingredient and associated information would be recorded.

Environmental Fate

Water Solubility: Service personnel would record values for water solubility (S_w), which describes the amount of pesticide that dissolves in a known quantity of water. S_w is expressed as mg/L (ppm). Pesticide S_w values would be categorized as one of the following: insoluble <0.1 ppm, moderately soluble = 100 to 1000 ppm, highly soluble >10,000 ppm (US Geological Survey 2000). As pesticide S_w increases, there would be greater potential to degrade water quality through run-off and leaching.

Sw would be used to evaluate potential for bioaccumulation in aquatic species [see **Octanol-Water Partition Coefficient (K_{ow})** below].

Soil Mobility: Service personnel would record available values for soil adsorption coefficient (K_{oc} [μg/g]). It provides a measure of a chemical's mobility and leaching potential in soil. K_{oc} values are directly proportional to organic content, clay content, and surface area of the soil. K_{oc} data for a pesticide may be available for a variety of soil types (e.g., clay, loam, sand).

K_{oc} values would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Persistence: Service personnel would record values for soil half-life ($t_{½}$), which represents the length of time (days) required for 50% of the deposited pesticide to degrade (completely or partially) in the soil. Based upon the $t_{½}$ value, soil persistence would be categorized as one of the following: nonpersistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et. al. 1996).

Threshold for Approving PUPs:

If soil $t_{½}$ ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.
If soil $t_{½}$ >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the **Specific Best Management Practices (BMPs) section** *to minimize potential surface run-off and leaching that can degrade water quality:*

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10' and average annual precipitation >12".*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil $t_{½}$ values would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below).

Soil Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade and move from a treated site; whereas, soil $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Field dissipation time would be the preferred data for use to estimate pesticide concentrations in the environment because it is based upon field studies compared to soil $t_{½}$, which is derived in a laboratory. However, soil $t_{½}$ is the most common persistence data available in the published literature. If field dissipation data is not available, soil half-life data would be used in a Chemical Profile. The average or representative half-life value of most important degradation mechanism would be selected for quantitative analysis for both terrestrial and aquatic environments.

Based upon the DT_{50} value, environmental persistence in the soil also would be categorized as one of the following: nonpersistent <30 days, moderately persistent = 30-100 days, and persistent >100 days.

Threshold for Approving PUPs:

If soil DT_{50} ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.
If soil DT_{50} >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface run-off and leaching that can degrade water quality:

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10' and average annual precipitation >12".*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Along with K_{oc}, soil DT_{50} values (preferred over soil $t_{½}$) would be used in evaluating the potential to degrade groundwater by leaching (see **Potential to Move to Groundwater** below), if available.

Aquatic Persistence: Service personnel would record values for aquatic $t_{½}$, which represents the length of time required for 50% of the deposited pesticide to degrade (completely or partially) in water. Based upon the $t_{½}$ value, aquatic persistence would be categorized as one of the following: nonpersistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days (Kerle et. al. 1996).

Threshold for Approving PUPs:

If aquatic $t_{½}$ ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.
If aquatic $t_{½}$ >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface run-off and leaching that can degrade water quality:

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10' and average annual precipitation >12".*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Aquatic Dissipation: Dissipation time (DT_{50}) represents the time required for 50% of the deposited pesticide to degrade or move (dissipate); whereas, aquatic $t_{½}$ describes the rate for degradation only. As for $t_{½}$, units of dissipation time are usually expressed in days. Based upon the DT_{50} value, environmental persistence in aquatic habitats also would be categorized as one of the following: nonpersistent <30 days, moderately persistent = 30 to 100 days, and persistent >100 days.

Threshold for Approving PUPs:

If aquatic DT_{50} ≤100 days, then a PUP would be approved without additional BMPs to protect water quality.
If aquatic DT_{50} >100 days, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface run-off and leaching that can degrade water quality:

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10' and average annual precipitation >12".*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Potential to Move to Groundwater: Groundwater Ubiquity Score (GUS) = $\log_{10}$(soil $t_{½}$) x [4 – $\log_{10}(K_{oc})$]. If a DT_{50} value is available, it would be used rather than a $t_{½}$ value to calculate a GUS score. Based upon the GUS value, the potential to move toward groundwater would be recorded as one of the following categories: extremely low potential<1.0, low - 1.0 to 2.0, moderate - 2.0 to 3.0, high - 3.0 to 4.0, or very high>4.0.

Threshold for Approving PUPs:

If GUS ≤4.0, then a PUP would be approved without additional BMPs to protect water quality.
If GUS >4.0, then a PUP would only be approved with additional BMPs specifically to protect water quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to minimize potential surface run-off and leaching that can degrade water quality:

- *Do not exceed one application per site per year.*
- *Do not use on coarse-textured soils where the ground water table is <10' and average annual precipitation >12".*
- *Do not use on steep slopes if substantial rainfall is expected within 24 hours or ground is saturated.*

Volatilization: Pesticides may volatilize (evaporate) from soil and plant surfaces and move off-target into the atmosphere. The potential for a pesticide to volatilize is a function of its vapor pressure that is affected by temperature, sorption, soil moisture, and the pesticide's water solubility. Vapor pressure is often expressed in mm Hg. To make these values easier to compare, vapor pressure would be recorded by Service personnel in exponential form ($I \times 10^{-7}$), where I represents a vapor pressure index. In general, pesticides with I<10 would have low potential to volatilize; whereas, pesticides with I >1,000 would have a high potential to volatilize (Oregon State University 1996). Vapor pressure values for pesticides are usually available in the pesticide product MSDS or the USDA Agricultural Research Service (ARS) pesticide database (see **References**).

Threshold for Approving PUPs:

If I ≤1000, then a PUP would be approved without additional BMPs to minimize drift and protect air quality.
If I >1000, then a PUP would only be approved with additional BMPs specifically to minimize drift and protect air quality. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to reduce volatilization and potential to drift and degrade air quality:

- *Do not treat when wind velocities are <2 or >10 mph with existing or potential inversion conditions.*
- *Apply the large-diameter droplets possible for spray treatments.*
- *Avoid spraying when air temperatures >85^{o}F.*
- *Use the lowest spray height possible above target canopy.*
- *Where identified on the pesticide label, soil incorporate pesticide as soon as possible during or after application.*

Octanol-Water Partition Coefficient (K_{ow}): The octanol-water partition coefficient (K_{ow}) is the concentration of a pesticide in octanol and water at equilibrium at a specific temperature. Because octanol is an organic solvent, it is considered a surrogate for natural organic matter. Therefore, K_{ow} would be used to assess potential for a pesticide to bioaccumulate in tissues of aquatic species (e.g., fish). If K_{ow} >1000 or S_w<1 mg/L AND soil $t_{½}$>30 days, then there would be high potential for a pesticide to bioaccumulate in aquatic species such as fish (USGS 2000).

Threshold for Approving PUPs:

If there is not a high potential for a pesticide to bioaccumulate in aquatic species, then the PUP would be approved.
If there is a high potential to bioaccumulate in aquatic species (K_{ow}>1000 or S_w<1 mg/L AND soil $t_{½}$>30 days), then the PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

Bioaccumulation/Bioconcentration: The physiological process where pesticide concentrations in tissue would increase in biota because they are taken and stored at a faster rate than they are metabolized or excreted. The potential for bioaccumulation would be evaluated through bioaccumulation factors (BAFs) or bioconcentration factors (BCFs). Based upon BAF or BCF values, the potential to bioaccumulate would be recorded as one of the following: low – 0 to 300, moderate – 300 to 1000, or high >1000 (Calabrese and Baldwin 1993).

Threshold for Approving PUPs:

If BAF or BCF≤1000, then a PUP would be approved without additional BMPs.
If BAF or BCF>1000, then a PUP would not approved, except under unusual circumstances where approval would only be granted by the Washington Office.

Worst-Case Ecological Risk Assessment

Max Application Rates (acid equivalent): Service personnel would record the highest application rate of an active ingredient (ae basis) for habitat management and cropland/facilities maintenance treatments in this data field of a Chemical Profile. These rates can be found in Table CP.1 under the column heading "Max Product Rate – Single Application (lbs/acre – AI on acid equiv basis)". This table would be prepared for a chemical profile from information specified in labels for trade name products identified in PUPs. If these data are not available in pesticide labels, then write "NS" for "not specified on label" in this table.

EECs: An estimated environmental concentration (ECC) represents potential exposure to fish and wildlife (birds and mammals) from using a pesticide. EECs would be derived by Service personnel using an USEPA screening-level approach (USEPA 2004). For each max application rate [see description under **Max Application Rates (acid equivalent)**], Service personnel would record 2 EEC values in a Chemical Profile; these would represent the worst-case terrestrial and aquatic exposures for habitat management and croplands/facilities maintenance treatments. For terrestrial and aquatic EEC calculations, see description for data entry under **Presumption of Unacceptable Risk/Risk Quotients**, which is the next field for a Chemical Profile.

Presumption of Unacceptable Risk/Risk Quotients: Service personnel would calculate and record acute and chronic risk quotients (RQs) for birds, mammals, and fish using the provided tabular formats for habitat management and/or cropland/facilities maintenance treatments. RQs recorded in a Chemical Profile would represent the worst-case assessment for ecological risk. See Section 7.2 for discussion regarding the calculations of RQs.

For aquatic assessments associated with habitat management treatments, RQ calculations would be based upon selected acute and chronic toxicological endpoints for fish and the EEC would be derived from Urban and Cook (1986) assuming 100% overspray to an entire 1-foot deep water body using the max application rate (ae basis [see above]).

For aquatic assessments associated with cropland/facilities maintenance treatments, RQ calculations would be done by Service personnel based upon selected acute and chronic toxicological endpoints for fish and an EEC would be derived from the aquatic assessment in AgDRIFT® model version 2.01 under Tier I ground-based application with the following input variables: max application rate (acid basis [see above]), low boom (20”), fine to medium/coarse droplet size, 20 swaths, EPA-defined wetland, and 25-foot distance (buffer) from treated area to water.

For terrestrial avian and mammalian assessments, RQ calculations would be done by Service personnel based upon dietary exposure, where the “short grass” food item category would represent the worst-case scenario. For terrestrial spray applications associated with habitat management and cropland/facilities maintenance treatments, exposure (EECs and RQs) would be determined using the Kanaga nomogram method through the USEPA’s Terrestrial Residue Exposure model (T-REX) version 1.2.3. T-REX input variables would include the following: max application rate (acid basis [see above]) and pesticide half-life (days) in soil to estimate the initial, maximum pesticide residue concentration on general food items for terrestrial vertebrate species in short (<20 cm tall) grass. For granular pesticide formulations and pesticide-treated seed with a unique route of exposure for terrestrial avian and mammalian wildlife, see Section 7.2. for the procedure that would be used to calculate RQs.

All calculated RQs in both tables would be compared with Levels of Concern (LOCs) established by USEPA (see Table E.2 in Section 7.2). If a calculated RQ exceeds an established LOC value (in brackets inside the table), then there would be a potential for an acute or chronic effect (unacceptable risk) to federally listed (T&E) species and nonlisted species. See Section 7.2 for detailed descriptions of acute and chronic RQ calculations and comparison to LOCs to assess risk.

Threshold for approving PUPs:

If RQs≤LOCs, then a PUP would be approved without additional BMPs.
If RQs>LOCs, then a PUP would only be approved with additional BMPs specifically to minimize exposure (ecological risk) to bird, mammal, and/or fish species. One or more BMPs such as the following would be included in the Specific Best Management Practices (BMPs) section to reduce potential risk to nonlisted or listed species:

- *Lower application rate and/or fewer number of applications so RQs≤LOCs*
- *For aquatic assessments (fish) associated with cropland/facilities maintenance, increase the buffer distance beyond 25’ so RQs≤LOCs.*

Justification for Use: Service personnel would describe the reason for using the pesticide based control of specific pests or groups of pests. In most cases, the pesticide label will provide the appropriate information regarding control of pests to describe in the section.

Specific Best Management Practices (BMPs): Service personnel would record specific BMPs necessary to minimize or eliminate potential effects to nontarget species and/or degradation of environmental quality from drift, surface runoff, or leaching. These BMPs would be based upon scientific information documented in previous data fields of a Chemical Profile. Where necessary and feasible, these specific practices would be included in PUPs as a basis for approval.

If there are no specific BMPs that are appropriate, then Service personnel would describe why the potential effects to Refuge resources and/or degradation of environmental quality is outweighed by the overall resource benefit(s) from the proposed pesticide use in the BMP section of the PUP. See Section 4.0 of this document for a complete list of BMPs associated with mixing and applying pesticides appropriate for all PUPs with ground-based treatments that would be additive to any necessary, chemical-specific BMPs.

References: Service personnel would record scientific resources used to provide data/information for a chemical profile. Use the number sequence to uniquely reference data in a chemical profile.

The following on-line data resources are readily available for toxicological endpoint and environmental fate data for pesticides:

1. California Product/Label Database. Department of Pesticide Regulation, California Environmental Protection Agency. (http://www.cdpr.ca.gov/docs/label/labelque.htm#regprods)

2. ECOTOX database. Office of Pesticide Programs, USEPA , Washington, DC. (http://cfpub.epa.gov/ecotox/)

3. Extension Toxicology Network (EXTOXNET) Pesticide Information Profiles. Cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University and University of Idaho through Oregon State University, Corvallis, Oregon. (http://extoxnet.orst.edu/pips/ghindex.html)

4. FAO specifications and evaluations for plant protection products. Pesticide Management Unit, Plant Protection Services, Food and Agriculture Organization, United Nations. (http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/)

5. Human health and ecological risk assessments. Pesticide Management and Coordination, Forest Health Protection, US Department of Agriculture, US Forest Service. (http://www.fs.fed.us/foresthealth/pesticide/risk.htm)

6. Pesticide Chemical Fact Sheets. Clemson University Pesticide Information Center. (http://entweb.clemson.edu/pesticid/Document/Labels/factshee.htm)

7. Pesticide Fact Sheets. Published by Information Ventures, Inc. for BLM , Dept. of Interior; Bonneville Power Administration, U.S. Dept. of Energy; and Forest Service, US Department of Agriculture. (http://infoventures.com/e-hlth/pesticide/pest-fac.html)

8. Pesticide Fact Sheets. National Pesticide Information Center. (http://npic.orst.edu/npicfact.htm)

9. Pesticide Fate Database. US Environmental Protection Agency, Washington, DC. (http://cfpub.epa.gov/pfate/home.cfm).

10. Pesticide product labels and material safety data sheets. Crop Data Management Systems, Inc. (CDMS) (http://www.cdms.net/pfa/LUpdateMsg.asp) or multiple websites maintained by agrichemical companies.

11. Registered Pesticide Products (Oregon database). Oregon Department of Agriculture. (http://www.oda.state.or.us/dbs/pest_products/search.lasso)

12. Regulatory notes. Pest Management Regulatory Agency, Health Canada, Ontario, Canada. (http://www.hc-sc.gc.ca/pmra-arla/)

13. Reptile and Amphibian Toxicology Literature. Canadian Wildlife Service, Environment Canada, Ontario, Canada. (http://www.cws-scf.ec.gc.ca/nwrc-cnrf/ratl/index_e.cfm)

14. Specific Chemical Fact Sheet – New Active Ingredients, Biopesticide Fact Sheet and Registration Fact Sheet. U.S Environmental Protection Agency, Washington, DC. (http://www.epa.gov/pestidides/factsheets/chemical_fs.htm)

15. Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas. The Invasive Species Initiative. The Nature Conservancy. (http://tnsweeds.ucdavis.edu/handbook.html)

16. Wildlife Contaminants Online. US Geological Survey, Department of Interior, Washington, D.C. (http://www.pwrc.usgs.gov/contaminants-online/)

17. One-liner database. 2000. USEPA , Office of Pesticide Programs, Washington, D.C.

Chemical Profile

Date:			
Trade Name(s):		**Common Chemical Name(s):**	
Pesticide Type:		**EPA Registration Number:**	
Pesticide Class:		**CAS Number:**	
Other Ingredients:			

Toxicological Endpoints

Mammalian LD_{50}:	
Mammalian LC_{50}:	
Mammalian Reproduction:	
Avian LD_{50}:	
Avian LC_{50}:	
Avian Reproduction:	
Fish LC_{50}:	
Fish ELS/Life Cycle:	
Other:	

Ecological Incident Reports

Environmental Fate

Water solubility (S_w):	
Soil Mobility (K_{oc}):	

Soil Persistence ($t_{½}$):	
Soil Dissipation (DT_{50}):	
Aquatic Persistence ($t_{½}$):	
Aquatic Dissipation (DT_{50}):	
Potential to Move to Groundwater (GUS score):	
Volatilization (mm Hg):	
Octanol-Water Partition Coefficient (K_{ow}):	
Bioaccumulation/Biocentration:	**BAF:`** **BCF:**

Worst Case Ecological Risk Assessment

Max Application Rate (ai lbs/acre – ae basis)	**Habitat Management:** **Croplands/Facilities Maintenance:**
EECs	**Terrestrial (Habitat Management):** **Terrestrial (Croplands/Facilities Maintenance):** **Aquatic (Habitat Management):** **Aquatic (Croplands/Facilities Maintenance):**

Habitat Management Treatments

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Cropland/Facilities Maintenance Treatments

Presumption of Unacceptable Risk		**Risk Quotient (RQ)**	
		Listed (T&E) Species	**Nonlisted Species**
Acute	Birds	[0.1]	[0.5]
	Mammals	[0.1]	[0.5]
	Fish	[0.05]	[0.5]
Chronic	Birds	[1]	[1]
	Mammals	[1]	[1]
	Fish	[1]	[1]

Justification for Use:	
Specific Best Management Practices	

(BMPs):	
References:	

Table CP.1 Pesticide Name

Trade Name[a]	Treatment Type[b]	Max Product Rate – Single Application (lbs/acre or gal/acre)	Max Product Rate -Single Application (lbs/acre - AI on acid equiv basis)	Max Number of Applications Per Season	Max Product Rate Per Season (lbs/acre/season or gal/acre/season)	Minimum Time Between Applications (Days)

[a]From each label for a pesticide identified in pesticide use proposals (PUPs), Service personnel would record application information associated with possible/known uses on Service lands.
[b]Treatment type: H – habitat management or CF – cropland/facilities maintenance. If a pesticide is labeled for both types of treatments (uses), then record separate data for H and CF applications.

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Appendix F. Endangered Species Act Section 7 Consultation

INTRA-SERVICE SECTION 7 EVALUATIO N FORM
Consultation/Conference/Concurrenc

Reduction of Spotted-winged Midge Emergence with Strike® Pellets (s-methoprene)
Maui National Wildlife Refuge Compl :

Originatio Person:	Mike Nishimoto
	Glynnis Nakai
Telephon : Number:	808 875-1582
Date:	December 3, 2001

I. Region 1: Portland, OR

II. Service Activity:

The Maui National Wildlife Refuge Complex proposes tc reduce emergence of spotted-winged midge larvae (Polypedilum nubifer) at K alia Pond National Wildlife Refuge with Strike® pellets. Adult midges frequently s arm towards lights at nearby condominiums during the winter. Nuisance levels usual occur during a one- or two-month period resulting in complaints by residents. Optic s are limited due to endangered waterbird habitat. Waterbirds are known to f ed on midge larvae. Benthic sampling during the winter suggests that midges are prot ibly the dominant forage species at Kealia Pond. The proposed project is not int ded to eradicate midges, but to reduce larval emergence in portions of the pond whei midges are less accessible to waterbirds (e.g., deep areas of the pond). Important wa rbird feeding areas (within vegetation and along shallow shoreline) will be exclude An area (51 acres) in the center of the pond was identified to represent a conserv ive treatment area based on waterbird census data from the previous eight years. Ho vever, given the results and conclusions of the midge study (Attachment 1) conduct January to March 2001, the Refuge proposes to treat a larger area (approximately 1 1 acres) which will be delineated before application, based on the current wate level in the main pond. The rate of application will be 10 pounds per acre. The tim f treatment will be based on continuous monitoring of larvae and emergence (initiat December 12, 2001), and will target the approaching peak and nuisance level. Str e pellets will be applied by boat using a granular spreader. The initial application s uld be effective for at least 28 days. A second application of Strike® will be cond ed if another midge emergence approaches nuisance levels; however, treatme it will occur only within the conservative area of 51 ac. A second application in a sm aller area would allow us to evaluate impacts of more than one treatment on this wa bird forage species.

III. A. Listed species and/or their critical/essential habitat

1. **Within the action that will be or may be affect d:**

Hawaiian stilt (*Himantopus mexicanus knudseni*) and Hawaiian coot (*Fulica alai)* may be affected.

2. **Within the action area that will not be affected:**

Same as above.

B. Proposed species and/or proposed critical habitat

1. **Within the action that will be or may be affect d:**

There are no proposed species or proposed critic l habitat within the action area.

2. **Within the action area that will not be affect :**

None.

IV. Geographic area or station name and action.

Maui National Wildlife Refuge Complex, Kealia l ond NWR, Maui, Hawaii. Control of Midge Emergence with Strike® Pellet

V. Location (See attached maps):

A. County and State:

Maui County, State of Hawaii.

B. Distance and direction to nearest town:

Maalaea is 1.5 miles southwest of Kealia Pond NWR.

VI. Action Objectives:

1. Reduce midge larval emergence below nuisance de ities.

VII. Explanation of impacts of action:

Application and monitoring activities may disturb Hawai n coots and Hawaiian stilts. Multiple applications of Strike may reduce midge larvae elow optimal waterbird foraging densities within the conservative 51 acre treatm nt area (center of the pond).

VIII. Effect determination and response requested:

A. Listed species/critical/essential habitat:

Determination	**Response Requested**
____ will not affect	____ concurrence
____ beneficial affect	____ concurrence
	____ formal consultation
_x_ is not likely to adversely affect	_x_ concurrence
	____ formal consultation
____ is likely to adversely affect	____ formal consultation

B. Proposed species/proposed critical habitat: N/A

Determination	**Response Requested**
____ will not affect	____ concurrence
____ beneficial affect	____ concurrence
____ is not likely to adversely affect	____ concurrence
____ is likely to adversely affect	____ formal consultation
____ is likely to jeopardize/adverse modification of critical habitat	conference

REMARKS:

A study was conducted during the 2000-2001 midge season by qualified researchers from Michigan State University, Loyola University Chicago, and University of Florida. A summary of the study results of their study on the efficacy of two larvicides (Bacillus thuringiensis var. israelensis and s-methoprene) on spotted-winged midges and non-target Chironomus (native midge) is included (Attachment 1). Research during this midge season (December 2001-April 2002) is a continuation of last season's study and will hopefully provide a better understanding of the spotted-winged midges' life cycle, association with abiotic factors and distribution within the pond.

Strike® is being proposed as one component of an integrated pest management plan and is intended as a short-term solution for addressing the midge swarming issue. Long-term solutions are being sought by expanding the biological/ecological knowledge through research and monitoring programs: ground and surface water monitoring; water quality/chemistry analyses; soil analyses; fish population dynamics and biological/ecological role and requirements;

invertebrate composition, seasonal occurrence, and distribution; wat bird ecology and biology; and habitat restoration to provide alternative foraging and nesting ha itat for endangered waterbirds. Habitat manipulation and water level/quality managemer are currently being examined for long-term solutions.

Glynnis J Nakai
Refuge Manager
Maui National Wildlife Refuge Complex

12/07/01
Date

Comments:

Jerry F. Leinecke
Project Leader
Hawaii/Pacific Islands NWR Complex

12/11/01
Date

IX. Reviewing ESO Evaluation:

A. Concurrence X Nonconcurrence ____

B. Formal consultation required ____

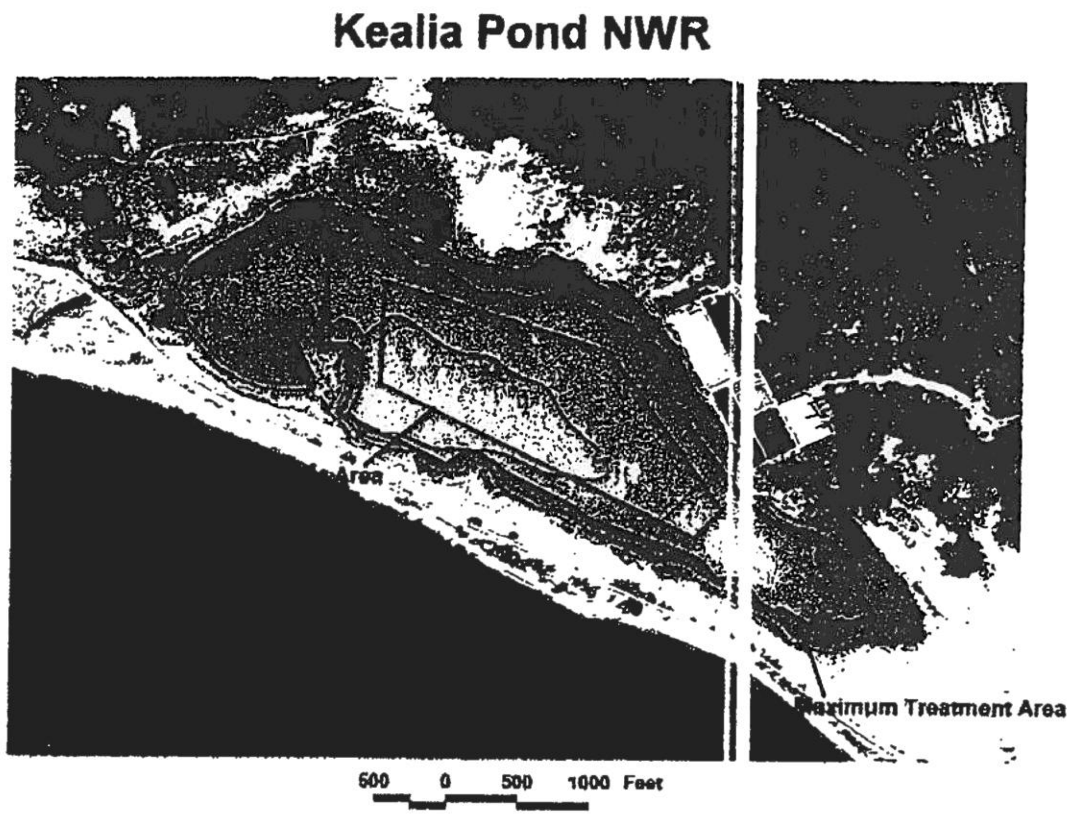
C. Conference required ____

D. Informal conference required ____

E. Remarks

Field Supervisor
Ecological Services, Pacific Islands Office

1/2/02
Date


Kealia Pond NWR
Area
Maximum Treatment Area
600 0 500 1000 Feet

COPY

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

In Reply Refer To: MSR

MEMORANDUM

To: Glynnis Nakai, Refuge Manager, Maui NWR Complex, Kihei, Hawaii

cc: Jerry Leinecke, Project Leader, HI/Pacific Islands NWRC, Honolulu, Hawaii

From: Paul Henson, Field Supervisor, Ecological Services, U.S. Fish and Wildlife Service, Honolulu, Hawaii

Subject: Section 7 Consultation to test Strike product (methoprene) for control of introduced spotted-winged midges (*Polypedilum nubiferum*) at Kealia Pond NWR, Maui

This acknowledges the U.S. Fish and Wildlife Service's (Service) November 14, 2000, receipt of your November 7, 2000, letter requesting our biological opinion under section 7 of the U.S. Endangered Species Act of 1973 [16 U.S.C. 1531 et seq.; 87 Stat. 884], as amended (Act) regarding the proposed *Polypedilum* midge larvae control program at Kealia Pond National Wildlife Refuge, Kihei, Maui. At issue are the possible effects of the proposed use of Strike product (methoprene) an insect growth regulator insecticide, on the federally endangered Hawaiian stilt (*Himantopus mexicanus knudseni*) and Hawaiian coot (*Fulica alai*), and on endemic and native insects including *Chironomus hawaiiensis* (Chironomidae) and *Scatella* spp. flies (Ephydridae). With the intent to avoid adverse impacts to the aforementioned animals, your letter stated that the Refuge staff will restrict experimental treatment of the insecticide to areas of the pond within 800 meters of the condominiums and outside of waterbird feeding areas.

As your letter and supporting documents acknowledge, the methoprene product proposed for experimental use in Kealia Pond could effectively minimize the extent of *Polypedilum* midge emergence without direct physiological impacts to any endangered birds present at the refuge. However, our office believes methoprene may lack sufficient specificity to avoid and minimize impacts to non-target invertebrates present in the pond at the time of treatment. Therefore, we recommend only experimental testing of methoprene in this situation until the exact effects upon the native invertebrates can be determined. Because our office finds that the proposed midge larvae control program at Kealia Pond National Wildlife Refuge, as described, will not likely adversely affect the endangered Hawaiian stilt and coot, no biological opinion will be prepared at this time.

Page 2: Section 7 Consultation to test Strike product (methoprene) for control of introduced spotted-winged midges (*Polypedilum nubiferum*) at Kealia Pond NWR, Maui

It is widely accepted that invertebrates including the *Polypedilum* midge are an important food source for both the Hawaiian stilt and coot. Due to this importance of invertebrates as a food source and the uncertainty concerning methoprene's effect on native invertebrates, we can only give approval to test methoprene for a one-time seasonal trial period to take place during the winter 2000/2001 midge swarming season. Furthermore, we require as a stipulation, that the Kealia Pond Refuge hire an entomologist to conduct surveys of the pond's invertebrate fauna before and after the treatment for the purpose of more completely cataloguing the potential existing native fauna and assessing whether the treatment program adversely impacts non-target invertebrates. Entomologists specializing in midge control with whom we have recently consulted recommend that surveys investigating non-target impacts of either *Bacillus thuringensis* (BT) or methoprene be conducted approximately one and two weeks after application.

Our office believes the proposed midge larvae control program is a temporary control measure, and we recommend that the Kealia Pond Refuge staff continue to examine habitat manipulation and water level management strategies. Reducing nutrient input into the pond ecosystem could provide a longer term and cost-effective solution to the midge problem while still benefitting and enhancing the native fish and wildlife at the refuge.

We believe that the requirements of section 7 of the Act are satisfied for the application to take place in the 2000/2001 midge season. However, obligations under section 7 of the Act must be reconsidered if (1) new information reveals impacts of the defined action that may affect listed species or critical habitat in a manner that was not previously considered; (2) this action is subsequently modified in a manner not previously considered in this assessment; or (3) a new species is listed or critical habitat determined that may be affected by the identified action.

We appreciate the opportunity to work with the Kealia Pond Refuge staff to avoid adverse impacts to endangered, threatened, and native Hawaiian species. If you have any questions or concerns about this consultation or the consultation process in general, please contact either Vertebrate Listing and Recovery Program Leader Marilet Zablan or entomologist Mike Richardson, at phone: (808) 541-3441; fax: (808) 541-3470.

INTRA-SERVICE SECTION 7 EVALUATION FORM
Consultation/Conference/Concurrence

Effects of "Strike" (Methoprene) on Midges and Non-target Species
Maui National Wildlife Refuge Complex

Originating Person: Mike Nishimoto
Telephone Number: 808-875-1582
Date: January 18, 2000 (Rev. 10/13/00)

I. **Region 1: Portland, Oregon**

II. The Maui National Wildlife Refuge Complex proposes to conduct a study to evaluate the effectiveness of the methoprene-based product, Strike, on spotted-winged midge larve on the east side of Kealia Pond. Adult midges frequently swarm towards lights in nearby condominiums during the winter. Nuisance levels usually occur during a one or two month period resulting in complaints by residents. Options are limited due to endangered waterbird habitat. Waterbirds are known to feed on midge larvae. Benthic sampling during the winter suggests that midges are probably the dominant forage species at Kealia Pond. The proposed project is not intended to eradicate midges, but to evaluate the effectiveness of experimental treatment on larval emergence in portions of the pond where midges are less accessible to waterbirds and are close to condominiums. Primary waterbird feeding areas will be excluded from this experimental treatment. We propose to treat areas within 800 meters of the condominiums, which is consistent with development guidelines recommended in Australia (Pinder, et al. 1991:127). Treatment will occur when midge numbers approach nuisance levels. The study protocol will be designed by qualified entomologists and approved by the Fish and Wildlife Service, and will involve applications at established intervals for a period of one or two months. The refuge recommends an initial limit of five 20 X 20 meter plots, but will allow more if a larger sample size is necessary. The primary questions of effectiveness on midge emergence and effects on non-target invertebrate species must be answered before considering a shift from this localized research project to a more aggressive midge control program.

III. A. **Listed species and/or their critical/essential habitat**

1. **Within the action that will be or may be affected:**

Hawaiian stilt (*Himantopus mexicanus knudseni*) and Hawaiian coot (*Fulica alai*) may be affected.

2. Within the action area that will not be affected:

Same as above.

B. Proposed species and/or proposed critical habitat

1. Within the action that will be or may be affected:

There are no proposed species or proposed critical habitat within the action area.

2. Within the action area that will not be affected:

None

IV. Geographic area or station name and action.

Maui National Wildlife Refuge Complex, Maui, Hawai'i
Effects of "Strike" (Methoprene) on Midges and Non-target Species

V. Location (See attached maps):

A. County and State:

Maui County, State of Hawai'i

B. Distance and direction to nearest town:

Ma'alaea is 1.5 miles southwest of Kealia Pond NWR

VI. Action Objectives:

1. To test methods to reduce midge larval emergence below nuisance densities.

VII. Explanation of impacts of action:

We request a biological opinion on the proposed action.

VIII. Effect determination and response requested:

A. Listed species/critical/essential habitat:

Determination	Response Requested
_____ will not affect	_____ concurrence
_____ beneficial affect	_____ concurrence

		X	formal consultation
____	is not likely to adversely affect	____	concurrence
		____	formal consultation
____	is likely to adversely affect	____	formal consultation

B. Proposed species/proposed critical habitat:

	Determination		Response Requested
____	will not affect	____	concurrence
____	beneficial affect	____	concurrence
____	is not likely to adversely affect	____	concurrence
____	is likely to adversely affect	____	formal consultation
____	is likely to jeopardize/adverse modification of critical habitat		conference

REMARKS:

The methoprene product, Strike, is being proposed as one component of an Integrated Pest Management Plan. Habitat manipulation and water level management are currently being examined.

Glynnis J Nakai ____ 11/30/00
Refuge Manager ____ Date
Maui National Wildlife Refuge Complex

Comments:

Jerry F Leinecke ____ 11/30/00
Project Leader ____ Date
Hawaii/Pacific Islands NWR Complex

IX. Reviewing ESO Evaluation:

A. Concurrence X Nonconcurrence _______

B. Formal consultation required _______

C. Conference required ______

D. Informal conference required ______

E. Remarks

Paul Henson

Field Supervisor
Ecological Services, Pacific Islands Office

11/28/00

Date

Appendix G. WILDLAND FIRE MANAGEMENT PLAN

KEĀLIA POND NATIONAL WILDLIFE REFUGE

Kīhei, Maui, Hawai‘i

2004

2004 WILDLAND FIRE MANAGEMENT PLAN

KEĀLIA POND NATIONAL WILDLIFE REFUGE

Prepared: Glynnis L. Nakai — 9/23/04
Glynnis L. Nakai, Refuge Manager — Date
Maui National Wildlife Refuge Complex

Concurred: Jerry F. Leinecke — 9/24/04
Jerry Leinecke, Project Leader — Date
Hawaiian and Pacific Islands National Wildlife Refuge Complex

Concurred: Pamela Ensley — 9/27/04
Pamela Ensley, Regional Fire Management Coordinator — Date
Pacific Region, U.S. Fish and Wildlife Service

Approved: David B. Allen — 9/30/04
David B. Allen, Regional Director — Date
Pacific Region, U.S. Fish and Wildlife Service

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INTRODUCTION

This document will establish a Fire Management Plan for Keālia Pond National Wildlife Refuge (NWR), of the Maui NWR Complex. This plan will meet the requirements of the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA). Compliance with NEPA was met through a Categorical Exclusion and associated Environmental Action Statement (Appendix D). For ESA Section 7 compliance, informal consultation with Ecological Services led to May Affect, Not Likely to Adversely Affect determination (Appendix E). Compliance with the NHPA will be accomplished at the project level through submission of a Request for Cultural Resources Compliance form (Appendix F) to the Regional Archaeologist.

This plan is written as an operational guide for managing the refuge's wildland fire and prescribed fire programs. It defines levels of protection needed to provide for safety, protect facilities and resources, and restore and perpetuate natural processes, given current understanding of the complex relationships in natural ecosystems. It is written to comply with a service-wide requirement that refuges with burnable vegetation develop a fire management plan (620 DM 1).

This plan will outline a program of suppression of all wildland fires and pile burning (as a limited form of prescribed fire). These piles will be generated from habitat enhancement and maintenance activities covered within the refuge’s ESA documentation.

There is no dedicated fire management staff on the refuge. Fire Management oversight is provided by the Regional Office located in Portland. Day-to-day fire management responsibilities are provided by the Refuge Manager located onsite. Suppression of wildland and structural fires on the refuge will be provided by Maui County Fire Department, Kahului Station, based on County of Maui emergency policy.

COMPLIANCE WITH USFWS POLICY

Keālia Pond National Wildlife Refuge was established in 1992 to provide nesting and maintenance habitat for three native Hawaiian endangered waterbirds as well as migratory waterfowl and shorebirds. The endangered waterbirds include Hawaiian stilt (*Himantopus mexicanus knudseni*), Hawaiian coot (*Fulica alai*), and Hawaiian duck (*Anas wyvilliana*).

This plan meets NEPA / NHPA compliance and will be implemented in cooperation with the Endangered Species Act of 1973, as amended, and will take appropriate action to identify and protect from adverse effects on any rare, threatened, or endangered species. Compliance with NEPA was met through a Categorical Exclusion and associated Environmental Action Statement (Appendix D). For ESA Section 7 compliance, informal consultation with Ecological Services led to a "May Affect, Not Likely to Adversely Affect" determination (Appendix E). Compliance with the NHPA will be accomplished at the project level through submission of a Request for Cultural Resources Compliance form (Appendix F) to the Regional Archaeologist.

At this time, no Master Plan or Comprehensive Conservation Plan (CCP) exists for the Refuge. Development of a CCP for the entire complex is scheduled to begin in 2006. An interim Management Plan for Keālia Pond National Wildlife Refuge was developed in 2001 (U.S. Fish and Wildlife Service 2001) that identified the goals of the Refuge, objectives supporting those goals, and strategies addressing each objective. The Refuge purpose and goals can be found in the Maui National Wildlife Refuge Complex's Refuge Management Information System, and are as follows:

REFUGE PURPOSE

- "to conserve (A) fish or wildlife which are listed as endangered species or threatened species...or (B) plants." 16 U.S.C. § 1534 (Endangered Species Act of 1973).

REFUGE GOALS

- **Endangered Species:** Promote the conservation of endangered species, especially native Hawaiian coot and Hawaiian stilt through healthy functioning of this wetland floodplain.

- **Habitat:** Optimize water levels for maximum habitat size and value for endangered, resident, and migrating waterfowl and shorebirds while reducing the growth and reproduction of problematical exotic species.

- **Visitor Use:** Expand understanding and appreciation of the environment through wildlife-oriented educational opportunities. Provide opportunities for quality, wildlife-dependent recreation, education, and research to enhance public appreciation, understanding, and enjoyment of refuge wildlife and habitats.

- **Habitat Restoration:** Restore and maintain the diversity and abundance of native species naturally occurring on the Refuge.

Authority and guidance for implementing this plan are found in:

- Protection Act of September 20, 1922 (42 Stat. 857; 16 U.S.C.594): authorizes the Secretary of the Interior to protect from fire, lands under the jurisdiction of the Department directly or in cooperation with other Federal agencies, states, or owners of timber.
- Economy Act of June 30, 1932: authorizes contracts for services with other Federal agencies.
- Reciprocal Fire Protection Act of May 27, 1955 (69 Stat. 66, 67; 42 U.S.C. 1856, 1856a and b): authorizes reciprocal fire protection agreements with any fire organization for mutual aid with or

without reimbursement and allows for emergency assistance in the vicinity of agency lands in suppressing fires when no agreement exists.
- Disaster Relief Act of May 22, 1974 (88 Stat. 143; 42 U.S.C. 5121): authorizes Federal agencies to assist state and local governments during emergency or major disaster by direction of the President.
- National Wildlife Refuge System Administrative Act of 1966 as amended by the National Wildlife Refuge System Improvement Act of 1997, 16 U.S.C. 668dd et seq.: defines the National Wildlife Refuge System as including wildlife refuges, areas for the protection and conservation of fish and wildlife which are threatened with extinction, wildlife ranges, game ranges, wildlife management areas and waterfowl production areas. It also establishes a conservation mission for the Refuge System, defines guiding principles and directs the Secretary of the Interior to ensure that biological integrity and environmental health of the system are maintained and that growth of the system supports the mission.
- Federal Fire Prevention and Control Act of October 29, 1974 (88 Stat. 1535; 15 U.S.C.2201): provides for reimbursement to state or local fire services for costs of firefighting on federal property.
- Wildfire Suppression Assistance Act of 1989. (Pub.L. 100-428, as amended by Pub.L 101- 11, April 7, 1989).
- Departmental Manual (Interior), Part 620 DM, Chapter 1, Wildland Fire Management: General Policy and Procedures (April 10, 1998): defines Department of Interior fire management policies.
- Service Manual, Part 621, Fire Management (February 7, 2000): defines U.S. Fish and Wildlife Service fire management policies.
- National Environmental Policy Act of 1969: regulations implementing the National Environmental Policy Act (NEPA) encourages the combination of environmental comments with other agency documents to reduce duplication and paperwork (40 CFR 1500.4(o) and 1506.4).
- Clean Air Act (42 United State Code (USO) 7401 et seq.): requires states to attain and maintain the national ambient air quality standards adopted to protect health and welfare. This encourages states to implement smoke management programs to mitigate the public health and welfare impacts of Wildland and prescribed fires managed for resource benefit.
- Endangered Species Act of 1973.
- U.S. Fish & Wildlife Service Fire Management Handbook.

The authority for funding (normal fire year programming) and all emergency fire accounts is found in the following authorities:
- Section 102 of the General Provisions of the Department of Interior's annual Appropriations Bill provides the authority under which appropriated monies can be expended or transferred to fund expenditures arising from the emergency prevention and suppression of wildland fire.
- P.L. 101-121, Department of the Interior and Related Agencies Appropriation Act of 1990, established the funding mechanism for normal year expenditures of funds for fire management purposes.
- 31 US Code 665(E)(1)(B) provides the authority to exceed appropriations due to wildland fire management activities involving the safety of human life and protection of property.

Authorities for procurement and administrative activities necessary to support wildland fire suppression missions are contained in the Interagency Fire Business Management Handbook.

FIRE MANAGEMENT OBJECTIVES

The overall objective for fire management on Keālia Pond NWR is to promote a program to provide for firefighter and public safety, reduce the incidence of human-caused fires, and ensure appropriate suppression response capability to meet expected wildland fire complexity. Wildland fire potential exists on the refuge due to the proximity to sugar cane operations along the north side of the refuge and beach sites along Ma'alaea Flats. Specific fire management objectives are:

- Promote a fire management program and control all wildland fires.
- Provide for the protection of life, property, and resources from wildland fires at costs commensurate with resource values at risk.
- Use appropriate suppression tactics and strategies that minimize long-term impacts of suppression actions.
- Use pile burning to safely and efficiently remove debris from resource management activities and reduce hazardous fuels.

DESCRIPTION OF REFUGE

GENERAL DESCRIPTION

Keālia Pond National Wildlife Refuge is located adjacent to Ma'alaea Bay, along the south central coast on the Island of Maui, Hawai'i (Figure 1). The 700-acre refuge is a naturally formed wetland within the isthmus separating the West Maui Mountains and Haleakala. The property is bisected by North Kihei Road (Highway 31), separating the main pond from the coastal dune and mudflats habitat. The nearest community, Kihei, is located southeast of the refuge boundary.

The refuge is comprised of approximately 200 acres of open water (Keālia Pond proper), 350 acres of mudflats and 200 acres of scrub-shrub and upland habitats bordering the wetlands. In 1970, aquaculture ponds (25 acres) were constructed at the north side of the main pond where the refuge office is located. The aquaculture operation terminated in 1995 and the ponds (Kanuimanu Ponds) are now managed for waterbird and visitor use.

CLIMATE

The refuge receives five to 20 inches of rain annually. Mean monthly rainfall averages less than five inches. Mean maximum daily temperatures are in the high 70s and 80s (°F). The average annual temperature is approximately 74°F with August to October having the warmest months of the year. Warmest weather occurs with "Kona" weather. Seasonal and diurnal variability in cloud cover occur with clouds tending to be more abundant during the day. Average daily relative humidity ranges from 65% to 90%.

VEGETATION

The vegetative communities of the refuge vary from wetland to upland habitats. Vegetation is primarily non-native, invasive plants which have formed large, monotypic stands. Mudflats are predominantly pickleweed (*Batis maritima*), which forms dense, tall mats of old growth. Moist soil areas along the dikes have dense coverage of Indian marsh fleabane (*Pluchea indica*), and upland areas along the north boundary consist of kiawe or mesquite (*Prosopis pallida*), common ironwood (*Casuarina equisetifolia*), Australian saltbush (*Atriplex semibaccata*), castor bean (*Ricinus communis*), koa haole (*Leucaena leucocephala*), and various grasses (*Brachiaria mutica, Cenchrus ciliaris, Cynodon dactylon*, and *Leptochloa uninervia*). Large stands of American mangrove (*Rhizophora mangle*) and California bulrush (*Schoenoplectus californicus*) occur along the eastern edge of the wetland. The weather conditions on Maui promotes year-round growing season resulting in dense understory in most areas.

FISH AND WILDLIFE

Keālia Pond NWR was established to protect and manage endangered waterbird populations (Hawaiian stilt and Hawaiian coot) and their habitats. The pond is one of the last natural wetlands remaining within the Hawaiian islands and is also host to more than 20 species of migratory waterfowl, including Northern shoveler (*Anas clypeata*), Northern pintail (*Anas acuta*), scaup (*Aythya* spp.), and American wigeon (*Anas americana*), and shorebirds including wandering tattler (*Heteroscelus incanus*), sanderling (*Calidris alba*), and ruddy turnstone (*Arenaria interpres*). The Refuge also contains populations of other native species including black-crowned night heron (*Nycticorax nycticorax*) and short-eared owl or pueo (*Asio flammeus sandwichensis*), and non-native cattle egrets (*Bubulcus ibis*). Numerous non-native passerines are present within the upland habitat, including spotted doves (*Streptopelia chinensis*), zebra doves (*Geopelia striata*), common myna (*Acridotheres tristis*), Northern cardinal (*Cardinalis cardinalis*), house finch (*Carpodacus mexicanus*), orange-cheeked waxbill (*Estrilda melpoda*), and gray francolin (*Francolinus pondicerianus*).

Fish population consists of predominantly introduced tilapia (*Tilapia* spp.), and mosquito fish (*Gambusia* sp.). Mammals found on the refuge are all non-native and include black rat (*Rattus rattus*), Norwegian rat, feral cats, and mongoose, all of which are controlled to protect endangered waterbirds.

THREATENED AND ENDANGERED SPECIES

Endangered waterbirds at Keālia Pond NWR include the Hawaiian stilt, Hawaiian coot, and historically, the Hawaiian duck. The latter species has hybridized with local mallards (non-migratory) resulting in physical characteristics that are difficult to distinguish; therefore, it is possible the pure species is present but not nesting on the refuge. Depending upon water levels Hawaiian stilts and coots use a majority of the main pond and mudflats. Hawaiian stilts are limited to shallow water (approximately seven inches or less) and nest (April through August) on the ground adjacent to water and vegetation. Hawaiian coots prefer deeper water (18 inches or less) for nesting (December through March/April) but are also present in shallow water along the water's edge. The critical period for both waterbirds is from December through August during their breeding season.

The endangered hawksbill sea turtle (*Eretmochelys imbricata*) is known to nest on the adjacent Keālia Beach, but is not found on the refuge. Nesting season occurs from May through September/October.

A majority of the vegetation present on the refuge is non-native, invasive species; there is no threatened or endangered plant species recorded. The refuge does not contain designated Critical Habitat or portions thereof, does not possess any areas designated as Critical Habitat.

Table 1. Threatened and Endangered Species Found at Keālia Pond NWR.

Common Name	Scientific Name	Federal Status
Hawaiian Duck	*Anas wyvilliana*	Endangered
Hawaiian Coot	*Fulica alai*	Endangered
Hawaiian Stilt	*Himantopus mexicanus knudseni*	Endangered
Hawksbill Sea Turtle*	*Eretmochelys imbricata**	Endangered

* Nests on adjacent Keālia Beach, but not found on the refuge.

CULTURAL RESOURCES

The Service has not conducted a comprehensive archaeological survey on the refuge; however, small sites have been surveyed and evaluated by the State Historic Preservation Office prior to construction of visitor service facilities (Keālia Coastal Boardwalk) and an area adjacent to the entrance road off Mokulele Highway. Other site-specific surveys will be conducted prior to any land-altering activities on the refuge.

As well as being an important source of salt, Keālia Pond was once used as a fish pond. About 400 years ago, the people living around the bay built ditches and sluice gates through the coastal dune, allowing nearshore fish into the pond. A rock platform near the refuge may once have been a heiau or fishing shrine.

During World War II, 5000 soldiers of the 2nd and 4th Marine Divisions used the area as a training site. Remnants of a firing range and airstrip lie just outside the refuge boundary. In 1943 and 1944, in preparation for the Marianas campaign, amphibious landings using LSTs were practiced on the refuge beachfront and mudflats.

PHYSICAL RESOURCES

Elevation of Keālia Pond National Wildlife Refuge ranges from sea level to 10 feet. The soils are poorly-drained and have a high salt content. A majority of the soil has been characterized as a Keālia silt loam and contains relatively high salt content. During periods of heavy rain and surface runoff, ponding occurs in many areas. When dry, salt crystals accumulate on the surface. Soil profiles indicate a dark reddish-brown silt loam in the top three inches and stratified layers of silt loam, loam, and fine sandy loam below. Mean annual soil temperature is approximately 75°F.

Wind conditions on the refuge are relatively constant. Due to the refuge's location between the mountains, a vortex and funneling occurs with trade winds typically blowing from the northeast side of the island. South winds ("Kona") occur periodically throughout the year. Wind speed ranges from eight to 12 knots (9-14 miles per hour), typically less in the early morning hours.

The topography of the entire refuge ranges from sea level to no more than ten feet elevation that acts as a settling basin for approximately 56-square miles of the West Maui Mountains. Water from this watershed sheetflows into the refuge from three streams: Pohakea, Paleaahu, and Waikapu. Two streams, Pulehu and Kolalau, enter the refuge from Haleakala; however, streamflow is infrequent (one to two times per year). All these streams are diverted into reservoirs or ditches for agricultural purposes (primarily sugar cane which is adjacent to the refuge's northern boundary). The typical hydrology of the refuge is characterized by high water conditions (maximum 4.8 feet above sea level) during winter months (November-March) and shallow water during summer, with lowest water levels in September-October. In most years, supplemental pumping of water is performed beginning in August to provide shallow water feeding conditions for waterbirds and minimize wind blown sediment to the adjacent community.

STRUCTURES AND FACILITIES

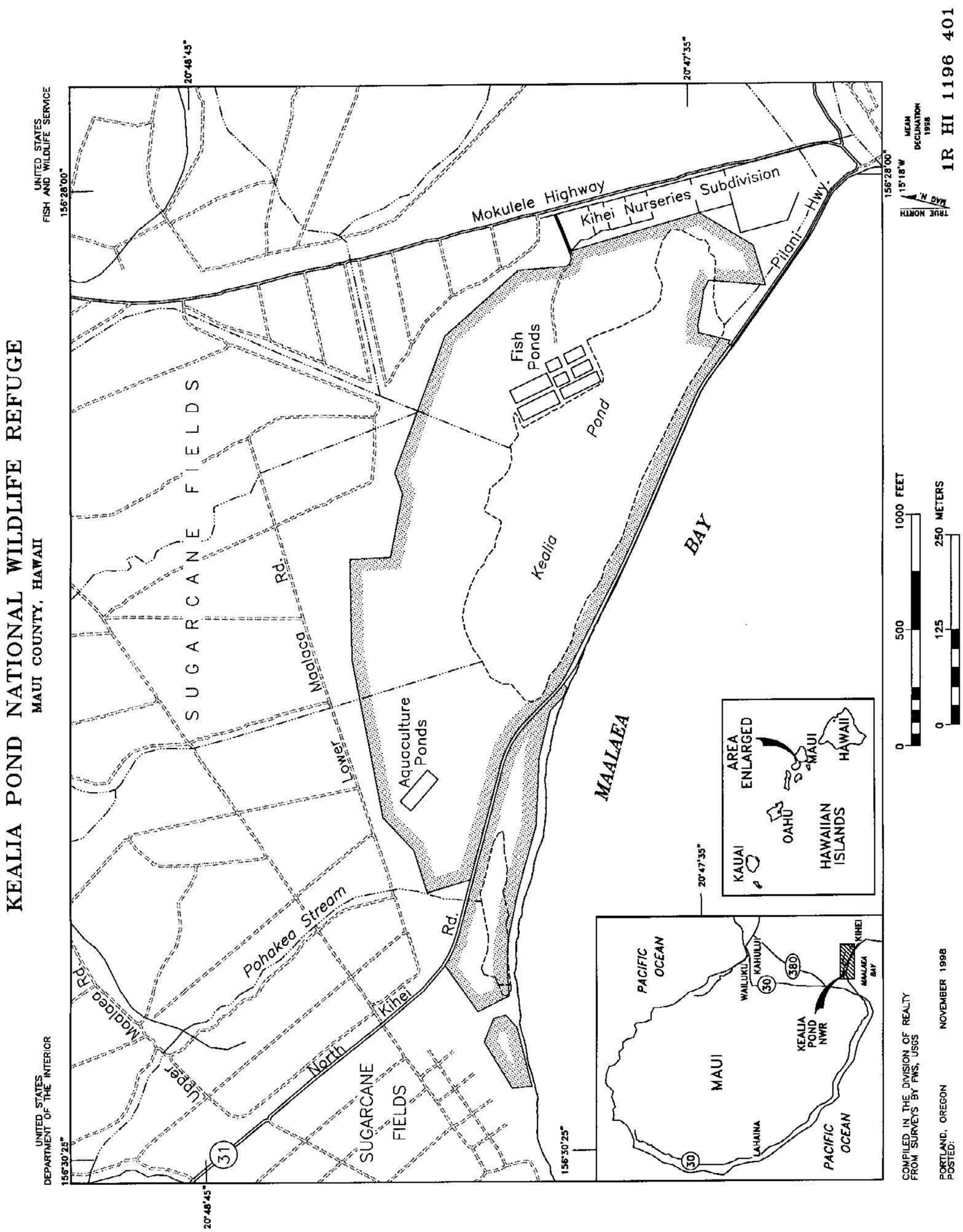
The Refuge Headquarters is situated on the north side of the Kanuimanu ponds and consists of an elevated, double-wide (56 ft x 38 ft) trailer building. Above-ground holding tanks are located under the building. The maintenance area is located off Mokulele Highway (Highway 311) approximately 0.2 mile along the entrance road. This area contains metal storage containers (2 at 30 ft x 12 ft and one at 50 ft x 12 ft) and parking area for Refuge vehicles (5) and equipment (bobcat, tractor, portable pump, 14-ft boat and trailer). A greenhouse is located across the maintenance area.

Structures are also located at the old baitfish ponds on the northeast side of the refuge and include one metal container for storage, one wooden building for environmental education, and one aluminum storage shed. Other facilities on the Refuge include three pumps with miscellaneous valves on groundwater wells, two of which have wooden roofs, various water distribution pipes (PVC and transite), and recycled materials for fencing (installed at Ma'alaea Flats and stored at Baitfish pond site). The public use areas include the refuge office and a 2,200 feet elevated boardwalk. The latter facility is located at Ma'alaea Flats on the south side of North Kihei Road (Highway 31).

PUBLIC USE AND ACCESS

A majority of the Refuge is inaccessible for vehicles due to the flooded and/or moist soil conditions. Vehicle use and the general public are limited to levees of the Kanuimanu Ponds. Hiking is allowed on designated trails. Hunting, fishing, camping, and off-road vehicles are prohibited at all times.

Figure 1. Keālia Pond National Wildlife Refuge.



WILDLAND FIRE MANAGEMENT SITUATION

HISTORIC ROLE OF FIRE

Historic natural fires on Maui have been limited to volcanic eruptions and lightning and are very infrequent. In general the native vegetation is not well adapted to fire disturbances. Non-native (invasive) species typically colonize burned areas to the exclusion of native species.

Pre-settlement Fires

There is no clear indication that fire was an integral part of the native ecosystem. There are no records indicating fire frequency prior to settlement, although rare fire events likely occurred as a result of volcanic activity and lightning.

Post-settlement Fire History

In the 10 year history of the refuge there have been four known wildland fires. Three of these fires were due to sugar cane operations adjacent to the refuge and one was the result of beach activity. The largest of the four known fires was 47 acres in September of 2001; the fire was caused by an escaped cane burn. All fires required assistance from Maui County. Throughout the state, fire season is considered by the Hawaii Department of Forestry and Wildlife (DOFAW) to occur during a three-month period in late summer. However, given the extreme variability of weather in Hawaii, fires may occur at any time during the year. There is no clearly-defined fire season for the refuge.

Prescribed Fire History

There is no history of prescribed fire use on the refuge. Prescribed burns (piles) will only be performed in September when endangered waterbirds are not breeding and before the influx of migratory shorebirds and waterfowl.

RESPONSIBILITIES

Keālia Pond NWR does not have a dedicated fire management organization. The Project Leader and Refuge Manager are responsible for planning and implementing the fire management program on the Refuge. Staff from the Regional Office in Portland will act as the Zone Fire Management Officer (FMO), and are responsible for fire management program oversight. The Project Leader will assign fire management responsibilities as collateral duties to staff who possess appropriate training, experience, and incident qualifications. Preparedness planning and work is accomplished by Refuge staff in accordance with national and regional fire management direction under guidance from the Regional Office. Emergency fire management actions will be handled by Refuge staff according to training and incident qualifications. The Regional Office will be immediately notified of all emergency actions. Additional information and direction is included in the Fire Dispatch Plan (Appendix C).

Refuge Manager

- Is responsible for implementation of all fire management activities within the Refuge and will ensure compliance with Department and Service policies.
- Selects the appropriate management responses to wildland fires.
- Approves any Pile Burn Plan.
- Coordinates Complex programs to ensure personnel and equipment are made available and utilized for fire management activities.
- Ensures that the fire management program is considered during refuge-related planning and project implementation.
- Acts as the primary Resource Advisor during fire management planning and operations.
- Coordinates with cooperators to ensure adequate resources are available for fire operational needs.

Biologist

- Coordinates through Project Leader to provide biological input for the fire program.
- Participates, as requested in fire suppression and rehabilitation projects according to level of training and qualifications.
- May act as primary Refuge Resource Advisor for the Project Leader.
-

Zone Fire Management Officer

- Responsible for all fire-related planning for the Refuge.
- Solicits program input from the Project Leader and Biologist.
- Coordinates fire related training.
- Coordinates with cooperators to ensure adequate resources are available for fire operational needs.
- Is responsible for preparation of fire reports following the suppression of wildland fires.
- Prepares an annual report detailing fire activities undertaken in each calendar year. This report will serve as a post-year's fire management activities review, as well as provide documentation for development of a comprehensive fire history record for the Complex.
- Submits budget requests and monitors FIREBASE funds.
- Maintains records for all personnel involved in related activities, detailing each individual's qualifications and certifications for such activities.

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Incident Commander

Incident Commanders (ICs) of any level use strategies and tactics as directed by the Project Leader and WFSA where applicable to implement selected objectives on a particular incident. A specific Limited Delegation of Authority (Appendix I) will be provided to each Incident Commander prior to assuming responsibility for an incident. Major duties of the Incident Commander are given in the National Wildfire Coordinating Group (NWCG) Fireline Handbook, including:

- Brief subordinates, direct their actions, and provide work tools.
- Ensure that safety standards identified in the Fire Orders, the Watch Out Situations, and agency policies are followed at all times.
- Personally scout and communicate with others to be knowledgeable of fire conditions, fire weather, tactical progress, safety concerns and hazards, condition of personnel, and needs for additional resources.
- Order resources to implement the management objectives for the fire.
- Inform appropriate dispatch of current situation and expected needs.
- Coordinate mobilization and demobilization with dispatch and the Zone FMO.
- Perform administrative duties, i.e., approving work hours, completing fire reports for command period, maintaining property accountability, providing or obtaining medical treatment, and evaluating performance of subordinates.
- Assure aviation safety is maintained to the highest standards.

Resource Advisor

The Resource Advisor (RA) is a technical specialist appointed by the Agency Administrator and reports to the IC or designee and provides guidance for natural and cultural resource protection from suppression operations. The RA provides input to the IC in the development of fire suppression strategies and tactics to minimize or mitigate the expected impacts of fire and fire and fire suppression actions upon natural and cultural resources. The RA also provides input required for the development of rehabilitation plans. Resource Advisor responsibilities include (NWCG 1996):

- Provides analysis, information, and advice to fire managers for areas of concern, including critical watersheds, riparian areas, fisheries, and water sources; threatened or endangered species;

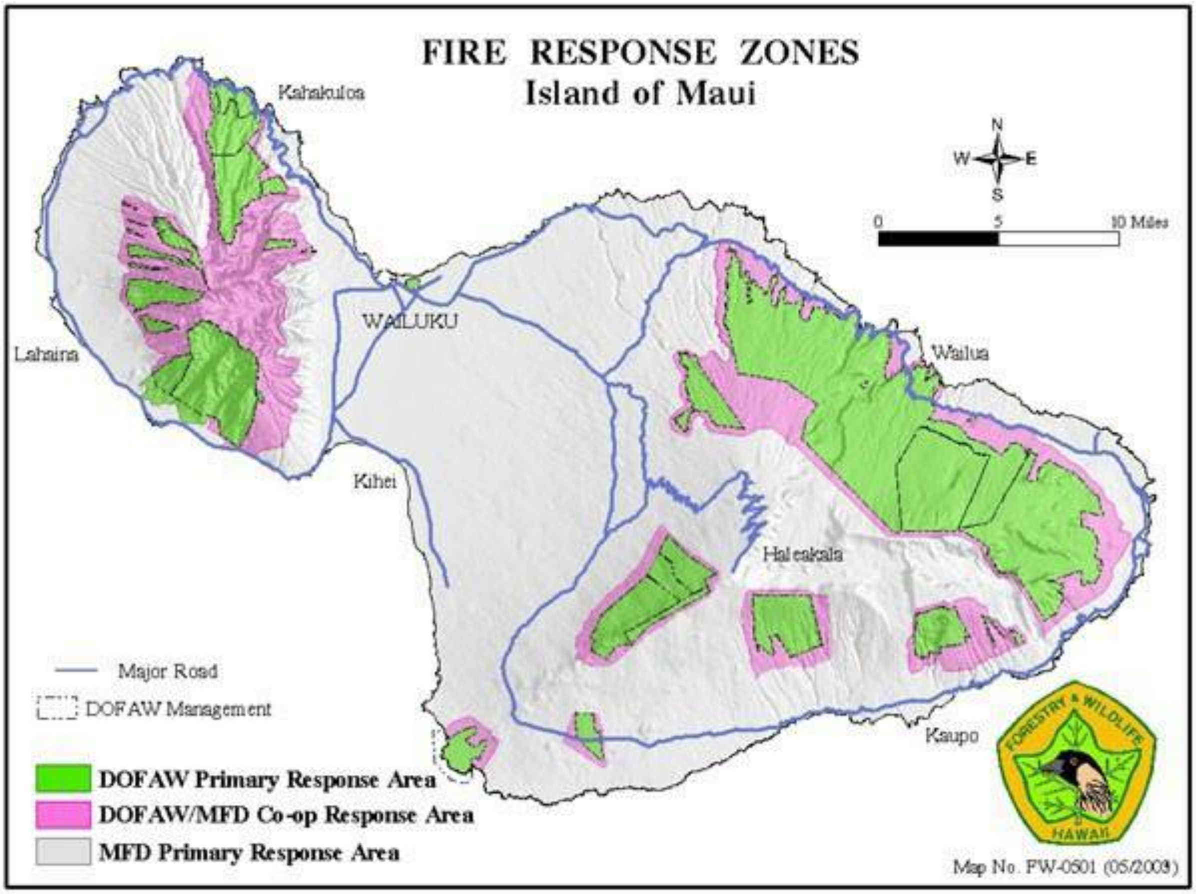
- prehistoric and historic archaeological sites and cultural landscapes; fuel breaks B locations and specifications; urban interface impact B structures and improvements; and hazardous materials
- Assists the planning function in developing fire maps and identifying areas of concern
- Determines environmental restrictions commensurate with FMP resource protection in the fire area
- Provides recommendations to fire management personnel and agency administrators for fire suppression rehabilitation needs
- Documents potential and actual suppression/fire-related resource impacts and the rationale for protection of priority areas
- Provides resource information to local initial attack ICs, dispatchers, or other fire personnel during pre-season training and planning meetings.

INTERAGENCY OPERATIONS

Maui County Fire Department (Kahului Station) will provide initial attack response to wildland and structural fires on the refuge (Figure 2). If qualified resources are not available, resources will be ordered through proper dispatch procedures (Appendix C). The Hawaii Department of Fish and Wildlife (DOFAW) would be able to respond to fires in the white areas of the figure below only under specific conditions (i.e., extreme threats to public safety, local resources fully committed, extreme fire behavior, etc.). In this case, the request for assistance must come from the County Fire Department through the County Civil Defense to State Civil Defense. No formal cooperative agreements exist with these agencies. When they are developed, they will be added to Appendix G.

Keālia Pond will use the Incident Command System (ICS) as a guide for fireline organization. Qualifications for individuals are per DOI Wildland Fire Qualifications and Certification System, part of NIIMS and the National Wildland Fire Coordination Group (NWCG) Prescribed F ire Qualification Guide. Depending on fire complexity, some positions may be filled by the same person.

Figure 2. Fire Response Zones for the Island of Maui.



PROTECTION OF SENSITIVE RESOURCES

Resource advisors will be required for all wildland fires on the refuge. The advisor will work with the suppression resources to limit environmental impact.

The Regional Archaeologist will work with fire staff, Project Leaders, and Incident Commanders to ensure that cultural resources are protected from fire and fire management activities. The "Request For Cultural Resource Compliance" (RCRC) form (Appendix F) will be used to inform the Regional Archaeologist of impending activities, thereby meeting the regulations and directions governing the protection of cultural resources as outlined in Departmental Manual Part 519, National Historic Preservation Act (NHPA) of 1966, Code of Federal Regulations (36CFR800), the Archaeological Resources Protection Act of 1979, as amended, and the Archaeological and Historic Preservation Act of 1974. The NHPA Section 106 clearance will be followed for any fire management activity that may affect historic properties (cultural resources listed or eligible for listing on the National Register of Historic Places).

Impacts to archaeological resources by fire resources vary. The four basic sources of damage are (1) fire intensity, (2) duration of heat, (3) heat penetration into soil, and (4) suppression actions. Of the four, the most significant threat is from equipment during line construction for prescribed fires or wildfire holding actions (Anderson 1983).

The following actions will be taken to protect archaeological and cultural resources:

Wildland Fires

- Minimum impact fire suppression tactics will be used to the fullest extent possible.
- The Resource Advisor will inform fire suppression personnel of any areas with cultural resources. The Resource Advisor should contact the Regional Archaeologist for more detailed information.
- Foam use will be minimized in areas known to harbor surface artifacts.
- Mechanized equipment should not be used in areas of known cultural significance.
- The location of any sites discovered as the result of fire management activities will be reported to the Regional Archaeologist.
- Rehabilitation plans will address cultural resources impacts and will be submitted to the Regional Archaeologist using the RCRC.

Pile Burns

- The refuge fire staff will submit a completed RCRC to the Regional Archaeologist as soon as the burn area is identified (i.e., as soon as feasible).
- Upon receipt of the RCRC, the Regional Archaeologist will be responsible for consulting with the Zone FMO and evaluating the potential for adverse impacts to cultural resources.
- When necessary, the Regional Archaeologist will coordinate with the State Historic Preservation Officer (SHPO). The SHPO has 30 days to respond. The Refuge will consider all SHPO recommendations.
- Mechanized equipment should not be used in areas of known cultural significance.
- The location of any sites discovered as the result of fire management activities will be reported to the Regional Archaeologist .

WILDLAND FIRE SUPPRESSION ACTIVITIES

Fire program management describes the operational procedures necessary to implement fire management at Keālia Pond. Program management includes fire prevention, preparedness, emergency preparedness, fire behavior predictions, fire detection, minimum impact fire suppression, minimum impact rehabilitation, and documentation.

All fires not classified as prescribed fires are wildland fires and will be appropriately suppressed. Maui County will provide wildland fire suppression resources under most circumstances. Most suppression activities will necessitate the use of heavy equipment to create firebreaks or allow the fire to burn to the water.

There is no clearly defined fire season for the refuge and records show that fires may occur at any during the year.

FIRE MANAGEMENT STRATEGIES

Although resource impacts of suppression alternatives must always be considered in selecting a fire management strategy, managing fire for resource benefit is not authorized on this refuge. Appropriate suppression action will be taken to provide for firefighter safety, public safety, and protection of resources.

Critical protection areas, including all refuge structures and facilities, will receive priority consideration in fire control planning efforts. In all cases, the primary concerns of fire suppression personnel will be safety. If needed, all individuals not involved in the suppression effort will be evacuated.

Suppression strategies should be applied so that the equipment and tools used to meet the desired objectives are those that inflict the least impacts upon the natural and cultural resources. Minimum impact suppression tactics (MIST) will be employed to protect all resources. Natural and artificial barriers will be used as much as possible for containment. When necessary, fire line construction will be conducted in such a way as to minimize long-term impacts to resources. Sites impacted by fire suppression activities or by the fire will be rehabilitated as necessary, based on an approved course of action for each incident.

Specific wildland fire management and suppression strategies for Keālia Pond are:

- All wildland fires will be controlled using the appropriate suppression strategy which considers safety, property, natural and cultural resources, and economics.
- Mechanical treatment will be used to reduce hazardous fuels around structures and improvements.

PREPAREDNESS

Preparedness is the work accomplished prior to fire occurrence to ensure that the appropriate response, as directed by the Fire Management Plan, can be carried out. Preparedness activities include: budget planning, equipment acquisition, equipment maintenance, dispatch (initial attack, extended, and expanded), equipment inventory, personnel qualifications, and training. The preparedness objective is to have a well trained and equipped fire management organization to manage all fire situations within the monument. Preparedness efforts are to be accomplished in the time frames outside the normal fire season dates.

Historical Weather Analysis

There is no clearly defined fire season for the refuge and records show that fires may occur at any during the year.

General fire weather information can be obtained through the National Oceanic and Air Administration (NOAA) at fire.boi.noaa.gov. Keālia Pond NWR is located in the area serviced by the National Weather Service (NWS) office in Honolulu, Hawaii. The Fire Weather section of the Honolulu NWS website, www.prh.noaa.gov/hnl/pages/firewx.php, contains zone maps, fire weather forecasts, and instructions for requesting a spot weather forecast. The refuge falls within the Maui Central Valley (019) Fire Weather Zone.

Fire Prevention
An active fire prevention program will be conducted, as needed, in conjunction with other agencies to protect human life and property, and prevent damage to cultural resources or physical facilities.

A program of internal and external education regarding potential fire danger may be implemented. Visitor contacts, bulletin board materials, handouts and interpretive programs can be utilized to increase visitor and neighbor awareness of fire hazards.

During periods of extreme or prolonged fire danger area closures or emergency restrictions regarding refuge operations may become necessary. Such restrictions, when imposed, will usually be consistent with those implemented by cooperators.

Hazard Reduction for Structure Protection
Hazard reduction is conducted to prevent wildland fires from spreading onto structures owned by the FWS and adjacent landowners. All vegetation around FWS buildings and storage containers is trimmed to a minimum of two feet from the structure. Currently, trimmings are disposed of by way of Maui Disposal to the County of Maui's green waste facility. Non-FWS structures include privately-owned condominiums located along the southeast boundary; however, North Kihei Road would provide sufficient protection from a wildland fire under most normal circumstances.

Staffing Priority Levels
No dedicated fire staff exists on the refuge. If drought conditions require additional fire preparedness and funding, addition qualified fire personnel may be assigned to the refuge.

Training
Departmental policy requires that all personnel engaged in suppression and prescribed fire duties meet the standards set by the National Wildfire Coordinating Group (NWCG), in addition to Service-specific standards. Kealiea Pond NWR will conform strictly to the requirements of the wildland fire management qualification and certification system and USFWS guidelines.

Basic wildland fire training refreshers are offered annually for red-carded firefighters through surrounding agencies, and records are kept in a centralized database. Additional training is available from surrounding agencies in pump and engine operation, power saws, firefighter safety, fire weather and fire behavior, helicopter safety and prescribed fire objectives and activities. On-the-job training is encouraged and will be conducted at the field level. Whenever appropriate, the use of fire qualification task books will be used to document fire experience of trainees. The Zone FMO will coordinate fire training needs with those of other nearby refuges, cooperating agencies, and the Regional Office.

The refuge supports the development of individual Incident Command System (ICS) overhead personnel from among qualified and experienced refuge staff for assignment to overhead teams at the local, regional, and national level.

Fire suppression is an arduous duty. On pile burns, personnel may be required to shift from implementation and/or monitoring activities to suppression. Poor physical condition of crew members can endanger safety and lives during critical situations. Personnel performing fire management duties will maintain a high level of physical fitness. This requires successful completion of a fitness pack test. Personnel must complete a three mile hike with a 45 pound pack in less than 45 minutes. Employees participating in any wildland fire activities on Fish and Wildlife Service or cooperators= lands will meet fitness requirements established in PMS 310-1, except where Service-specific fitness requirements apply.

Supplies and Equipment
Currently, the refuge does not possess any fire equipment or maintain a fire cache. Equipment and supplies are available through the interagency cache system.

DETECTION
Fires are generally reported by the public to the Maui County Fire Department. The Fire Department notifies refuge staff of any suppression operations on the refuge.

COMMUNICATIONS
Currently, refuge communications are limited to telephones (Appendix C). No personnel will be on-site at a wildland fire without direct communications with the suppression resources.

PRE-ATTACK PLAN
Upon discovery of a fire, all subsequent actions will be based on the following:

- The Incident Commander (IC) will locate, size-up, and coordinate suppression actions. The IC will complete the pre-attack planning checklist.
- Provide for public safety.
- Considering the current and predicted fire conditions, the Incident Commander will assess the need for additional suppression resources and estimate the final size of the fire. The potential for spread outside of the refuge should be predicted, as well as the total suppression force required to initiate effective containment action at the beginning of each burning period.
- The Incident Commander will assess the need for law enforcement personnel for traffic control, investigations, evacuations, etc., and make the request to the FMO.
- Document decisions and complete the fire report (DI-1202).
- Should a wildland fire move into an extended attack a Delegation of Authority will be invoked. Once a Delegation of Authority has been authorized the Incident Commander will make the final decisions pertaining to the fire. A copy of the Delegation of Authority is in Appendix ?.

FIRE MANAGEMENT UNITS
Fire Management Units (FMUs) are areas on a refuge which have common wildland fire management objectives and strategies, are manageable units from a wildland fire standpoint, and can be based on natural or man-made fuel breaks. Keālia Pond NWR will be managed as a single FMU.

Due to staff limitations, relatively small land management parcels, long response times, valuable resources, and values at risk on neighboring lands, this plan does not authorize managing wildland fire for resource benefit. Wildland fires will be suppressed using the appropriate suppression response. Pile burning, as a limited form of prescribed burning, will be used to reduce hazardous fuels and to meet resource management objectives.

FUELS AND FIRE BEHAVIOR

Fuel Types and Fire Behavior

There are two general fuel types on the refuge. These fuel types correspond to Anderson's (1982) Fuel Models 3 and 6 (Table 2). These types of fuels promote rapid spread and flame heights that may exceed 20 feet, thus causing control problems. Steady trade winds help promote rapid fire growth.

Table 2. Habitat types and fuel models on Keālia Pond NWR.

Habitat Type	Fuel Model*	Acres
Wetlands	1/3	500
Uplands	6	200
Open Water/Roads	N/A	200

* NFFL Fuel Model (Anderson 1982)

Fuel Model 3. The 300 acres of wetlands (excluding open water) on the refuge are characteristic of Fuel Model 3. Mudflats surrounding the open water are comprised of *Pluchea indica* and a diversity of herbaceous species (*Atriplex spp., Sonchus oleraceus, Verbesina encelioides, and Batis martima*), grasses (*Brachiaria mutica, Cenchrus ciliaris, Cynodon dactylon,* and *Leptochloa uninervia)* and sedges (*Bolboschoenus maritimus* and *Cyperus laevigatus*). Depending on flooding and climatic conditions, the vegetation in some areas of this pond may be shorter and more closely resemble Fuel Model 1. In September 2001, a prescribed burn in the cane fields passed the fire break and entered the refuge through the upland habitat into the mudflats where vegetation (which contained over 90% *Batis maritima*) burned readily and intensely, and displayed a high rate of spread under the influence of wind. Wind may drive fire into the upper heights of the vegetation and across small areas of standing water. Table 3 shows predicted flame lengths and rates of spread in Fuel Models 1 and 3 under varying conditions from an old burn plan for the former Hawaiian Wetlands NWRC. These predictions are only for backing fires, which assumes no wind. Wind will cause heading fires and may significantly increase flame lengths and rates of spread for these fuel models.

Fuel Model 6. The refuge's 200 acres of uplands are covered with dense stands of koa-haole (*Leucaena leucocephala*), kiawe trees (*Prosopis pallida*), and Indian marsh fleabane (*Pluchea indica*). Fires carry through the shrub layer, but this requires moderate winds. Fire will drop to the ground at low wind speeds or at openings in the stand. With winds of 5 miles/hour, dead fuel moisture content of 8%, and live fuel moisture content of 100%, predicted flame length is 6 feet, and rate of spread is 32 chains/hour (Anderson 1982).

Table 3. Backing fire behavior predictions for Keālia Pond NWR in Fuel Models 1 and 3.

Parameter	Fuel Model 1		Fuel Model 3			
20-ft Windspeed	0-10 mi/hr		0-10 mi/hr			
Effective Midflame Windspeed*	0 mi/hr		0 mi/hr			
Time of Day	0800	1000	0800	0800	1000	1000
Cloud Canopy Cover (%)	Clear	Clear	Clear	Clear	Clear	Clear
Temperature (°F)	70	90	70	70	90	90
Relative Humidity (%)	65	20	65	65	20	20
Dead Fuel Moisture (%)	12	5	12	13	5	6
Slope (degrees)	Flat	Flat	Flat	Flat	Flat	Flat
Flame Length (ft)	0	1	2	2	3	3
Rate of Spread (ch/hr)	0	5	4	3	5	5

* Backing fire assumes effective mid-flame wind speed = 0.

Fire Effects
Fire can promote non-native species, but can be an effective management tool to reduce the density and complexity of these species and enhance endangered waterbird habitat. If a wildland fire were to occur on the refuge, other than short-term impacts, no negative ecological impacts would be anticipated from either suppression methods or the fire itself. A fire during peak Hawaiian stilt or coot nesting could account for some nesting failure; however, the benefits to waterbirds of reducing coverage by rank stands of non-native species would outweigh any immediate negative effects.

Suppression Tactics

Suppression involves a wide range of possible tactics from the initial attack to final control. To this end, all wildland fires will be suppressed in a safe, aggressive, and cost-effective manner to produce efficient action with minimal resource damage and limit smoke impacts to local communities.

Typically, initial attack suppression actions are conducted by the Maui County Fire Department. All fires will be assessed by the initial on-scene Incident Commander and attacked using minimum impact fire suppression tactics for the Refuge. Roads and natural barriers will be used as much as possible to reduce fireline construction. Fireline and mop-up through riparian areas should consider long-term damage to vegetation. Unnecessary cutting and bucking should be replaced with alternative actions whenever possible. Where wildland fires cross roads, the burned area adjacent to the road should be mopped up and dangerous snags felled.

A Resource Advisor should be assigned to the incident from the beginning to assist with on-the-ground tactical decisions and to document rehabilitation needs. There will be only one Incident Commander who will be responsible to the Refuge Project Leader. The Incident Commander will designate all overhead positions on fires requiring extended attack. Reference should be made to a Delegation of Authority (Appendix G).

Suppression Conditions
A full suppression alternative was selected for this refuge which requires containment and control of all wildland fires. Wildland fires will not be managed to achieve resource objectives, although impacts to resources may be considered in selecting suppression strategies. Suppression guidelines and restrictions (Table 4) were developed for this refuge to protect natural and cultural resources. These guidelines will be discussed annually with Maui County Fire Department to ensure their compliance. The Refuge Manager should review these guidelines annually and document any changes.

A Resource Advisor will be used to ensure impacts to natural and cultural resources are minimized. The use of heavy, ground-disturbing equipment (including bulldozers) is prohibited for normal fire suppression operations. The use of foams and retardants is also prohibited due to the presence of endangered waterbirds and extensive wetlands. Off-road travel, firelines constructed with hand tools and/or chainsaws, and the use of low-flying aircraft must be approved by the Resource Advisor at all times. Helicopter water drops and hose lays from engines must be approved by the Resource Advisor from April through August due to the presence of nesting endangered waterbirds; the Incident Commander has approval authority all other times.

Table 4. Keālia Pond NWR Wildland Fire Suppression Guidelines.

Keālia Pond National Wildlife Refuge – Wildland Fire Suppression Guidelines	
NOTE: If human life is threatened, the Incident Commander has the authority to order any suppression strategy or tactic available to mitigate the threat.	
	FIRE MANAGEMENT UNIT – Keālia POND NWR
FMU Description	All lands within Keālia Pond National Wildlife Refuge, Maui, Hawaii.
Special Considerations	• Smoke/fire may cause a health hazard to neighboring communities. • Endangered waterbirds present in wetlands.
Preferred Suppression Strategies	Aggressively suppress fire, holding it to the fewest burned acres possible within safety constraints, with minimal effect on endangered species and their habitats.
TACTIC	**MUST BE APPROVED BY:**
Hand line/Chainsaws	Resource Advisor
Heavy Equipment	Prohibited
Off-road Travel	Resource Advisor
Hose Lays	Resource Advisor (April-August); Incident Commander otherwise
Foam/Retardant	Prohibited
Water Drops	Resource Advisor (April-August); incident commander otherwise
Helicopters, other AC	Resource Advisor
Safety Considerations	High rates of fire spread, especially in windy conditions.

Wildland Fire Situation Analysis
For fires that cannot be contained in one burning period, a Wildland Fire Situation Analysis (WFSA) must be prepared. In the case of a wildland fire, the Project Leader, in conjunction with the Zone FMO, will prepare the WFSA. Approval of the WFSA resides with the Project Leader.

The purpose of the WFSA is to allow for a consideration of alternatives by which a fire may be controlled. Damages from the fire, suppression costs, safety, and the probable character of suppression actions are all important considerations.

Public safety will require coordination between all refuge staff and the IC. Notices should be posted to warn visitors, trails may be closed, traffic control will be necessary where smoke crosses roads, etc. Where wildland fires cross roads, the burned area adjacent to the road should be mopped up and dangerous snags felled. Every attempt will be made to utilize natural and constructed barriers, including changing fuel complexes, in the control of wildland fire. Rehabilitation efforts will concentrate on the damages done by suppression activities rather than on the burned area itself.

Aircraft Operations

Aircraft may be used in all phases of fire management operations. All aircraft must be Office of Aircraft Services (OAS) or Forest Service approved. An OAS Aviation Policy Department Manual will be provided by OAS. As in all fire management activities, safety is the primary consideration. Qualified aviation personnel will be assigned to all flight operations.

Helicopters may be used for reconnaissance, bucket drops and transportation of personnel and equipment. Natural helispots and parking lots are readily available in most cases. Clearing for new helispots should be avoided where possible. Improved helispots will be rehabilitated following the fire.

BURNED AREA EMERGENCY STABILIZATION AND REHABILITATION

There are three methods of repairing damage caused by wildland fires and wildland fire suppression activities – emergency stabilization, rehabilitation, and fire suppression activity damage repair.

Policy and Implementation Guidance

Departmental policy for emergency stabilization and rehabilitation (ESR) on Service lands following wildland fire, including objectives, implementation, plan submittal, monitoring, and funding, is found in the Department Manual (620 DM 3). Service ESR supplemental policy can be found in the Service Manual (095 FW 3.9), with policy implementation guidance provided in Chapter 5 of the FWS Fire Management Handbook. More detailed guidance for can be found in the Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook (2002) and Technical Reference (2002). The Service maintains an internet web site (http://fire.fws.gov/ifcc/rehab/) that provides access to these and several other guidance documents.

Any treatment or activity will have an approved plan developed prior to implementation. Monitoring specifications will be included in the plan for each treatment or activity. Emergency stabilization and rehabilitation treatments and activities will be written in separate plans. The Project Leader, Biologist, and Zone FMO will review all plans. The final plans will be submitted to the Region for review prior to submission to the Washington Office.

Compliance

Implementation activities will be conducted in a manner that is compatible with long-term goals and approved land management plans (e.g., Comprehensive Conservation Plan, Habitat Management Plan, Fire Management Plan), in compliance with applicable law and policy, including the National Environmental Policy Act, Endangered Species Act, Clean Water Act, and National Historic Preservation Act.

Required Reporting

The IC will be responsible for documenting decisions and completing the fire report (e.g., ICS-214, DI-1202). The Zone FMO will be responsible for any additional required reports.

Fire Investigation

Fire management personnel will attempt to locate and protect the probable point of origin and record pertinent information required to determine fire cause. They will be alert for possible evidence, protect the scene and report findings to the fireline supervisor.

Prompt and efficient investigation of all suspicious fires will be carried out. However, fire management personnel should not question suspects or pursue the fire investigation unless they are currently Law Enforcement Commission qualified.

Personnel and services of other agencies may be utilized to investigate wildland fire arson or fire incidents involving structures. All fire investigations should follow the guidelines outlined in the Fire Management Handbook (2004).

HAZARD FUEL REDUCTION

Hazard fuel is vegetation which presents a risk of ignition and sustaining spread of a wildland fire in relationship to a threat to some value. Hazard fuel reduction is both a fire prevention activity and a wildland fire protection measure. The objectives of this activity are:

- Reduce the hazard risk to service structures and facilities from an approaching wildland fire.
- Reduce the risk of fire spreading to the wildland from a fire originating in a Service owned structure or facility.
- Provide defensible space and safety to personnel at those facilities during a wildland fire.
- Meet federal, state and local fire hazard reduction ordinances.

HAZARD FUEL REDUCTION STRATEGIES

Strategies include mechanical treatment of the hazard fuels and the debris disposal. Mechanical treatment is accomplished using normal maintenance procedures. Currently, due to limited staff and equipment required to accomplish clearing of large areas, hazard fuel reduction is a result of general habitat management activities which consists of mechanical (tractor mower, tracked bobcat, weedwacker) and chemical (herbicide) treatments to clear dense areas suitable for waterbird habitat and promote growth of non-woody vegetation. A majority of this activity occurs along the north mudflats of the main pond, typically during August-October when water level has receded and the areas are accessible by the tractor and/or bobcat. The upland areas of the Refuge are not cleared of vegetation for the purpose of hazard fuel reduction. Cutting by chainsaw is only performed if truck access is needed. Vegetation along the office building is cleared approximately 2 feet from the building.

Debris must be disposed of to complete the mitigation of the hazard. Debris disposal may be accomplished by scattering, chipping or pile burning. The quantity of vegetation, diameter size, crew availability, and logistical support will dictate the method used. If scattering of cut vegetation is used, an evaluation of the overall fuel loading needs to be considered so as to not add to the hazard fuel problem.

PILE BURNING GUIDELINES

When planning to dispose of debris by pile burning, specific guidelines must be followed in order to provide for safety and reduce the escape potential. General guidelines for pile burning are the same as for prescribed burning. Service guidelines are found in the FWS Fire Management Handbook, Section 2. This section of the Fire Management Plan is for the purpose of outlining the steps to take when conducting pile burning only. No prescribed burning of standing vegetation will be conducted. References to a burn plan and burn boss are only for the purpose of pile burning.

Pile burning will be used to dispose of cut vegetation resulting from refuge activities such as annual hazard reduction around structures. Limbs and branches of overhanging trees and brush will annually need to be trimmed back. At times trees may have been blown down during storms which will require debris removal. The most economical and expedient method is through burning of the piled vegetation on site. Pile burning is typically rated as complexity level 3 due to the low risk of escape, limited control forces, and time of year conducted. Safety concerns are still present even at the low complexity level. Careful consideration must be given to smoke management, escape potential and resource benefit when planning and rating the pile burn. The complexity of each pile burn would be evaluated using the NWCG Prescribed Fire Complexity Rating System Guide.

Pile Burn Plan
A Burn Boss will conduct a field reconnaissance of the proposed pile burn location with the Refuge Manager to discuss objectives, special concerns, and gather all necessary information to write the burn plan. After completing the reconnaissance, a qualified Burn Boss will write the Pile Burn Plan.

All pile burning will have a Pile Burn Plan. The Pile Burn Plan is a site-specific action plan describing the purpose, objectives, prescription, and operational procedures needed to prepare and safely conduct the burn. The project area, objectives, and constraints will be clearly outlined. No piles will be ignited unless all prescriptions of the plan are met. Fires not within those parameters will be suppressed. Pile Burn Plans will follow the format found in the FWS Fire Management Handbook, Section 2.2. Pile burning is considered a complexity level 3 prescribed burn (in most cases) and should use the plan format contained in Appendix C. Each burn plan will be reviewed by the Project Leader, Refuge Manager, Refuge Biologist, Zone FMO, and Burn Boss. The Project Leader has the authority to approve the burn plan.

The Pile Burn Plan requires the following items to be completed prior to ignition:
- Contingency plan
- Complexity analysis
- Review and approval signatures
- Go/no go checklist
- Spot weather forecast

Pile Burning Strategies and Personnel
Pile burning will only be executed by qualified personnel. Pile burning requires a qualified Burn Boss. The Burn Boss will fill all required positions to conduct the burn with qualified personnel. All positions listed in the burn plan must be available for the duration of the pile burn or it will not be initiated.

Weather and fuel moisture conditions must be monitored closely in the project area to determine when the prescription criteria are met. A belt weather kit may also be utilized to augment monitoring.

When pertinent prescription criteria are within the acceptable range, the Burn Boss will select an ignition time based on current and predicted weather forecasts. A thorough briefing will be given by the Burn Boss on the day of the burn and specific assignments and placement of personnel will be discussed. An updated spot weather forecast will be obtained on the day of ignition and all prescription elements will be re-checked to determine if all elements are still within the approved ranges. If all prescription elements are met, a test fire will be ignited to determine on-site fire behavior conditions as affected by current weather. If conditions are not satisfactory, the test fire will be suppressed and the burn will be rescheduled. If conditions are satisfactory, the burn will continue as planned.

Maui County Fire Department will be made aware of any planned burn. If the burn pile escapes the predetermined burn area, all further ignition will be halted except as needed for suppression efforts. Suppression efforts will be initiated, as discussed in the pre-burn briefing. The Zone FMO will be notified immediately of any control actions on a prescribed burn. If the burn exceeds the initial suppression efforts, the burn will be declared a wildland fire and suppressed using guidelines established in the burn plan. A WFSA will be completed and additional personnel and resources ordered as determined by the Incident Commander. If the fire continues to burn out of control, additional resources based on the contingency plan will be called from the local cooperating agencies via the servicing dispatch. A management overhead team may be requested to assume command of the fire if necessary. Each Pile Burn Plan will detail the contingency plan with identified resources for suppression. This plan will serve as the incident action plan during the initial attack phase of an escape.

Monitoring and Evaluation

During pile burns, monitoring can serve as a precursor to invoking suppression action by determining if the burn is in prescription, assessing its overall potential, and determining the effects of the pile burn. Pile burning does not usually require extensive monitoring. Weather, fire behavior, and smoke management are elements that require monitoring. The Burn Boss will assume responsibility for coordinating and implementing this section. Personnel may be assigned specific tasks such as weather monitoring to document these elements and keep the Burn Boss informed of conditions. Special situations or projects may dictate more extensive monitoring and evaluation.

Required Reports

All forms will be completed as outlined by the Pile Burn Plan. Accomplishments, costs, fire report (DI-1202), weather data, and first order fire effects monitoring are the responsibility of the Burn Boss. The Burn Boss may prepare a final report on the project for the Refuge Manager as requested. Information should include a narrative of the burn operation, a determination of whether objectives were met, weather and fire behavior data, number of work hours, and final cost of the burn.

AIR QUALITY / SMOKE MANAGEMENT GUIDELINES

An annual burn permit is required by the State of Hawaii, Department of Health for each prescribed burn. This permit process evaluates the burn in relation to emissions and local air quality standards. Typically, smoke from fires does not significantly affect air quality standards. The Refuge is required to report the schedule of each burn to the Department of Health and is also required to follow permit conditions provided by the Department of Health that are designed to minimize effects on air quality. These conditions include a specified time period when burns are permitted and attention to not burning on specified "no-burn" days for specified islands as provided on or before 1600 hr by radio broadcast through the National Weather Service, or other appropriate means, applicable for the succeeding day. The State of Hawaii, Department of Health, Agricultural Burn Permit along with an approved Prescribed Burn Plan for the refuge are maintained in the Refuge Complex office. The Agricultural Burn Permit must be renewed annually and in possession at the burn site while burning.

FIRE RESEARCH

There are no ongoing fire research projects at Keālia Pond NWR.

PUBLIC SAFETY

Keālia Pond is dedicated to ensuring the safety of each visitor and to all residents and property adjacent to the refuge's boundary. The refuge will be closed to the public during suppression and possibly during pile burn activities.

Areas of fire activity may be clearly signed at the refuge entrance gate. Residents adjacent to the refuge (Appendix C, Table 3) will be notified in advance of any pile burn and if any fire poses a threat to burn outside the refuge boundaries.

During pile burns at least one burn team member will have first aid training. A first aid kit will be on-site for prescribed burns as well as wildland fires. The local police, fire, and emergency medical services will be notified prior to the ignition. They will also be notified of the location of any wildland fires.

PUBLIC INFORMATION AND EDUCATION

Educating the public on the value of fire as a natural process is important to increasing public understanding and support for the fire management program. The refuge will use the most appropriate and effective means to explain the overall fire and smoke management program. This may include supplemental handouts, signing, personal contacts, auto tour routes, or media releases. When deemed necessary, interpretive presentations will address the fire management program and explain the role of fire in the environment.

The public information program will be developed as follows:

- The fire management program may be incorporated into visitor contacts. Particular attention will be given when fires are conspicuous from roads or visitor use areas.
- News releases will be distributed to the media as appropriate.
- The public information outlets of neighboring and cooperating agencies and the regional office will be provided with all fire management information.
- The fire management program will be discussed in informal talks with all employees , volunteers, residents, and neighbors.

As outlined in the prevention section, emergency closures or restrictions may become necessary during periods of extreme or extended fire danger.

FIRE CRITIQUES AND ANNUAL PLAN REVIEW

FIRE CRITIQUES
Fire reviews will be documented and filed with the final fire report. The Refuge Manager will retain a copy for the refuge files.

ANNUAL FIRE SUMMARY REPORT
The Refuge Manager will be responsible for completing an annual fire summary report. The report will contain the number of fires by type, acres burned by fuel type, cost summary (pile burns and wildland fires), personnel utilized, and fire effects.

ANNUAL FIRE MANAGEMENT PLAN REVIEW
The Fire Management Plan will be reviewed annually. Necessary updates or changes will be accomplished prior to the next fire season. Any additions, deletions, or changes will be reviewed by the Project Leader to determine if such alterations warrant a re-approval of the plan.

CONSULTATION AND COORDINATION
The following agencies, organizations and/or individuals were consulted in preparing this plan.

Bruce Babb, Wildland/Urban Interface Coordinator, Pacific Region, USFWS, Portland, OR.

Forrest Cameron, Refuge Supervisor, USFWS, Portland, OR.

Jerry Leinecke, Project Leader, Hawaii/Pacific Islands NWR Complex, Honolulu, HI.

Amanda McAdams, (former) Fire Ecologist, Pacific Region, USFWS, Portland, OR.

Mike Nishimoto, Wildlife Biologist, Maui NWR Complex, Kihei, HI.

James Roberts, Fire Planner, Pacific Region, USFWS, Portland, OR.

Linda Watters, Assistant Refuge Supervisor, USFWS, Portland, OR.

APPENDICES

APPENDIX A: REFERENCES CITED

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Appendix B: Definitions

Agency Administrator. The appropriate level manager having organizational responsibility for management of an administrative unit. May include Director, State Director, District Manager or Field Manager (BLM); Director, Regional Director, Complex Manager or Project Leader (FWS); Director, Regional Director, Park Superintendent, or Unit Manager (NPS), or Director, Office of Trust Responsibility, Area Director, or Superintendent (BIA).

Appropriate Management Action. Specific actions taken to implement a management strategy.

Appropriate Management Response. Specific actions taken in response to a wildland fire to implement protection and fire use objectives.

Appropriate Management Strategy. A plan or direction selected by an agency administrator which guides wildland fire management actions intended to meet protection and fire use objectives.

Appropriate Suppression. Selecting and implementing a prudent suppression option to avoid unacceptable impacts and provide for cost-effective action.

Bureau. Bureaus, offices or services of the Department.

Class of Fire (as to size of wildland fires).
Class A - 3 acre or less.
Class B - more than 3 but less than 10 acres.
Class C - 10 acres to 100 acres.
Class D - 100 to 300 acres.
Class E - 300 to 1,000 acres.
Class F - 1,000 to 5,000 acres.
Class G - 5,000 acres or more.

Emergency Fire Rehabilitation/Burned Area Emergency Rehabilitation (EFR/BAER). Emergency actions taken during or after wildland fire to stabilize and prevent unacceptable resource degradation or to minimize threats to life or property resulting from the fire. The scope of EFR/BAER projects are unplanned and unpredictable requiring funding on short notice.

Energy Release Component (ERC). A number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire. It is generated by the National Fire Danger Rating System, a computer model of fire weather and its effect on fuels. The ERC incorporates thousand hour dead fuel moistures and live fuel moistures; day to day variations are caused by changes in the moisture content of the various fuel classes. The ERC is derived from predictions of (1) the rate of heat release per unit area during flaming combustion and (2) the duration of flaming.

Extended Attack. A fire on which initial attack forces are reinforced by additional forces.
Fire Suppression Activity Damage. The damage to lands, resources and facilities directly attributable to the fire suppression effort or activities, including: dozer lines, camps and staging areas, facilities (fences, buildings, bridges, etc.), handlines, and roads.

Fire Effects. Any consequences to the vegetation or the environment resulting from fire, whether neutral, detrimental, or beneficial. **Fire Intensity.** The amount of heat produced by a fire. Usually compared by reference to the length of the flames.

Fire Intensity. The amount of heat produced by a fire. Usually compared by reference to the length of the flames.

Fire Management. All activities related to the prudent management of people and equipment to prevent or suppress wildland fire and to use fire under prescribed conditions to achieve land and resource management objectives.

Fire Management Plan. A strategic plan that defines a program to manage wildland and prescribed fires and documents the Fire Management Program in the approved land use plan. The plan is supplemented by operational procedures such as preparedness plans, preplanned dispatch plans, prescribed fire plans and prevention plans.

Fire Prescription. A written direction for the use of fire to treat a specific piece of land, including limits and conditions of temperature, humidity, wind direction and speed, fuel moisture, soil moisture, etc., under which a fire will be allowed to burn, generally expressed as acceptable range of the various fire-related indices, and the limit of the area to be burned.

Fuels. Materials that are burned in a fire; primarily grass, surface litter, duff, logs, stumps, brush, foliage, and live trees.

Fuel Loadings. Amount of burnable fuel on a site, usually given as tons/acre.

Hazard Fuels. Those vegetative fuels which, when ignited, threaten public safety, structures and facilities, cultural resources, natural resources, natural processes, or to permit the spread of wildland fires across administrative boundaries except as authorized by agreement.

Initial Attack. An aggressive suppression action consistent with firefighter and public safety and values to be protected.

Maintenance Burn. A fire set by agency personnel to remove debris; i.e., leaves from drainage ditches or cuttings from tree pruning. Such a fire does not have a resource management objective.

Natural Fire. A fire of natural origin, caused by lightning or volcanic activity.

NFDRS Fuel Model. One of 20 mathematical models used by the National Fire Danger Rating System to predict fire danger. The models were developed by the U.S. Forest Service and are general in nature rather than site-specific.

NFFL Fuel Model. One of 13 mathematical models used to predict fire behavior within the conditions of their validity. The models were developed by US Forest Service personnel at the Northern Forest Fire Laboratory, Missoula, Montana.

Prescription. Measurable criteria which guide selection of appropriate management response and actions. Prescription criteria may include safety, public health, environmental, geographic, administrative, social, or legal considerations.

Prescribed Fire. A fire ignited by agency personnel in accord with an approved plan and under prescribed conditions, designed to achieve measurable resource management objectives. Such a fire is designed to produce the intensities and rates of spread needed to achieve one or more planned benefits to natural resources as defined in objectives. Its purpose is to employ fire scientifically to realize maximize net benefits at minimum impact and acceptable cost. A written, approved prescribed fire plan must exist and NEPA requirements must be met prior to ignition. NEPA requirements can be met at the land use or fire management planning level.

Preparedness. Actions taken seasonally in preparation to suppress wildland fires, consisting of hiring and training personnel, making ready vehicles, equipment, and facilities, acquiring supplies, and updating agreements and contracts.

Prevention. Activities directed at reducing the number or the intensity of fires that occur, primarily by reducing the risk of human-caused fires.

Rehabilitation. Actions to (1) limit the adverse effects of suppression on soils, watershed, or other values, or (2) to mitigate adverse effects of a wildland fire on the vegetation-soil complex, watershed, and other damages.

Suppression. A management action intended to protect identified values from a fire, extinguish a fire, or alter a fire's direction of spread.

Unplanned Ignition. A natural fire that is permitted to burn under specific conditions, in certain locations, to achieve defined resource objectives.

Wildfire. An unwanted wildland fire.

Wildland Fire. Any non-structure fire, other than prescribed fire, that occurs in the wildland.

Wildland Fire Situation Analysis (WFSA). A decision-making process that evaluates alternative management strategies against selected safety, environmental, social, economical, political, and resource management objectives as selection criteria.

Wildland/Urban Interface Fire. A wildland fire that threatens or involves structures.

Appendix C: Fire Dispatch Plan

2004 Fire Dispatch Plan
Keālia Pond National Wildlife Refuge

FIRE SIZE-UP

Use the following or the card, pocket guide, fireline handbook or red book guides.

Reporting party's name and phone number:____

Time discovered:____

Location of smoke or fire (plot on map; legal description):_______________________________

____

Fire Behavior: ____Smoldering ____Creeping ____Running ____Crowning ____Spotting

Estimated size (acres): ____Spot ____1/4-1/2 ____1/2-3/4 ____1 ____1-5 ____5+

Wind (midflame speed & direction):____

Dry Bulb Temperature (°F):____________________ Relative Humidity (%):____________________

Fuel Type: ____Grass ____Brush ____Timber ____Slash

Adjacent Fuels: ____Grass ____Brush ____Timber ____Slash

Aspect:___________ Percent Slope:___________

Additional Resources Needed:____

Special Considerations:____

____

NOTIFICATION

Upon report of a wildland fire, follow these procedures:

1. Call Maui County Fire Department (911) – request response, ambulance if necessary, traffic control.

2. Notify Refuge Manager/Resource Advisor, Glynnis Nakai, at the Refuge Office (808-875-1582), residence (808-878-3269), or cell phone (808-281-9698). Assignments will be made at this time to notify other personnel and agencies.

3. Notify other Refuge personnel at the Refuge Office (808-875-1582) or at their residence:

Mike Nishimoto, Wildlife Biologist/Resource Advisor	Residence: (808) Cell: (808)
Calvin Willis, Maintenance Worker	Residence: (808) Cell: (808)
Pat Savino, Admin. Support Asst.	Residence: (808)

4. Notify Project Leader, at the Hawaiian and Pacific Islands NWRC Office in Honolulu (808-792-9540)

5. ***Contact one of the following Regional FWS Duty Officers:***

Pam Ensley – Regional Fire Management Coordinator	Work: Cell:
Roger Spaulding – Regional Fire Management Officer	Work: Cell:
(vacant) – Regional Prescribed Fire Specialist	Work: Cell:
Bruce Babb – Fire Management Specialist/Regional WUI Coordinator	Work: Cell:

ESTABLISHED SUPPRESSION GUIDELINES

A full suppression alternative was selected for this refuge which requires containment and control of all wildland fires. Wildland fires will not be managed to achieve resource objectives, although impacts to resources may be considered in selecting suppression strategies. Suppression guidelines and restrictions (Table 4) were developed for this refuge to protect natural and cultural resources. These guidelines will be discussed annually with Maui County Fire Department to ensure their compliance. The Refuge Manager should review these guidelines annually and document any changes.

A Resource Advisor will be used to ensure impacts to natural and cultural resources are minimized. The use of heavy, ground-disturbing equipment (including bulldozers) is prohibited for normal fire suppression operations. The use of foams and retardants is also prohibited due to the presence of endangered waterbirds and extensive wetlands. Off-road travel, firelines constructed with hand tools and/or chainsaws, and the use of low-flying aircraft must be approved by the Resource Advisor at all times. Helicopter water drops and hose lays from engines must be approved by the Resource Advisor from April through August due to the presence of nesting endangered waterbirds; the Incident Commander has approval authority all other times.

Keālia Pond National Wildlife Refuge – Wildland Fire Suppression Guidelines	
NOTE: If human life is threatened, the Incident Commander has the authority to order any suppression strategy or tactic available to mitigate the threat.	
	FIRE MANAGEMENT UNIT – Keālia Pond NWR
FMU Description	All lands within Keālia Pond National Wildlife Refuge, Molokai, Hawaii.
Special Considerations	• Smoke/fire may cause a health hazard to neighboring communities. • Endangered waterbirds present in wetlands.
Preferred Suppression Strategies	Aggressively suppress fire, holding it to the fewest burned acres possible within safety constraints, with minimal effect on endangered species and their habitats.
TACTIC	**MUST BE APPROVED BY:**
Hand line/Chainsaws	Resource Advisor
Heavy Equipment	Prohibited
Off-road Travel	Resource Advisor
Hose Lays	Resource Advisor (April – August); Incident Commander otherwise
Foam/Retardant	Prohibited
Water Drops	Resource Advisor (April – August); Incident Commander otherwise
Helicopters, other AC	Resource Advisor
Safety Considerations	High rates of fire spread, especially in windy conditions.

COMMUNICATIONS

Currently, refuge communications are limited to telephones. No personnel will be on-site at a wildland fire without direct communications with the suppression resources.

Currently, refuge communications are limited to telephones. No personnel will be on-site at a wildland fire without direct communications with the suppression resources.

CONTACT LIST

Table 5. Maui National Wildlife Refuge Complex Staff.

Maui NWRC	P.O. Box 1042 (Mile 6 Mokulele Hwy.) Kihei, HI 96753	Phone: (808) 875-1582 Fax: (808) 875-2945
Refuge Complex Manager		Work: (808) Cell: (808) Home: (808)
Wildlife Biologist		Work: (808) 875-1582 Cell: (808) Home: (808)
Maintenance Worker		Work: Cell: Home:
Administrative Officer		Work: (808) 875-1582 Home:
		Work: Cell: Home:

ADJACENT LANDOWNERS

Table 6. Landowners adjacent to Keālia Pond NWR.

Landowner	Address	Phone Number
Alexander & Baldwin Properties, Inc.	33 Lono Ave., Ste. 400, Kahului, HI 96732	(808)
Hawaiian Commercial & Sugar Co.	P.O. Box 266, Puunene, HI 96784	(808)
Maui Humane Society	Mokulele Highway, Kihei, HI 96753	(808)
Maui Electric Company	210 W. Kaahumanu Ave., Kahului, HI 96732	(808)
Puanani o Kula Nursery	Mokulele Hwy., Kihei, HI 96753	(808)
Keālia Resort	191 N. Kihei Rd., Kihei, HI 96753	(808)
Sugar Beach Resort	145 N. Kihei Rd., Kihei, HI 96753	(808)
Kihei Sands	115 N. Kihei Rd., Kihei, HI 96753	(808)
Nani Kai Hale	73 N. Kihei Rd., Kihei, HI 96753	(808)
Kihei Kai Resort	61 N. Kihei Rd., Kihei, HI 96753	(808)
Maalaea Surf	12 S. Kihei Rd., Kihei, HI 96753	(808)

APPENDIX D: NEPA COMPLIANCE

UNITED STATES FISH AND WILDLIFE SERVICE

ENVIRONMENTAL ACTION STATEMENT FOR CATEGORICAL EXCLUSION

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act of 1969 (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the action of:

Implementation of the 2004 Wildland Fire Management Plan for Keālia Pond National Wildlife Refuge, which includes guidance for wildland fire suppression, hazard fuel reduction, and pile burning as a limited form of prescribed fire

Check One:

__X__ Is a categorical exclusion as provided by 516 DM 6, Appendix 1.4. No further NEPA documentation will be made.

____ Is found not to have significant environmental effects as determined by the attached Environmental Assessment and Finding of No Significant Impact.

____ Is found to have significant effects and, therefore, further consideration of this action will require a notice intent to be published in the *Federal Register* announcing the decision to prepare an environmental impact statement.

____ Is not approved because of unacceptable environmental damage, or violation of Fish and Wildlife Service mandates, regulations, or procedures.

____ Is an emergency action within the context of 40 CFR 1506.11. Only those actions necessary to control the immediate impacts of the emergency will be taken. Other related actions remain subject to NEPA review.

Proposed Action and Alternatives: Use of prescribed fire to reduce fuels, restore the natural processes and vitality of ecosystems, improve wildlife habitat, remove or reduce non-native species and noxious weeds, and/or conduct research.

Categorical Exclusions: The specific categorical exclusions from NEPA allowing for this action pursuant to 516 DM 6, Appendix 1.4 are:

B.(4) The use of prescribed burning for habitat improvement purposes, when conducted in accordance with departmental and Service procedures.

B.(5) Fire management activities, including prevention and restoration measures, when conducted in accordance with departmental and Service procedures.

Permits/Approvals: The Wildland Fire Management Plan for Keālia Pond National Wildlife Refuge must be approved by the Refuge Manager, Project Leader, Regional Fire Management, and Regional Director. All prescribed fire projects require a burn plan approved by the Project Leader.

Public Involvement/Interagency Coordination: Maui County Fire Department Kahului Station is notified prior to any prescribed burning.

Supporting Documents:

- 2004 Wildland Fire Management Plan for Keālia Pond National Wildlife Refuge.
- ESA Section 7 Biological Evaluation for pile and debris burning for refuges within the Maui National Wildlife Refuge Complex (Keālia Pond NWR and Kakahaia NWR) (Appendix E of this FMP).

Signature Approval:

Jerry F Leinecke   9/23/04

Jerry Leinecke, Project Leader
Hawaiian and Pacific Islands National Wildlife Refuge Complex

Date

APPENDIX E: ESA SECTION 7 COMPLIANCE

INTRA-SERVICE SECTION 7 BIOLOGICAL EVALUATION

Pile and Debris Burning for refuges within the Maui National Wildlife Refuge Complex (Keālia Pond NWR and Kakahaia NWR)

Originating Person: Glynnis Nakai
Telephone Number: (808) 875-1582
Date: July 13, 2003

I. Region: Pacific (Region 1), Portland Oregon.

II. Service Activity:

Pile and debris burning as a marsh vegetation management technique at Keālia Pond National Wildlife Refuge on Maui and Kakahaia National Wildlife Refuge on Molokai.

III. Pertinent Species and Habitat:

A. Listed species and/or their critical habitat within the action area:
Hawaiian coot (*Fulica alai*) – Endangered
Hawaiian stilt (*Himantopus mexicanus knudseni*) – Endangered

B. Proposed species and/or proposed critical habitat within the action area: NONE

C. Candidate species within the action area: NONE

IV. Geographic area or station name and action:

Refuges of this Complex are located in the state of Hawaii, County of Maui: Keālia Pond NWR on the island of Maui and Kakahaia NWR on the island of Molokai.

Pile and debris burning to control and remove non-native vegetation in wetland marsh and mudflats.

V. Location (attach map):

A. County and State: Maui County, State of Hawai'i

B. Distance (miles) and direction to nearest town:

Ma'alaea is 1.5 miles southwest of Keālia Pond NWR
Kaunakakai is approximately 5.5 miles northeast of Kakahaia NWR.

VI. Action Objectives:

Pile and debris burning will be conducted on these wetland refuges as a means of controlling noxious and exotic vegetation that interferes with nesting and maintenance of endangered and migratory waterbirds. Control of the establishment and spread of these species is required to provide secure, viable, adequate habitat for endangered waterbirds, migratory waterfowl and shorebirds. Specific goals include: providing open water areas interspersed with escape, nesting, and maintenance cover; limiting predator cover and access; providing mudflat areas for nesting (Hawaiian stilts) and feeding; and promotion of desirable wetland plant species with water areas for Hawaiian coot nesting and maintenance.

VII. Explanation of Impacts of Action:

This action will result in enhanced wetlands for endangered and other species using the refuge. Undesirable plant species will be controlled encouraging growth of more beneficial species. Dense predator concealment cover will be reduced making it more difficult for predators to prey on endangered species and allow waterbirds to detect predators at a greater distance, reducing predation. Increased habitat for a diversity of species, both resident and migratory, will be made available. The ratio of open water to vegetation will be altered to provide additional habitat diversity within the wetlands.

All burns will be conducted outside major endangered species nesting seasons. Burns will normally be conducted between August and October. Burns will not be initiated when pre-fledgling birds are present. A check of each burn site will be made to determine the presence of waterbirds, young, and/or nests. If any of the above are discovered, no burning in that area of the wetlands will be undertaken. To provide necessary foraging habitat while burning, not all areas will be drawn down or dry at the same time. Wetland habitat on the refuge will continue to be provided for endangered and other waterbirds to utilize until worked ponds are re-flooded.

VIII. Effect determination and response requested: **[* = optional]**

A. Listed species/designated critical habitat:

Determination	Response requested
No effect/no adverse modification	____*Concurrence
May affect, but is not likely to adversely affect species/adversely modify critical habitat	_X__ Concurrence
Hawaiian coot (*Fulica alai*) – Endangered Hawaiian stilt (*Himantopus mexicanus knudseni*) – Endangered	
May affect, and is likely to adversely affect species/adversely modify critical habitat	____Formal Consultation

B. Proposed species/proposed critical habitat: NONE

C. Candidate species: NONE

IX. Signature

____ ______________________

Glynnis Nakai, Refuge Manager — Date

Maui National Wildlife Refuge Complex

X. Reviewing ESO Evaluation:

A. Concurrence ______ Nonconcurrence ______

B. Formal consultation required ______

C. Conference required ______

D. Informal conference required ______

E. Remarks (attach additional pages as needed):

____ ______________________

Field Supervisor — Date

Ecological Services, Pacific Islands Field Office

Appendix F: Request for Cultural Resource Compliance

REQUEST FOR CULTURAL RESOURCE COMPLIANCE

NHPA COMPLIANCE

❑ Appendix __________ Item ___________
of the Programmatic Agreement applies.

❑ 36CFR800.4 to 800.6 applies.

______________________________ _____________
Cultural Resources Team Date

Project Name: ________________________________

USFWS Unit: ________________________________

Org Code: ________________________________

Ecoregion: ________________________________
(By ARD; CBE, IPE, KCE, NCE)

Program: ________________________________
(Partners, WSECP, Refuges, Hatcheries, Jobs, Federal Aid, Other)

Location: ________________________ **County:** ___________________ **State:** _____________________
(nearest town)

Township(s): ________ **Range(s):** ________ **Section(s):** ________ **Meridian:** ________________________

7.5' USGS Quad(s): ____
(Name, Date)

Project acres or linear meters/feet: ____

Date you want to start the project: ________________________ **Date of this request:** _____________________

USFWS Contact: _______________________________________ **Phone:** ___________________________________

Address: ____ **Fax:** _____________________________________

Directions to project (if not obvious):

Attach to this form:

- A **project (sketch) map** showing the Area of Potential Effect with locations of specific ground altering activities *(required)*.
- A **photocopy** of the **USGS quad** clearly marking the project area *(required)*.
- A **photocopy** of an **air photo** showing the project may be attached *(if available)*.

Return form and direct questions to:

USFWS Region 1 Cultural Resources Team
c/o Tualatin River NWR
20555 SW Gerda Lane
Sherwood, OR 97140
Phone: (503) 625-4377
Fax: (503) 625-4887

The Undertaking: *Describe the proposed project and means to facilitate it (e.g., provide funds to revegetate 1 mile of riparian habitat, restore 250 acres of seasonal wetlands, and construct a 5-acre permanent pond). How is the project designed (e.g., install 2 miles of fence and create approximately 25 feet of 3 foot high check dam)?*

Area of Potential Effect: *Describe where disturbance of the ground will occur. What are the dimensions of the area to be disturbed? How deep will you excavate? How long is the ditch, fence, etc? Where will fill be obtained? Where will spoil be dumped? What tools or equipment will be used? Are you replacing or repairing a structure? Are you moving dirt in a relatively undisturbed area? Will the project reach below or beyond the limits of prior land disturbance? Differentiate between areas slated for earth movement versus areas to be inundated only. Is the area to be inundated different from the area inundated today, in the recent past, or under natural conditions? Provide acres and/or linear meters or feet for all elements of the undertaking.*

Environmental Setting: *Describe the environmental setting of the Area of Potential Effect. A) What was the natural habitat prior to modifications, reclamation, agriculture, settlement? B) What is the land-use history? When was it first settled, modified? How deep has it been cultivated? Grazed? etc. C) What is the land-use and habitat today? What natural agents (e.g., sedimentation, or vegetation) or cultural agents (e.g., cultivation) might affect the ability to discover cultural resources? D) Do you (or does anybody else) know of cultural resources in or near the project area?*

APPENDIX G: INTERAGENCY AGREEMENTS

No interagency agreements have been developed. When completed, they will be added here.

APPENDIX H: PILE BURN PLAN TEMPLATE

REFUGE OR STATION:	**UNIT:**

Prepared By:	______________________ Prescribed Fire Specialist	__________ Date
Reviewed By:	______________________ Refuge Biologist	__________ Date
Reviewed By:	______________________ Prescribed Fire Burn Boss	__________ Date
Reviewed By:	______________________ Fire Management Officer	__________ Date
Reviewed By:	______________________ Biological Investigation Unit	__________ Date
Reviewed By:	______________________ Refuge Manager	__________ Date
The approved Pile Burn Plan constitutes the authority to burn, pending approval of Section 7 Consultations, Environmental Assessments or other required documents. No one has the authority to burn without an approved plan or in a manner not in compliance with the approved plan. Pile burning conditions established in the plan are firm limits. Actions taken in compliance with the approved Pile Burn Plan will be fully supported, but personnel will be held accountable for actions taken which are not in compliance with the approved plan.		
Approved By:	______________________ Project Leader	__________ Date

PILE BURN PLAN

Note: This plan is intended for burning debris and piles (activity fuels) from refuge operations such as fuel break construction and hazard reduction. This plan format should only be used outside of declared fire season for the area considered. THIS PLAN IS FOR COMPLEXITY LEVEL 3 PILE BURNING.

Refuge:	**Refuge Burn Number:**
Substation:	**Fire Number:**
Name of Area:	**Unit Number:**
Legal Description: T_____ R_____ S_____	**Meridian:**_________________________
Latitude:___________________	**Longitude:**_________________
County:	**State:**

Checklist:

1. EA optional.

2. Resource objectives.

3. Less than 1 ton per pile, completely dried.

4. Has minimum resources (equipment & personnel) required.

5. Has weather parameters been established.

6. Low potential for escape. Good clearance.

7. No fire behavior prediction required

8. Can be written to be good up to 3 years per site, with annual review.

9. Burn day required.

10. Less than (<) one acre in size.

11. Complexity level should rate as level 3

12. Intended for admin sites, campgrounds, occupancy trespass, etc.

Environmental Assessment Met (where documented): ____

Estimated Cost: ________________ 1202: __________________ Funding Code: ______________

Project Area Description (Attach Map of Burn Area)

Burn Objectives:

Number, Species, and Size of Piles:

Adjacent Fuel Description:

Weather Forecasts

The Pile Burn Boss is responsible for weather being taken every hour while burning to ensure prescription compliance. Contact the Emergency Communications Center (ECC) for weather forecasts and burn day designation. Contact ECC by radio when ignition is starting, giving legal description of area burning; and when burning is over, giving number of acres or piles burned.

Prescription: ____

Season of Burn (Fall, Spring, Summer, Winter): ______________________________________

		Acceptable Range	Desired
Air Temperature		____________________	____________________
Relative Humidity		____________________	____________________
Wind Speed		____________________	____________________
Fuel Moisture	1 Hour T.L.	____________________	____________________
	10 Hour T.L.	____________________	____________________
	100 Hour T.L.	____________________	____________________
Adjacent Live Fuel Moisture		____________________	____________________
Wind Direction Preferred		Acceptable: ____________	Unacceptable: ____________

Smoke Management

Permitting Agency:

Total Tons Per Acre Emissions:

Distance and Direction from Smoke Sensitive Area(s):

Necessary Transport Wind Direction(s):

Visibility Hazard(s) (i.e., roads, airports, etc.):

Actions to Reduce Visibility Hazard(s):

Can Residual Smoke Be a Problem?

Other Considerations:

Special Constraint(s)/Consideration(s):

Firing Technique:

Holding Force Instructions:

Mop Up Instructions

Contact Plan

Who will notify the following and when?

Key People:

Local Landowners:

Private Land Within Proposed Burn (Identify on Map):

Fire Protection Agencies:

Dispatcher:

Public Affairs Officer:

News Releases to Local Papers and News Media:

Safety Plan

All line employees involved in the actual burning of standing and/or piled fuels will have on their person and use as necessary the following protective clothing:

- Hard hat
- Goggles
- Gloves
- Fire resistant pants
- Fire resistant shirt
- Fire shelter
- Laced boots as used in fire suppression

Employees involved in a project with an assignment not related to actual burning should have with them all of the above safety equipment and be so equipped if their unplanned duties expose them to line work and/or the actual burning.

Each burning plan will designate fire safety responsibility. This designation should include the following considerations:

- Escape routes
- Safety areas
- Closest recognized burn treatment facility and specific methods of travel to burn center or hospital

Hospitals

Center Name	Address	Travel Time Air/Ground	Phone	Helipad Yes/No	Burn Yes/No

Medical Emergency Procedures

- Give First Aid at scene.
- Contact Maui County Fire Department
- Make transportation arrangements.

Comments:

Debris & Pile Burning Checklist

A "NO" response to any item means STOP!

	YES	NO
1. Are all fire prescriptions met?		
2. Has dispatch been notified?		
3. Is it a permissive burn day?		
4. Is fire weather forecast favorable?		
5. Are all personnel required in the burn plan on site?		
6. Have all personnel been briefed on the burn plan requirements?		
7. Have all personnel been briefed on safety hazards, escape routes and safety orders?		
8. Is all the required equipment in place an in working order?		
9. Are all personnel aware of mop up requirements before abandonment?		
10. Are all answers to all the above questions "Yes"?		

If all ten questions have been answered "Yes", you may proceed with lighting

Appendix I: Delegation of Authority

DELEGATION OF AUTHORITY

Region 1, U.S. Fish and Wildlife Service

Maui National Wildlife Refuge Complex

_________________________________, you are assigned as Incident Commander of the _________________________________ Incident on the ____ National Wildlife Refuge. You have full authority and responsibility for managing the fire suppression operation on this incident within the framework of legal statute, current policy, broad direction, and the Wildland Fire Situation Analysis (WFSA). Your primary responsibility is to achieve complete control of the fire by organizing and directing the fire suppression organization in an effective, efficient, economical and most importantly, safe manner.

You should be guided in your duties by the fire job descriptions relating to Incident Commander, as found in the Fireline Handbook. Strongly consider long-term ecosystem health, and the effects of suppression actions in the development of appropriate suppression responses. These issues are to be addressed and documented in the WFSA.

You are accountable to the Refuge Manager, ____ of the Maui National Wildlife Refuge Complex, who is the Line Officer. _______________________ may serve as the Line Officer Designee for this incident.

You will immediately notify me in person in the event of:
(1) a serious injury or fatality,
(2) threat to private property,
(3) if the incident exceeds the limits of the selected alternative of the WFSA.

Much of the Refuge Complex is home to endangered species. Your job as Incident Commander is critical, as you must minimize damage to the habitats, as well as provide for firefighter safety. Minimum environmental suppression tactics shall be used, commensurate with forecasted and threatened resource values.

You are to be guided by the Wildland Fire Situation Analysis, approved by ________________________, Project Leader.

The Resource Advisor assigned to your incident will be ____.

____ ___________________________

Glynnis Nakai, Refuge Manager | Date
Maui National Wildlife Refuge Complex

Appendix J: Wildland Fire Situation Analysis

WILDLAND FIRE

SITUATION ANALYSIS

Incident Name: ______________________________

Jurisdiction: ________________________________

Date and Time Completed: ____________________

I. WILDLAND FIRE SITUATION ANALYSIS

A. Jurisdiction(s)	**B. Geographic Area**
C. Unit(s)	**D. WSFA #**
E. Fire Name	**F. Incident #**

G. Accounting Code: ____

H. Date/Time Prepared: ______________________ @______________________

I. Attachments: ____

Complexity Matrix/Analysis * ____________

Risk Assessment/Analysis * ____________

Probability of Success * ____________

Consequences of Failure * ____________

Maps * ____________

Decision Tree ** ____________

Fire Behavior Projections * ____________

Calculations of Resource Requirements * ____________

Other (specify) ____________

* Required

** Required by FWS

This page is completed by the Agency Administrator(s)

II. OBJECTIVES AND CONSTRAINTS

A. Objectives (must be specific and measurable)

1. Safety

   - Public

   - Firefighter

2. Economic

3. Environmental

4. Social

5. Other

B. Constraints

This page is completed by the Agency Administrator(s)

III.	ALTERNATIVES		
	A	B	C
A. Wildland Fire Strategy			
B. Narrative			
C. Resources Needed Handcrews Engines Dozers Airtankers Helicopters			
D. Final Size			
E. Estimated Contain/ Control Date			
F. Costs			
G. Risk Assessment Probability of Success Consequences of Failure			
H. Complexity			
I.	**Attach maps for each alternative**		

This page is completed by the Agency Administrator(s) and FMO/Incident Commander

IV. EVALUATION OF ALTERNATIVES			
A. Evaluation Process	**A**	**B**	**C**
Safety			
Firefighter	_______	_______	_______
Aviation	_______	_______	_______
Public	_______	_______	_______
Sum of Safety Values			
Economic			
Forage	_______	_______	_______
Improvements	_______	_______	_______
Recreation	_______	_______	_______
Timber	_______	_______	_______
Water	_______	_______	_______
Wilderness	_______	_______	_______
Wildlife	_______	_______	_______
Other (specify)	_______	_______	_______
Sum of Economic Values			
Environmental			
Air	_______	_______	_______
Visual	_______	_______	_______
Fuels	_______	_______	_______
T & E Species	_______	_______	_______
Other (specify)	_______	_______	_______
Sum of Environmental Values			
Social			
Employment	_______	_______	_______
Public Concern	_______	_______	_______
Cultural	_______	_______	_______
Other (specify)	_______	_______	_______
Sum of Social Values			
Other			

This page is completed by the Agency Administrator(s) and FMO/Incident Commander

V. ANALYSIS SUMMARY

Alternatives	A	B	C
A. Compliance with Objectives			
Safety	______	______	______
Economic	______	______	______
Environmental	______	______	______
Social	______	______	______
Other (specify)	______	______	______
B. Pertinent Data			
Final Fire Size	______	______	______
Complexity	______	______	______
Suppression Cost	______	______	______
Resource Values	______	______	______
Probability of Success	______	______	______
Consequences of Failure	______	______	______

C. External/Internal Influences

National & Geographic Preparedness Level: ______________________________

Incident Priority: ______________________________

Resource Availability: ______________________________

Weather Forecast (long range): ______________________________

Fire Behavior Projections: ______________________________

This page is completed by the Agency Administrator(s) and FMO/Incident Commander

VI. DECISION
The Selected Alternative is: ______
Rationale: ______
______ **Agency Administrator's Signature** ______ **Date/Time**

This page is completed by the Agency Administrator(s) or designate

VII.		DAILY REVIEW						
To be reviewed daily to determine if still valid until containment or control								
			PREPAREDNESS LEVEL	INCIDENT PRIORITY	RESOURCE AVAILABILITY	WEATHER FORECAST	FIRE BEHAVIOR PROJECTIONS	WFSA VALID
Date	**Time**	**By**						
IF WFSA IS NO LONGER VALID, A NEW WFSA WILL BE COMPLETED!								

This page is completed by the Agency Administrator(s) or designate

VIII.	**FINAL REVIEW**	
The elements of the selected alternative were met on:	____________________ Date	_______ Time
By: ____________________ Agency Administrator(s)		

INSTRUCTIONS

Section I. WFSA Information Page

A. Jurisdiction(s): Assign the agency or agencies that have or could have fire protection responsibility, e.g., USFWS, BLM, etc.

B. Geographic Area: Assign the recognized "Geographic Coordination Area" the fire is located in, e.g., Northwest, Northern Rockies, etc.

C. Unit(s): Designate the local administrative unit(s), e.g., Hart Mountain Refuge Area, Flathead Indian Reservation, etc.

D. WFSA #: Identify the number assigned to the most recent WFSA for this fire.

E. Fire Name: Self-explanatory.

F. Incident #: Identify the incident number assigned to the fire.

G. Accounting Code: Insert the local unit's accounting code.

H. Date/Time Prepared: Self-explanatory.

I. Attachments: Check here to designate items used to complete the WFSA. "Other could include data or models used in the development of the WFSA. Briefly describe the "other" items used.

Section II. Objectives and Constraints

A. Objectives: Specify objectives that must be considered in the development of alternatives. Safety objectives for firefighter, aviation, and public must receive the highest priority. Suppression objectives must relate to resource management objectives in the unit resource management plan.

Economic objectives could include closure of all or portions of an area, thus impacting the public, or impacts to transportation, communication, and resource values.

Environmental objectives could include management objectives for airshed, water quality, wildlife, etc.

Social objectives could include any local attitudes toward fire or smoke that might affect decisions on the fire.

Other objectives might include legal or administrative constraints which would have to be considered in the analysis of the fire situation, such as the need to keep the fire off other agency lands, etc.

B. Constraints: List constraints on wildland fire action. These could include constraints to designated wilderness, wilderness study areas, environmentally or culturally sensitive areas, irreparable damage to resources or smoke management/air quality concerns. Economic constraints, such as public and agency cost, could be considered here.

Section III. Alternatives

A. Wildland Fire Management Strategy: Briefly describe the general wildland fire strategies for each alternative. Alternatives must meet resource management plan objectives.

B. Narrative: Briefly describe each alternative with geographic names, locations, etc., that would be used when implementing a wildland fire strategy. For example: "Contain within the Starvation Meadows' watershed by the first burning period."

C. Resources Needed: Resources described must be reasonable to accomplish the tasks described in Section III.B. It is critical to also look at the reality of the availability of these needed resources.

D. Final Fire Size: Estimated final fire size for each alternative at time of containment.

E. Estimated Contain/Control Date: Estimates of each alternative shall be made based on predicted weather, fire behavior, resource availability, and the effects of suppression efforts.

F. Cost: Estimate all incident costs for each alternative. Consider mop-up, rehabilitation, and other costs as necessary.

G. Risk Assessment - Probability of Success/Consequences of Failure: Describe probability as a percentage and list associated consequences for success and failure. Develop this information from models, practical experience, or other acceptable means. Consequences described will include fire size, days to contain, days to control, costs, and other information such as park closures and effect on critical habitat. Include fire behavior and long-term fire weather forecasts to derive this information.

H. Complexity: Assign the complexity rating calculated in "Fire Complexity Analysis" for each alternative, e.g., Type II, Type I.

I. A map for each alternative should be prepared. The map will be based on the "Probability of Success/Consequences of Failure" and include other relative information.

Section IV. Evaluation of Alternatives

A. Evaluation Process: Conduct an analysis for each element of each objective and each alternative. Objectives shall match those identified in Section II.A. Use the best estimates available and quantify whenever possible. Provide ratings for each alternative and corresponding objective element. Fire effects may be negative, cause no change, or may be positive. Examples are: 1) a system which employs a "-" for negative effect, a "0" for no change, and a "+" for positive effect; 2) a system which uses a numeric factor for importance of the consideration (soils, watershed, political, etc.) and assigns values (such as -1 to +1, -100 to +100, etc.) to each consideration, then arrives at a weighted average. If you have the ability to estimate dollar amounts for natural resource and cultural values, this data is preferred. Use those methods which are most useful to managers and most appropriate for the situation and agency. To be able to evaluate positive fire effects, the area must be included in the resource management plan and consistent with prescriptions and objectives of the Fire Management Plan.

Sum of Economic Values: Calculate for each element the net effect of the rating system used for each alternative. This could include the balance of pluses (+) and minuses (-), numerical rating (-3 and +3), or natural and cultural resource values in dollar amounts. (Again, resource benefits may be used as part of the analysis process when the wildland fire is within a prescription consistent with approved Fire Management Plans and in support of the unit's Resource Management Plan.)

Section V. Analysis Summary

A. Compliance with Objectives: Prepare narratives that summarize each alternative's effectiveness in meeting each objective. Alternatives that do not comply with objectives are not acceptable. Narrative could be based on effectiveness and efficiency. For example: "most effective and least efficient," "least effective and most efficient," or "effective and efficient." Or answers could be based on a two-tiered rating system such as "complies with objective" and "fully complies with or exceeds objective." Use a system that best fits the manager's needs.

B. Pertinent Data: Data for this Section has already been presented, and is duplicated here to help the Agency Administrator(s) confirm their selection of an alternative. Final Fire Size is displayed in Section III.D. Complexity is calculated in the attachments and displayed in Section III.H. Costs are displayed on page 4. Probability of Success/Consequences of Failure is calculated in the attachments and displayed in Section III.G.

C. External and Internal Influences: Assign information and data occurring at the time the WFSA is signed. Identify the Preparedness Index (1 through 5) for the National and Geographic levels. If available, indicate the Incident Priority assigned by the MAC Group. Designate the Resource Availability status. This information is available at the Geographic Coordination Center, and is needed to select a viable alternative. Designate "yes," indicating an up-to-date weather forecast has been provided to, and used by, the Agency Administrator(s) to evaluate each alternative. Assign information to the "Other" category as needed by the Agency Administrator(s).

Section IV. Decision

Identify the alternative selected. Must have clear and concise rationale for the decision, and a signature with date and time. Agency Administrator(s) is mandatory.

Section VII. Daily Review

The date, time, and signature of reviewing officials are reported in each column for each day of the incident. The status of Preparedness Level, Incident Priority, Resource Availability, Weather Forecast, and WFSA validity is completed for each day reviewed. Ratings for the Preparedness Level, Incident Priority, Resource Availability, Fire Behavior, and Weather Forecast are addressed in Section V.C. Assign a “yes” under "WFSA Valid" to continue use of this WFSA. A "no" indicates this WFSA is no longer valid and another WFSA must be prepared or the original revised.

Section VIII. Final Review

This Section is completed by the Agency Administrator(s). A signature, date, and time are provided once all conditions of the WFSA are met.

A GUIDE FOR ASSESSING FIRE COMPLEXITY

The following questions are presented as a guide to assist the Agency Administrator(s) and staff in analyzing the complexity or predicted complexity of a wildland fire situation. Because of the time required to assemble or move an Incident Management Team to wildland fire, this checklist should be completed when a wildland fire escapes initial attack and be kept as a part of the fire records. This document is prepared concurrently with the preparation of (and attached to) a new or revised Wildland Fire Situation Analysis. It must be emphasized this analysis should, where possible, be based on predictions to allow adequate time for assembling and transporting the ordered resources.

Use of the Guide:

1. Analyze each element and check the response "yes" or "no."

2. If positive responses exceed, or are equal to, negative responses within any primary factor (A through G), the primary factor should be considered as a positive response.

3. If any three of the primary factors (A through G) are positive responses, this indicates the fire situation is, or is predicted to be, Type I.

4. Factor H should be considered after all the above steps. If more than two of these items are answered "yes," and three or more of the other primary factors are positive responses, a Type I team should be considered. If the composites of H are negative, and there are fewer than three positive responses in the primary factors (A-G), a Type II team should be considered. If the answers to all questions in H are negative, it may be advisable to allow the existing overhead to continue action on the fire.

GLOSSARY OF TERMS

Potential for blow-up conditions - Any combination of fuels, weather, and topography excessively endangering personnel.

Rate or endangered species - Threat to habitat of such species or, in the case of flora, threat to the species itself.

Smoke management - Any situation which creates a significant public response, such as smoke in a metropolitan area or visual pollution in high-use scenic areas.

Extended exposure to unusually hazardous line conditions - Extended burnout or backfire situations, rock slide, cliffs, extremely steep terrain, abnormal fuel situation such as frost killed foliage, etc.

Disputed fire management responsibility - Any wildland fire where responsibility for management is not agreed upon due to lack of agreements or different interpretations, etc.
Disputed fire policy - Differing fire policies between suppression agencies when the fire involves multiple ownership is an example.

Pre-existing controversies - These may or may not be fire management related. Any controversy drawing public attention to an area may present unusual problems to the fire overhead and local management.

Have overhead overextended themselves mentally or physically - This is a critical item that requires judgment by the responsible agency. It is difficult to write guidelines for this judgment because of the wide differences between individuals. If, however, the Agency Administrator feels the existing overhead cannot continue to function efficiently and take safe and aggressive action due to mental or physical reasons, assistance is mandatory.

FIRE COMPLEXITY ANALYSIS

A. FIRE BEHAVIOR: Observed or Predicted	YES/NO
1. Burning Index (from on-site measurement of weather conditions) predicted to be above the 90% level using the major fuel model in which the fire is burning.	________
2. Potential exists for "blowup" conditions (fuel moisture, winds, etc.).	________
3. Crowning, profuse or long-range spotting.	________
4. Weather forecast indicating no significant relief or worsening conditions.	________
Total	________

B. RESOURCES COMMITTED	
1. 200 or more personnel assigned.	________
2. Three or more divisions.	________
3. Wide variety of special support personnel.	________
4. Substantial air operation which is not properly staffed.	________
5. Majority of initial attack resources committed.	________
Total	________

C. RESOURCES THREATENED	
1. Urban interface.	________
2. Developments and facilities.	________
3. Restricted, threatened, or endangered species habitat.	________
4. Cultural Sites.	________
5. Unique natural resources, special designation zones, or wilderness.	________
6. Other special resources.	________
Total	________

D. SAFETY	**YES/NO**
1. Unusually hazardous fire line conditions.	________
2. Serious accidents or fatalities.	________
3. Threat to safety of visitors from fire and related operations.	________
4. Restricted and/or closures in effect or being considered.	________
5. No night operations in place for safety reasons.	________
Total	________

E. OWNERSHIP

1. Fire burning or threatening more than one jurisdiction.	________
2. Potential for claims (damages).	________
3. Conflicting management objectives.	________
4. Disputes over fire management responsibility.	________
5. Potential for unified command.	________
Total	________

F. EXTERNAL INFLUENCES

1. Controversial wildland fire management policy.	________
2. Pre-existing controversies/relationships.	________
3. Sensitive media relationships.	________
4. Smoke management problems.	________
5. Sensitive political interests.	________
6. Other external influences.	________
Total	________

G. CHANGE	YES/NO
1. Change in strategy to confine/contain to control.	________
2. Large amount of unburned fuel within planned perimeter.	________
3. WFSA invalid or requires updating.	________
Total	________

H. EXISTING OVERHEAD	
Worked two operational periods without achieving initial objectives.	________
Existing management organization ineffective.	________
IMT overextended themselves mentally and/or physically.	________
Incident action plans, briefings, etc. missing or poorly prepared.	________
Total	________

I. SIGNATURE

____ ____________________

Name and Title **Date and Time**

Appendix H.

STATEMENT OF COMPLIANCE
for Implementation of the
Keālia Pond National Wildlife Refuge, Maui County, Hawai‘i
Comprehensive Conservation Plan

The following Executive orders and legislative acts have been reviewed as they apply to implementation of the Keālia Pond NWR CCP.

National Environmental Policy Act (1969). The planning process has been conducted in accordance with NEPA Implementing Procedures, DOI and Service procedures, and has been performed in coordination with the affected public.

The CCP is programmatic in many respects and specific details of certain projects and actions cannot be determined until a later date depending on funding and implementation schedules. Certain projects or actions may require additional NEPA compliance.

National Historic Preservation Act (1966). The implementation of the CCP should not affect cultural resources. The proposed action does not meet the criteria of an effect or adverse effect as an undertaking defined in 36 CFR 800.9 and 614 FW 2. The Service will comply with the National Historic Preservation Act if any management actions have the potential to affect any historic properties which may be present.

Executive Order 12372. Intergovernmental Review. Coordination and consultation with affected local and State governments, other Federal agencies, and the adjacent landowners has been completed through personal contact by Service planners, refuge managers, and supervisors.

Executive Order 12898. Federal Actions to Address Environmental Justice in Minority and Low-Income Populations. All Federal actions must address and identify, as appropriate, disproportionally high and adverse human health or environmental effects of its programs, policies, and activities on minority populations, low-income populations, and Indian Tribes in the United States. The CCP was evaluated and no adverse human health or environmental effects were identified for minority or low-income populations, Indian Tribes, or anyone else.

Wilderness Preservation Act of 1964. The Service has evaluated the suitability of the Refuge for wilderness designation and determined it does not qualify.

National Wildlife Refuge System Administration Act of 1966, as amended by the National Wildlife Refuge System Improvement Act of 1997 (16 U.S.C. 668dd-668ee). Appropriate Use Findings and Compatibility Determinations have been prepared for the following uses: Wildlife Observation, Interpretation, and Photography; Environmental Education; Research, Scientific Collecting, and Surveys; and Kiawe Tree Harvesting.

Executive Order 13186. Responsibilities of Federal Agencies to Protect Migratory Birds. The CCP is consistent with Executive Order 13186 because the CCP and NEPA analyses evaluate the effects of agency actions on migratory birds.

Endangered Species Act of 1973. The Service will conduct consultations under Section 7 of the ESA for any refuge management program actions that have the potential to affect listed species.

Coastal Zone Management Act, Section 307. Section 307(c)(1) of the Coastal Zone Management Act of 1972, as amended, requires each Federal agency conducting or supporting activities directly affecting the coastal zone, to conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved State coastal management programs. The CCP is consistent with Coastal Zone Management Act because CCP implementation would protect the coastal zone from adverse impacts as a result of modification or destruction.

Executive Order 11990. Protection of Wetlands. The CCP is consistent with Executive Order 11990 because CCP implementation would protect and enhance existing wetlands.

Executive Order 11988. Floodplain Management. Under this order Federal agencies "shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by flood plains." The CCP is consistent with Executive Order 11988 because CCP implementation would protect floodplains from adverse impacts as a result of modification or destruction.

Integrated Pest Management, 517 DM 1 and 569 FW 1. In accordance with 517 DM 1, an IPM approach has been adopted to eradicate, control, or contain pest and invasive species on the refuge. In accordance with 517 DM 1, only pesticides registered with the EPA in full compliance with FIFRA and as provided in regulations, orders, or permits issued by EPA may be applied on lands and waters under Refuge jurisdiction.

Chief, Division of Refuge Planning

9-27-2011

Date

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Appendix J. Common Acronyms and Abbreviations

A&B	Alexander and Baldwin, Incorporated
ac.	acre(s)
Administration Act	National Wildlife Refuge System Administration Act of 1966
BCE	Before Common Era
BIDEH	Biological Integrity, Diversity, and Environmental Health
BMPs	Best Management Practices
Bti	*Bacillus thuringiensis israelensis*
CCP	Comprehensive Conservation Plan
CD	Compatibility Determination
CE	Common Era
CFLHD	Central Federal Lands Highway Division
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
Complex	Maui National Wildlife Refuge Complex
DBEDT	Hawai‘i Department of Business, Economic Development, and Tourism
DIN	dissolved inorganic N concentration
DLNR	Hawai‘i Department of Land and Natural Resources
DM	Department Manual
DO	dissolved oxygen
DOA	Hawai‘i Department of Agriculture
DOCARE	Hawai‘i Division of Conservation and Resource Enforcement
DOE	Hawai‘i Department of Education
DOFAW	Hawai‘i Division of Forestry and Wildlife
DOH	Hawai‘i Department of Health
DOI	U. S. Department of Interior
EA	Environmental Assessment
EE	environmental education
e.g.	exempli gratia, “for example”
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
ESA	Endangered Species Act of 1973
F	Fahrenheit
FONSI	Finding of No Significant Impact
ft.	Feet (Foot)
GAO	Government Accountability Office
GHG	greenhouse gas(es)
gpm	gallon (U.S. fluid) per minute
HC&S	Hawaiian Commercial & Sugar Company
HDOT	Hawai‘i Department of Transportation
HQ/VC	headquarters and visitor center
Improvement Act	National Wildlife Refuge System Improvement Act of 1997
I&M	inventory and monitoring
in.	inch(es)
IPCC	Intergovernmental Panel on Climate Change

IPM	Integrated Pest Management
lb(s).	pound(s)
LCA	Land Commission Awards
MCPD	Maui County Planning Department
MEC	Maui Electric Company
mgd	Million gallons per day
mi.	mile(s)
MLLW	mean lower low water
mm	millimeter(s)
MOA	Memorandum of Agreement
N	Nitrogen
NAGPRA	Native American Graves Repatriation Act
NAS	Naval Air Station
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NTU	Nephelometric Turbidity Unit
NSM	National Staffing Model
NRCS	Natural Resources Conservation Service
NWHI	Northwestern Hawaiian Islands
NWR	National Wildlife Refuge
O	Oxygen
OPIC	Overseas Private Investment Corporation
P	Phosphorus
PCBs	Polychlorinated biphenyls
PCJV	Pacific Coast Joint Venture
PDO	Pacific Decadal Oscillation
pH	potential (of) hydrogen
PICCC	Pacific Islands Climate Change Cooperative
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PVC	polymerizing vinyl chloride
Refuge System	National Wildlife Refuge System
RHPO	Regional Historic Preservation Officer
Service, USFWS	U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Officer
Si	silicon
SLAMM	Sea Levels Affecting Marshes Model
SLR	Sea Level Rise
SRP	soluble reactive phosphorous
SRS	soluble reactive silicon
SUP	Special Use Permit
T&E	Threatened and Endangered
TOC	total oxygen content
TP	total phosphorus
TN	total nitrogen
TSS	total suspended solids

USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WWII	World War II
YCC	Youth Conservation Corps
yd(s).	yard(s)

Appendix K. Public Comments and Service Responses

In this appendix the Service responds to comments that were received on the Keālia Pond NWR Draft CCP/EA, August 2011 during the official public comment period from August 19-September 19, 2011. Comments were received via comment card and e-mail. All substantial comments regarding the Draft CCP/EA are presented below. Some comments have had formatting changes and other minor edits to correct spelling or punctuation, but the majority of comments are as received. Service responses indicate where changes were made to the CCP based on specific comments.

Index

Comments and Responses

1. Pat Waters

Comment:
As an owner in close proximity to Keālia Pond "Sugar Beach Resort" I am very concerned at any attempt to use water level as a mediation of midge population. The current level of control has been totally unsuccessful and the midges have been a complete out of control nuisance. The reason given by Ms. Nakai when she informed us that they were out of the methoprene at different times, pumps were down to so water level could not be controlled. I would hate to rely on water control based on prior performance on the pond management. Please do all that you can to reduce the nuisance of these midges, it is an economic disaster that has been promoted by the enhancement of the pond without proper management or oversight.

Service Response:
We are proposing to use an integrated pest management approach to control the adult midge population at Keālia Pond. As noted in your comment, we did not have proper water pumping equipment in the past to seasonally manipulate water level to reduce adult midge populations. Now, with installation of pumps and electrical service on Wells C and D which was completed in April 2011 and are now in operation, primarily when conditions are typically the driest (August-December) and data from our midge monitoring efforts, we believe water manipulation will reduce midge populations. We will continue to use methoprene as necessary in an integrated approach with water level manipulation to control excessive midge emergence from the Main Pond.

2. Richard and Laverne Stovicek

Comment:

Alternative C simply covers most of our concerns. As I recall, the bypass of the highway going on the east side of the pond was to be completed by 2020. Any news to verify the closing of the Hwy. and N.Kīhei Rd. would be a solution in keeping cars out of this area.

Service Response:

We will pursue discussions with the landowners, A&B and HC&S, to determine if it is a viable option. If the landowners endorse the possibility of a bypass, we can bring HDOT into the conversation for further evaluation. The HDOT was supportive of the proposal when it was proposed in association with a new housing project in Mā'alaea, which did not occur. If the landowners are not in favor of a N.Kīhei Rd. bypass, we will not pursue it.

Comment:

We now know more about the Keālia Pond!! And how very, very interesting. We have lived on Maui for over 30 years and finally know what a wonderful wildlife refuge we have in the Keālia Pond. Five Stars on the Comprehensive Conservation Draft Plan.

Service Response:

We appreciate the support expressed by this comment.

3. Diana Schulte

Comment:

In favor of Alternative C.

Service Response:

We appreciate the support expressed for our preferred Alternative.

4. Pam Daoust

Comment:

On behalf of the Mā'alaea Community Association (MCA) I am commenting here on the Kealia Pond NWR. We strongly support Alternative C. This Alternative appeals the most to us because:

a. It provides for the most comprehensive oversight of this community, island and State resource.

b. It offers the best opportunity for controlling water levels in the Refuge, the key element in the most successful management of the area.

c. It allows for better mitigation of the three nuisance issues associated with the refuge: control of insect populations (midges), control of blowing dust and sediment, and the tilapia problem.

d. It offers the best opportunity for protecting and expanding viable wildlife habitat, controlling alien species and eradicating predators, especially during nesting season.

e. It enhances opportunities for the public to enjoy the area and to participate in volunteer and educational activities.

Service Response:

We appreciate the support expressed for our preferred Alternative.

5. Skippy Hau, DAR

Comment:

I support Alternative C. It provides clear goals and objectives along with Environmental Education expansion for the next 15 years. (3-2) I strongly support a weather station or on-site monitoring and the new education center which should be an integral part in teaching climate and weather. Volunteer projects should be expanded with the Native Hawaiian Plant Society and Maui Botanical Garden (2-37)

Service Response:

We appreciate the support expressed for our preferred Alternative. Maui Nui Botanical Gardens and the Hawaiian Native Plant Society (Maui) have been added to the partnership list. Our list of partners was intended to provide examples and not be exhaustive. We welcome other partnerships to help us achieve the refuge purpose, Refuge System mission, and common goals.

Comment:

Will there be testing for contaminants? What is the status of the wells and possible pesticides and fertilizers coming from the sugarcane fields or the old Pu‘unēnē airfield. These nutrient sources should be identified and used for selected vegetation areas.

Service Response:

Soil and water analyses for Keālia Pond were completed in 2004 with no indication of contaminants in the brackish water wells, piezometers, surface water, and soils, even soil samples taken at the base of streams. Nutrients were also analyzed and were not detected at elevated levels.

Comment:

Are crayfish a serious problem? What about the status of axis deer, cattle egret, and other invasive species?

Service Response:

Crayfish are nonnative but do not pose a problem. They are eaten by ‘alae ke‘oke‘o and also fed to chicks – a good source of protein. Axis deer are on the Refuge; however, they are rarely seen and the staff has not seen evidence of negative impacts. Cattle egrets are a serious problem and we talk more about removal of their roosting areas in Chapter 4.

Comment:

Having Keālia Pond flowing into the ocean could improve estuary conditions for brackish and freshwater organisms. This could also allow tilapia and topminnows to re-infest drainage and gulch in South Maui areas that flow after heavy rain storms. What about the *Na Wai Eha* study?

Service Response:

It would not be appropriate for the Service to re-infest other drainages with nonnative tilapia and topminnows. As long as the ocean currents remain the same, the outlet will remain a sandplug with breaching during heavy rain events and high water.

The legal battle over Na Wai ‘Eha streamflow dates back to 2004, when Maui community groups petitioned the CWRM to restore the Waihe‘e, North & South Waiehu, ‘Iao, and Waikapū Streams. The final decision in 2009 did not direct any changes to the Waikapū Stream; the flow remained the same as what was designated in 1988.

Comment:
Has the Service considered the possibility of a resident caretaker or the building of a dorm to house visiting researchers or weekend education activities?

Service Response:
Neither of these actions (construction of a dorm or resident caretaker) were considered in this CCP.

Comment:
The Refuge or Rotary Clubs should not be the only ones actively managing the beach and dune areas. Together with the County and HDOT, a long-term management plan would be helpful. The recycled fence needs to be better aligned with dune protection. Dune accretion is allowed to blow across Kīhei Road. Camping and beach activities need to be better managed. What is being planned for the Boardwalk? Is there a landscaping plan? Will alien species removal or establishment of native plants be addressed?

Service Response:
Only a small portion of the dunes lie within the Refuge property. Restoration of the dunes is accomplished in coordination with a number of different agencies and groups (County, A&B Properties, CWD, HDOT, State Planning, Maui College, volunteer groups, etc.).

There is a rough restoration plan for the dunes and Boardwalk areas that includes removal of pest plant species and outplanting of native coastal plants. Replacement of plants is conducted as soon as possible to retain sand. In some areas the sand keeps building up along the vegetation and fence, and it does spill onto the highway. Camping and beach activities are not within our jurisdiction; however, if Refuge staff observes inappropriate use occurring on adjacent A&B Properties, we inform them and they notify/remove the people.

6. Jane Jermain

Comment:
None [of the alternatives] appeal to me!
In the 1970s into the 1980s the midges did not exist. The turtles are only affected by light at specific times but I would suggest putting strong flood lights at the visitor center and use them only at strategic times. Molokini has survived quite nicely without interference by NWR people.

The commenter also suggests reducing Refuge staff to save money; removal of the sandplug to allow tidal action; not pumping water; and removal of N. Kīhei Road.

Service Response:
According to the entomologist at Bishop Museum, the spotted-winged midge was first identified on Oʻahu in the early 1940s; however, we have no documentation indicating when the species initially occurred at Keālia Pond NWR on Maui. Although this same entomologist identified it at the Refuge in 1997, it was primarily because they were asked to sample and identify the species, and it is not valid to assume that was the first time they appeared at the Refuge. No matter when they first inhabited the pond, we are presently challenged with managing resources that have changed dramatically from outside sources (e.g., land use, loss of wetlands, and especially introduced nonnative invasive plant and animal species such as the spotted-wing midge). In 2002, we set up large lights around the ponds to deter the midges from going towards the lights at neighboring condominiums; yet, there was not a measureable decrease in midge abundance at the condominiums.

The Refuge has identified methods to control midges; however, it is not feasible or realistic to eradicate them entirely from the wetlands, including other wetlands in Kīhei.

We acknowledge that some residents may not see the value in protecting, preserving, and managing the natural resources, or like to see taxpayer dollars being directed to managing an area that they feel does not benefit them. However, we have strived to develop this plan with the purpose of restoring the wildlife habitat conditions and promoting wildlife-dependent public uses at Keālia Pond to meet our trust responsibility to conserve, manage, and restore fish, wildlife and plant resources for present and future generations of Americans in a cost-effective manner that does not significantly impact the human environment.

7. Fern Duvall

Comment:
Will Molokini remain "in" the State list of "seabird sanctuary system"? Or be managed in a compatible use only? The latter would be to remove it from the sanctuary system.

Service Response:
Once Molokini is established as an overlay refuge, it would no longer be a State-managed seabird sanctuary within the DLNR system. DOFAW's participation would be consultatory and would provide assistance in continuing the seabird monitoring program and development of a native plant restoration plan.

Comment:
CORRECTION NEEDED: *Nothocestrum latifolium* is ʻAiea the native tree; *Nicotiana glauca* is the non-native tree-tobacco. Molokini hosts a population of the tree-tobacco that could well support the Blackburn's Sphinxmoth. Monitoring the tree-tobacco plants for ʻōkai ʻaiea should occur. It is LIKELY that they occur on the plants on Molokini. They are known both from Maui and from Kahoʻolawe.

Service Response:
A correction was made with insertion of information re: tree tobacco host. We have included monitoring for ʻōkai ʻaiea when trips are made for planting.

Comment:
ʻIwa are known to regularly predate wedge-tailed shearwater chicks from shallow burrows on Molokini. Up to 163 ʻIwa have been counted at Molokini, when the shearwater chicks were young (end of August), hunting and grabbing chicks.

Service Response:
Thank you for sharing your expertise, we have added your sentence to the section.

Appendix L. Planning Team Members

The following members of the core planning team were responsible for preparing the CCP.

Glynnis Nakai	**Project Leader, Maui NWRC**
Michael Nishimoto	**Wildlife Biologist, Maui NWRC**
Laura Beauregard	**Refuge Planner, Hawaiian and Pacific Islands NWRC**
Tim Mayer	**Hydrologist, Region 1**

The following members of the extended planning team provided assistance and analysis to the core planning team of the CCP.

Sandra Hall	External Affairs Specialist, Hawaiian and Pacific Islands NWRC
Ben Harrison	Deputy Regional Chief, Region 1
Kevin Kilbride	Wildlife Biologist, Refuge Biology, Region 1
Mike Marxen	Chief, Visitor Services and Communications Division, Region 1
Barbara Maxfield	(former) External Affairs Specialist, Hawaiian and Pacific Islands NWRC
Scott McCarthy	Chief, Planning Division, Region 1
Lisa Oshiro-	Native Hawaiian Liaison, Department of the Interior, Honolulu
Donald Palawski	Deputy Project Leader, Hawaiian and Pacific Islands NWRC
Benton Pang	Native Hawaiian Liaison, Ecological Services, Honolulu
Fred Paveglio	(former) Chief, Branch of Refuge Biology, Region 1
Anan Raymond	Regional Archaeologist, Region 1
Pat Savino	Administrative Assistant, Maui NWRC
Barry Stieglitz	Project Leader, Hawaiian and Pacific Islands NWRC
Calvin Willis	Maintenance Worker, Maui NWRC

Maps were prepared by David Hoy.

Graphic design of cover by Patrick Stark.

Graphic design of Readers Guide by Sandra Hall.