Draft Revised Recovery Plan for Hawaiian Waterbirds

Second Draft of Second Revision

Clockwise from upper left:
Hawaiian ducks, Hawaiian stilt,
Hawaiian common moorhen, and Hawaiian coot.

Draft Revised Recovery Plan
for
Hawaiian Waterbirds,
Second Draft of Second Revision

(May 2005)

(Original approved 1978; First Revision approved 1985;
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Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, Region 1
U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXX

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- http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm
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Acknowledgments

Parts I and II of this recovery plan were drafted in 1997 for the U.S. Fish and Wildlife Service by Andrew Engilis, Jr. (then of Ducks Unlimited, currently of University of California, Davis) and Dr. Frederic A. Reid of the Western Regional Office of Ducks Unlimited. Modifications were made by Dr. Ann Marshall of the U.S. Fish and Wildlife Service, which resulted in the Draft Revised Recovery Plan for Hawaiian Waterbirds Second Revision dated May 1999. Since then, substantial revisions to the draft plan have been made by Leilani Takano and Dr. Eric VanderWerf of the U.S. Fish and Wildlife Service, including the addition of figures illustrating the population trend of each species and maps showing their abundance and distribution on each island. The primary authors of this second draft revised plan are Andrew Engilis, Jr., Dr. Ann Marshall, Dr. Frederic A. Reid, Leilani Takano, and Dr. Eric VanderWerf.

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Executive Summary

Current Species Status: This second draft revised recovery plan addresses four species of Hawaiian waterbirds: the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian coot or `alae ke`oke`o (*Fulica alai*), Hawaiian common moorhen or `alae `ula (*Gallinula chloropus sandvicensis*), and Hawaiian stilt or ae`o (*Himantopus mexicanus knudseni*), all listed as endangered. Historically, these four species were found on all of the main Hawaiian Islands except Lāna`i and Kaho`olawe. Currently, Hawaiian ducks are found on the islands of Ni`ihau, Kaua`i, O`ahu, Maui, and Hawai`i; Hawaiian coots and stilts are found on all of the main Hawaiian Islands except Kaho`olawe; and Hawaiian common moorhens are found only on the islands of Kaua`i and O`ahu. Population estimates based on the biannual waterbird count indicate the numbers of birds fluctuate among years and that currently none of these species consistently number more than 2,000 individuals, with the exception of the Hawaiian coot, but these estimates are reliable only for the coot and the stilt. Trend data collected over the past three decades show that Hawaiian coot, moorhen, and stilt populations are either stable or increasing. The status of the Hawaiian duck is difficult to judge due to the difficulty of distinguishing between Hawaiian ducks, feral mallards (*Anas platyrhynchos*), and hybrids. Hawaiian common moorhen numbers are difficult to estimate due to their secretive habits and use of densely vegetated wetland habitats.

Habitat Requirements and Limiting Factors: These endangered Hawaiian waterbirds are found in a variety of wetland habitats including freshwater marshes and ponds, coastal estuaries and ponds, artificial reservoirs, taro (*Colocasia esculenta*) patches, irrigation ditches, sewage treatment ponds, and in the case of the Hawaiian duck, montane streams and swamplands. The most important cause of decline of the four species of endangered Hawaiian waterbirds is loss of wetland habitat. Other factors that have contributed to waterbird population declines, and which continue to be detrimental, include predation by introduced animals, altered hydrology, alteration of habitat by invasive nonnative plants, disease, and possibly environmental contaminants. Hunting in the late 1800's and early 1900's took a heavy toll on Hawaiian duck populations, and to a lesser extent on populations of the other three endemic waterbirds (Swedberg 1967). Currently, predation by introduced animals may be the greatest threat to the coot, moorhen, and stilt, and hybridization with feral mallards is the most serious threat to the Hawaiian duck.

Recovery Priority Number: The recovery priority number for the Hawaiian duck is 2, on a scale of 1C (highest) to 18 (lowest; see Appendix D) reflecting a high degree of threat, a high potential for recovery, and the Hawaiian duck's taxonomic rank as a full

species. The moorhen and stilt each have a recovery priority number of 9, reflecting a moderate degree of threat, a high potential for recovery, and their taxonomic rank as a subspecies. The recovery priority number of 14 for the Hawaiian coot reflects a low degree of threat, a high potential for recovery, and taxonomic rank as a full species. The Hawaiian coot was considered a subspecies of the American coot (*Fulica americana*) at the time it was listed, but it was recently split from the American coot and is now regarded as a distinct species (*Fulica alai*; American Ornithologists' Union 1989).

Recovery Goal: The ultimate goal of the recovery program is to restore and maintain multiple self-sustaining populations of these Hawaiian waterbirds within their historical ranges, which will allow them to be reclassified to threatened status and eventually removed from the Federal List of Endangered and Threatened Wildlife and Plants.

Recovery Objectives: The recovery of the endangered waterbirds focuses on the following objectives:

1) increasing population numbers to statewide baseline levels (consistently stable or increasing with a minimum of 2,000 birds for each species);
2) establishing multiple, self-sustaining breeding populations throughout each species' historical range;
3) 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;
4) for all four species, eliminating or controlling the threats posed by introduced predators, avian diseases, and contaminants; and
5) for the Hawaiian duck, removing the threat of hybridization with feral mallards.

Recovery Criteria: For consideration of downlisting to threatened status, the following conditions must be met:

Hawaiian Duck downlisting criteria

Criterion 1. All core wetlands listed in Table 10 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2. Of the supporting wetlands listed in Table 11 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i, at least 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3. The statewide Hawaiian duck population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years;

Criterion 4. There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Maui, and Hawai`i; and

Criterion 5. The threat of hybridization with feral mallards is removed from all islands.

Hawaiian Coot downlisting criteria

Criterion 1. All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide coot population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i.

Hawaiian Common Moorhen downlisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i and O`ahu are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i and O`ahu, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide moorhen population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i and O`ahu, and on Maui/Moloka`i and/or Hawai`i.

Hawaiian Stilt downlisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide stilt population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, including populations on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i.

To consider delisting of the four species, the following criteria must be met:

Hawaiian Duck delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide Hawaiian duck population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years;

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Maui, and Hawai`i; and

Criterion 5: The threat of hybridization with feral mallards is removed from all islands.

Hawaiian Coot delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide coot population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/ Lāna`i.

Hawaiian Common Moorhen delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i and O`ahu are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i and O`ahu, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide moorhen population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Hawai`i, and Maui/Moloka`i.

Hawaiian Stilt delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide stilt population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/ Lāna`i.

Recovery Actions Needed:

1) Protect and manage core and supporting wetland habitats in order to maximize productivity and survival of endangered waterbirds. This would include the following actions: develop written management plans; secure water sources; manage water levels; manage vegetation; control predation; monitor waterbird populations and reproductive success; remove the threat of mallard-Hawaiian duck hybridization; minimize human disturbance; and monitor and control avian diseases and environmental contaminants (Tables 10 and 11). Some of these wetland habitat areas already have protected status but need to be more actively managed.

2) Conduct research to better understand factors limiting Hawaiian waterbird population numbers, refine recovery objectives, and improve management techniques.

3) Establish a Hawaiian duck population on one additional island and moorhen populations on two additional islands.

4) Plan and implement an education program to increase landowner and land manager knowledge of waterbird needs and increase public support for waterbird recovery.

5) Reevaluate recovery objectives as additional information becomes available.

Date of Recovery: Downlisting to threatened status could be initiated in 2010 and delisting could be initiated in 2015, if recovery criteria are met.

Total Cost of Recovery: The total estimated cost to implement all recovery actions for all four species as described in the Recovery Actions Narrative over the next 10 years is $18,059,000 This figure may be substantially reduced with the development of more effective methods to address threats such as predator control. Certain costs, such as for some research actions, have yet to be determined. The estimated costs for the first 5 years of recovery implementation is $11,369,000; a detailed breakdown of these costs is provided in the Implementation Schedule.

In addition to benefitting the four species of waterbirds addressed in this plan, the recovery actions described are also likely to aid in the recovery of the endangered Laysan duck (*Anas laysanensis*) and nēnē or Hawaiian goose (*Branta sandvicensis*). Fossil records indicate that the Laysan duck was formerly found throughout the main Hawaiian Islands, but it is currently restricted to the island of Laysan in the Northwestern Hawaiian Islands. Management of wetlands in the main islands, particularly control of introduced predators, could make them potentially suitable sites for reintroduction of Laysan ducks. Similarly, nēnē are currently found primarily in upland areas on most islands, but they have been reestablished in low elevation wetlands at Hanalei National Wildlife Refuge on Kaua`i. Management and control of predators could provide suitable sites for reintroduction of nēnē into other low elevation wetlands, where they can forage on the lush vegetation.

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I. Introduction and Overview

A. INTRODUCTION

Hawai`i accounts for less than 1 percent of the total land mass of the United States, yet it is home to approximately 40 percent of all animal and plant species federally listed as threatened or endangered (U.S. Fish and Wildlife Service [USFWS] 2004a). A total of 109 endemic (*i.e.*, found only in Hawai`i) species and subspecies of birds have been described in the Hawaiian Islands, 35 (32 percent) of which are still extant (Scott *et al.* 2001). Reasons for losses of many of the Hawaiian birds have been well documented, including destruction and alteration of habitat, hunting, introduced predatory mammals and nonnative birds, and diseases (Warner 1968; Atkinson 1977; van Riper *et al.* 1986; Cuddihy and Stone 1990; Engilis and Pratt 1993; Scott *et al.* 2001).

The Hawaiian Islands historically supported a diverse array of waterbirds in both wetland and forest habitats. At least 30 waterbird species are known from historical and fossil records (Scott *et al.* 2001). During the past 2,000 years of human presence, all of Hawai`i's endemic rails, flightless geese, and an ibis have become extinct (Olson and James 1991). This massive extinction is attributed to the impacts of humans and the plants and animals they introduced to Hawai`i. Both Polynesian and European settlers have played significant roles in the alteration of Hawaiian ecosystems and the resulting extinctions of species (Kirch 1982, 1983; Olson and James 1992).

The six endemic species of waterbirds that persist today are the Hawaiian duck or koloa maoli (*Anas wyvilliana*), Laysan duck (*A. laysanensis*), Hawaiian coot or `alae ke`oke`o (*Fulica alai*), Hawaiian common moorhen or `alae `ula (*Gallinula chloropus sandvicensis*), Hawaiian stilt or ae`o (*Himantopus mexicanus knudseni*), and the Hawaiian goose or nēnē (*Branta sandvicensis*). All of these species, with the exception of nēnē, require wetlands for their survival, and all are listed as endangered. Recovery actions for the Laysan duck and the nēnē are outlined in separate recovery plans (USFWS 2004b,c). In this document, unless otherwise noted, the term "endangered waterbirds" refers to the four species addressed by this plan: the Hawaiian duck, Hawaiian coot, Hawaiian common moorhen, and Hawaiian stilt. These four species are currently found on various "main Hawaiian Islands" (Figure 1). The term "main Hawaiian Islands" refers to the following eight islands: Ni`ihau, Kaua`i, O`ahu, Maui, Moloka`i, Lāna`i, Kaho`olawe, and Hawai`i (also known as "the Big Island"). The islands of Maui, Moloka`i, and Lāna`i collectively comprise "Maui Nui."

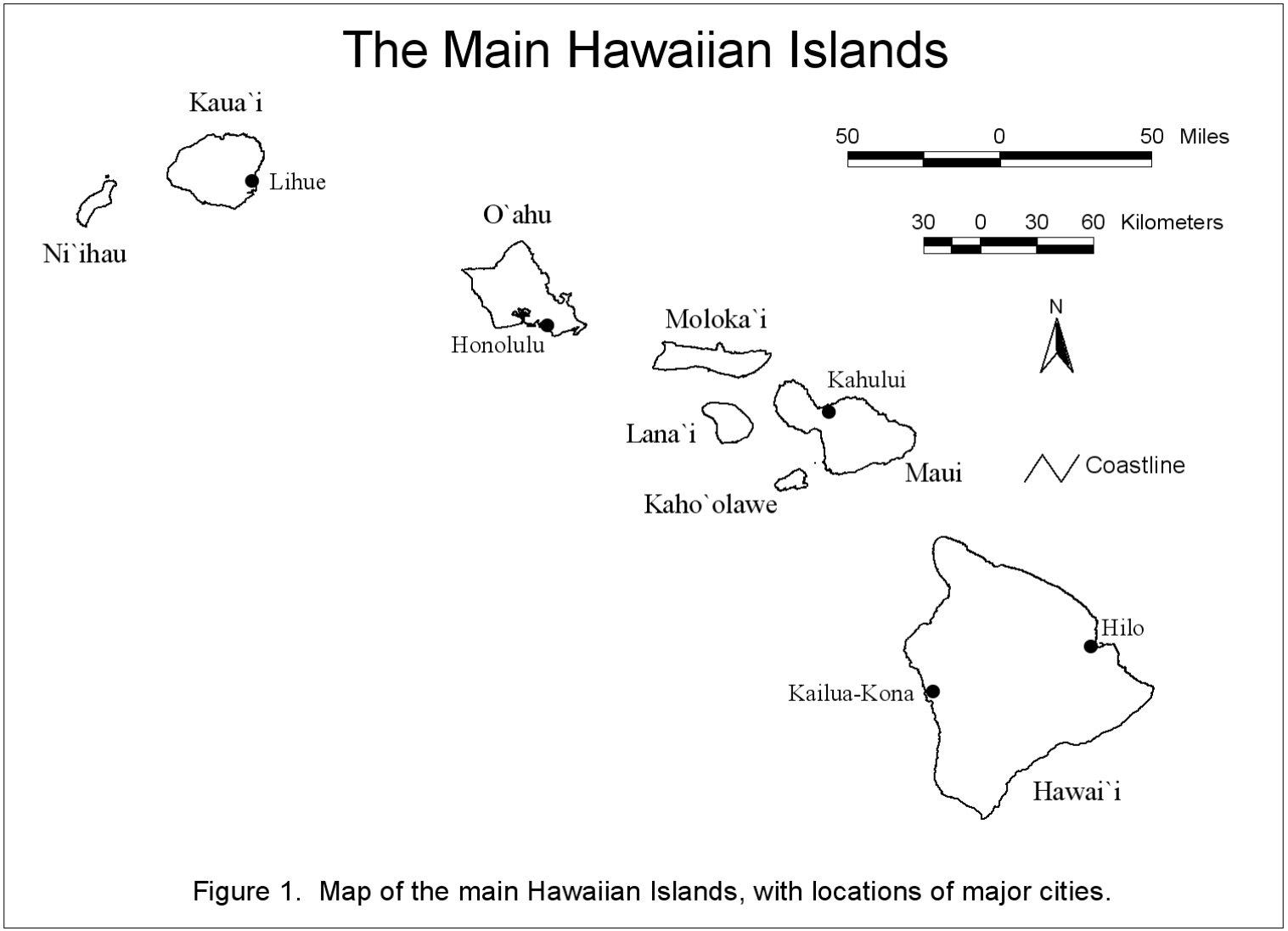

Figure 1. Map of the main Hawaiian Islands, with locations of major cities.

The Hawaiian duck and Hawaiian common moorhen were added to the Federal List of Endangered and Threatened Plants in 1967 (USFWS 1967), and the Hawaiian coot and stilt were added to this list in 1970 (USFWS 1970a). Recovery priority numbers ranging from 1C to 18 (1C being highest priority) are assigned to each listed species based on degree of threat, recovery potential, taxonomic status, and conflict with human activities (USFWS 1983a,b; Appendix D). Recovery priority numbers with a letter designation of "C" indicate conflict with human economic activity. The recovery priority number of 2 for the Hawaiian duck reflects a high degree of threat, a high potential for recovery, and its taxonomic status as a full species, which is given a higher priority than a subspecies. The Hawaiian common moorhen and Hawaiian stilt each have a recovery priority number of 9, reflecting a moderate degree of threat, a high potential for recovery, and their taxonomic status as subspecies. The recovery priority number of 14 for the Hawaiian coot reflects a low degree of threat, a high potential for recovery, and its taxonomic status as a distinct species. The Hawaiian coot was considered a subspecies of the American coot (*Fulica americana*) at the time it was listed, but it was recently split from the American coot and is now regarded as a distinct species (*Fulica alai*; American Ornithologists' Union [AOU] 1989). Critical habitat has not been designated for any of these species.

B. SPECIES ACCOUNTS

1. Hawaiian Duck or Koloa Maoli

(a) Taxonomy. The Hawaiian duck or koloa maoli (*Anas wyvilliana*) was first described in 1851. At the time, it was considered to be a species or possibly a subspecies of the mallard (*Anas platyrhynchos*). However, more recent genetic studies indicate that the Hawaiian duck is distinct at the species level and is closely related to the mallard (AOU 1983; Browne *et al.* 1993). Allozyme data indicate there has been extensive hybridization between Hawaiian ducks and feral mallards on O`ahu, with the near disappearance of Hawaiian duck alleles from the population on that island (Browne *et al*. 1993). On Maui, Kaua`i, and Hawai`i, Hawaiian duck-mallard hybrids have been documented but occur in apparently low numbers (Engilis *et al.* 2002; Hawai`i Department of Land and Natural Resources [HDLNR] 1976-2003).

(b) Species Description. The Hawaiian duck is a small (mean weight of males 604 grams [19 ounces], females 460 grams [15 ounces]), drab-brown duck (Griffin and Browne 1990). Both sexes are mottled brown and similar in appearance to a female mallard (Figure 2). Adult males are dark brown, variably spotted and mottled, with distinctive dark brown chevrons on the breast, flank, and back

Figure 2. Hawaiian duck female (front) and male. USFWS file photo.

feathers, and an olive bill (Engilis *et al.* 2002). Adult females are similar but are slightly smaller than males on average, and slightly lighter in color, with plainer, buff-colored chin and back feathers (Engilis *et al.* 2002). Both sexes have emerald green to blue speculums (brightly colored areas on the wings), bordered both in front and back by white, with orange to yellow-orange legs and feet. The plumage of first-year male Hawaiian ducks resembles the eclipse (non-breeding) plumage of male mallards, with a subdued green head and black upper and under-tail coverts (the short feathers covering the base of the tail feathers).

In areas where hybridization occurs with mallards, it may be difficult to distinguish between Hawaiian ducks, female mallards, and hybrids. Hawaiian ducks and mallards differ in size, behavior, voice, and coloration. The extent of the differences between these two species and hybrids is dependent upon the extent of hybridization at the location, the plumage at that time of year, and variation among individuals and islands, making it difficult to distinguish Hawaiian ducks and hybrids based on phenotypic (visible) characteristics alone. Research that combines morphological measurements and genetic identification, partly funded by the U.S. Fish and Wildlife Service, is currently being conducted in order to develop reliable criteria for distinguishing between Hawaiian ducks, female mallards, and hybrids (A. Engilis, Ducks Unlimited [formerly], pers. comm. 2003). Hawaiian ducklings can be distinguished from mallard ducklings more easily than adults. Hawaiian ducklings are primarily dark brown with a yellow mark on the chin, and do not have a yellow eyestripe or flank spot as do mallard ducklings (F. Duvall, Hawai`i Division of Forestry and Wildlife, pers. comm. 2004).

(c) Historical Range and Population Status. Hawaiian ducks were known historically from all of the main Hawaiian Islands except Lāna`i and Kaho`olawe. There are no population estimates prior to 1940, but in the 1800's they were fairly common in natural and farmed wetland habitats (Engilis *et al.* 2002). The arrival of the Polynesian people in Hawai`i about 1,600 years ago (Kirch 1982) and their cultivation of taro (*Colocasia esculenta*), an agricultural crop grown in a pond-like environment, considerably increased the amount of wetland habitat in the islands (Swedberg 1967). Rice (*Oryza sativa*) cultivation from the late 1800's to the 1940's continued to

provide wetland habitat for the Hawaiian duck. A decline in flooded agriculture had occurred by 1900, but there were still about 7,700 hectares (19,000 acres) of taro and 6,500 hectares (16,000 acres) of rice at that time (Bostwick 1982).

A variety of factors, including predation of eggs and chicks by rats (*Rattus* spp.), mongooses (*Herpestes auropunctatus)*, domestic dogs *(Canis familiaris*), domestic cats (*Felis catus*), introduced fish and birds, habitat reduction due to changes in agricultural practices and urban development, and local hunting pressure, brought about a significant population decline of the Hawaiian duck early in the 20th century. Introduced ungulates such as pigs (*Sus scrofa*) and goats (*Capra hircus*) have significantly impacted Hawaiian duck nesting habitat along Kauai's montane streams (T. Telfer, Hawai`i Division of Forestry and Wildlife, and A. Engilis, Ducks Unlimited, pers. comm. 1992). In 1949, an estimated 500 Hawaiian ducks remained on Kaua`i, and about 30 on O`ahu. By that time, Hawaiian ducks were considered only an occasional visitor to the island of Hawai`i, and were presumed extirpated on Maui and Moloka`i (Schwartz and Schwartz 1949). By 1960, they were apparently extirpated on O`ahu when Kaelepulu Pond in Kailua, the last Hawaiian duck stronghold on O`ahu, was modified as part of a housing development. By the 1960's, Hawaiian ducks were found in small numbers only on Kaua`i and probably on Ni`ihau.

From the late 1950's through the early 1990's, Hawaiian ducks were reintroduced to O`ahu, Maui, and Hawai`i (Paton 1981; Bostwick 1982; Engilis *et al.* 2002) through captive propagation and release (see Federal and State Actions under Section E, Conservation Measures, for details). Although populations of Hawaiian ducks still exist on each of these islands, these populations are impacted by hybridization with feral mallards to varying degrees.

(d) Current Range and Population Status. Engilis *et al.* (2002) estimated the current statewide population of pure Hawaiian ducks to be 2,200 birds, with 2,000 on Kaua`i and 200 on Hawai`i. The biannual waterbird count[1] produces a lower number, an average of 337 based on winter counts from 1998 through 2003, primarily because this survey does not include montane streams that harbor much of the Hawaiian duck population on Kaua`i and Hawai`i. In addition, approximately 300 and 50 Hawaiian duck-like birds occur on O`ahu and Maui, respectively, some of which may be Hawaiian ducks, with the remainder being mallard-Hawaiian duck hybrids. The total Hawaiian duck population appears to be increasing based on the biannual waterbird count, due primarily to increases in the Hawaiian duck population on Kaua`i, but Hawaiian

[1]See Section F. Monitoring (p. 63), for a description of the biannual waterbird counts.

ducks are declining on other islands (Figures 3 and 4) due to hybridization (Engilis and Pratt 1993; see Figures 23 –25, pages 54–56). On Kaua`i, seasonal movement of birds occurs from lowland wetlands to more secluded habitats in summer. Differences between the summer and winter bird surveys could represent altitudinal movements, dispersal up stream valleys, or possibly a reclusive post-breeding molt period.

**i. Kaua`i Population.** The Hawaiian duck population on Kaua`i has maintained itself without the release of captive-bred birds. Lowland surveys during the 1940's and 1950's estimated the population at 500 birds. Surveys in the 1960's estimated a population of 3,000 Hawaiian ducks (Swedberg 1967), mostly in remote montane streams and valleys. This apparent increase was probably a result of the underestimation of birds in the mountainous stream habitat by earlier observers. The island population was estimated to be between 1,500 and 2,000 Hawaiian ducks in 1988 (T. Telfer, pers. comm. 1988). The most recent estimate placed the Kaua`i population at 2,000 birds (Engilis *et al.* 2002). The Hawaiian duck population on Kaua`i is substantially larger than on all other islands combined. This comparatively large population size is probably due to the lack of an established population of mongooses and very low occurrence of hybridization. However, the threat of hybridization with mallards and its potential to increase on Kaua`i is of great concern, and mongooses have been detected recently on Kaua`i.

Many Hawaiian ducks on Kaua`i use lowland ponds and wetlands primarily for feeding and loafing, and nest along montane streams. Hawaiian ducks use the Hanalei National Wildlife Refuge and nearby taro fields throughout the year. They feed primarily in the taro lo`i (ponds), with a small number of ducks breeding in the area. Numbers of Hawaiian ducks increased at the refuge with the creation of impoundments in the 1980's and 1990's, which initially provided additional loafing areas. Modifications to the impoundments in 1999 provided additional foraging habitat. Manmade reservoirs, particularly near Līhu`e and on the Mānā Plain, are also used by Hawaiian ducks.

**ii. O`ahu Population**. Hawaiian ducks were reintroduced to O`ahu through a captive propagation and release program between 1958 and 1982. During this period, a total of 326 Hawaiian ducks were released by State biologists at Kawainui Marsh (177 birds), Nu`upia Ponds (45), Waimea Falls Park (66), and Ho`omaluhia City and County Park (38). However, the status of Hawaiian ducks on O`ahu is questionable due to the abundance of mallard-Hawaiian duck hybrids. A genetic study by Browne *et al.* (1993) found that all birds sampled on O`ahu were hybrids, although the sample of birds tested was small. Biannual

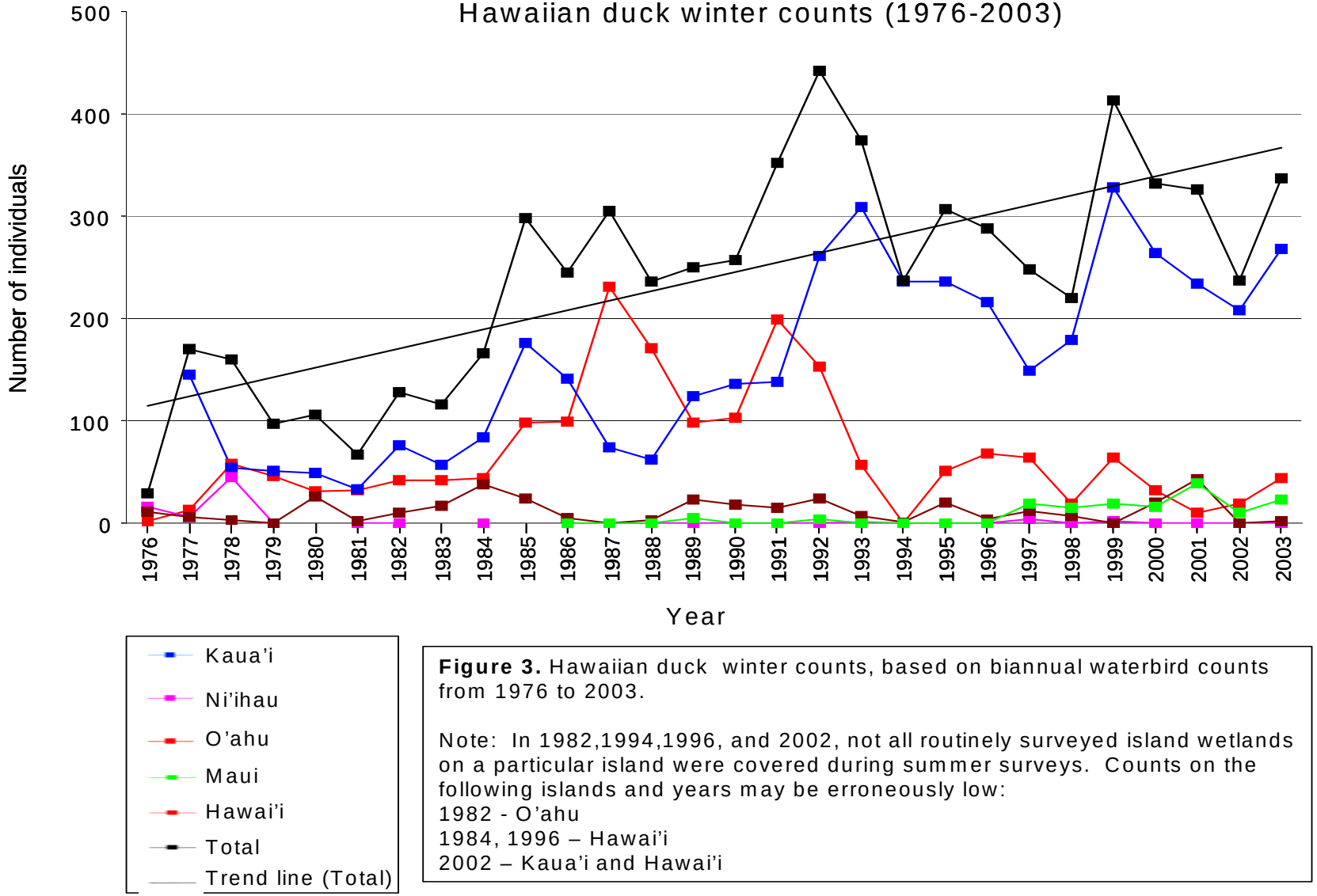

Figure 3. Hawaiian duck winter counts, based on biannual waterbird counts from 1976 to 2003.

Note: In 1982,1994,1996, and 2002, not all routinely surveyed island wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982 - O'ahu
1984, 1996 – Hawai'i
2002 – Kaua'i and Hawai'i

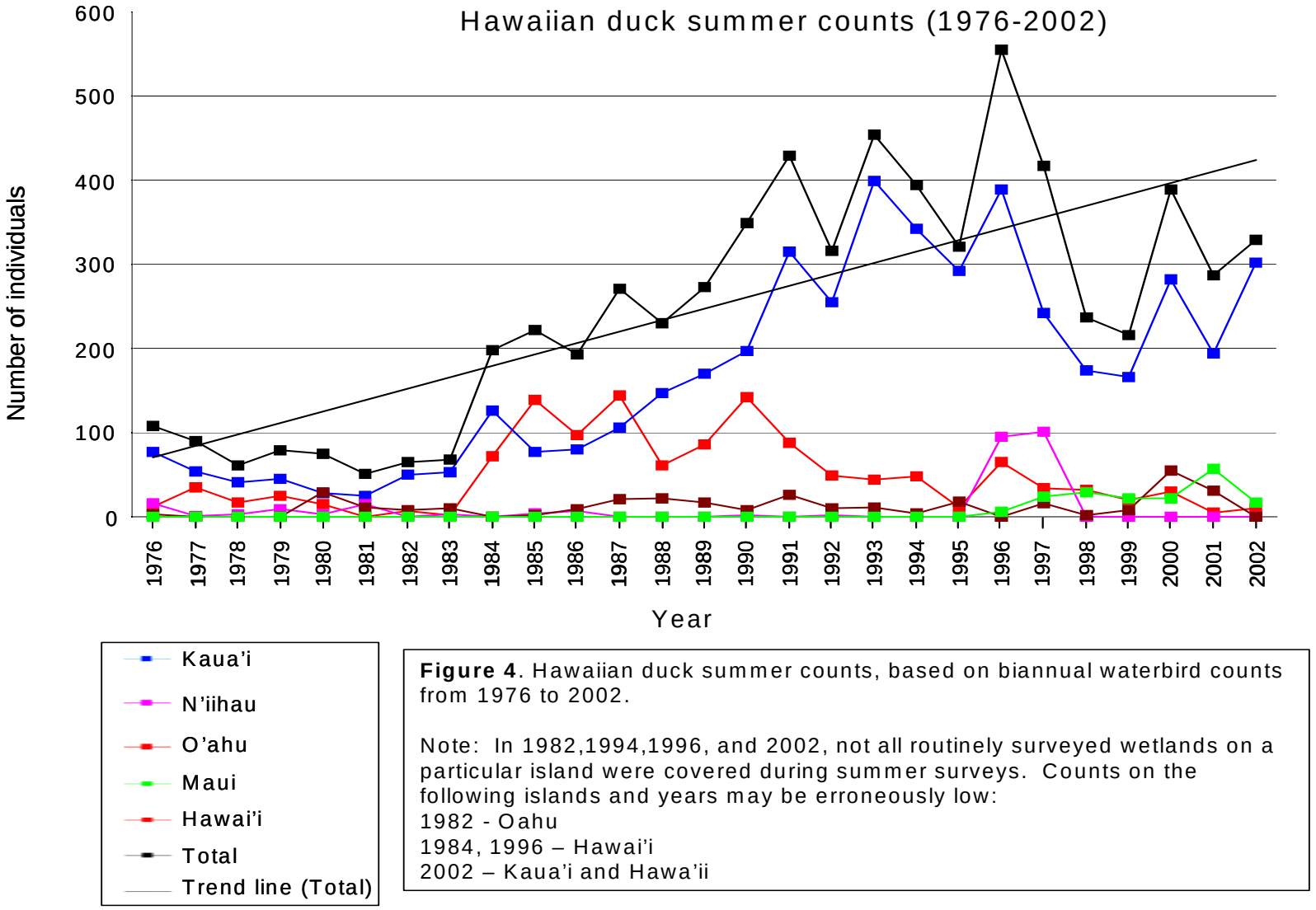

Figure 4. Hawaiian duck summer counts, based on biannual waterbird counts from 1976 to 2002.

Note: In 1982,1994,1996, and 2002, not all routinely surveyed wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982 - Oahu
1984, 1996 – Hawai'i
2002 – Kaua'i and Hawa'ii

waterbird surveys indicate a decreasing population trend over the past 5 years for the Hawaiian duck on O`ahu (Figures 3 and 4), while the number of mallard-Hawaiian duck hybrids has increased (Figure 23, page 54). Hawaiian ducks are still reported from wetlands on the windward coast of O`ahu (Kawainui, Hāmākua, and He`eia Marshes, Ka`elepulu and Nu`upia Ponds, and Ho`omaluhia Botanical Garden), north shore (James Campbell National Wildlife Refuge, Kahuku aquaculture ponds, Punaho`olapa, Hale`iwa), Pearl Harbor area (Pearl Harbor National Wildlife Refuge, Pouhala Marsh), and Lualualei (Figure 19, page 50), but whether these are Hawaiian ducks or hybrids is not clear.

iii. Maui Population. A release of fewer than 12 captive-bred Hawaiian ducks was conducted on Maui by the State of Hawai`i in 1989. From these birds, a small breeding population was established (F. Duvall, pers. comm. 2004). Currently, the Hawaiian duck population probably numbers fewer than 20 birds, which occur primarily at Kanahā Pond (Figure 15, page 36). Mallards were not eradicated from Maui prior to the release of Hawaiian ducks, and hybridization is now occurring. Biannual waterbird counts over the past 5 years indicate hybrids may outnumber Hawaiian ducks (HDLNR 1976-2003; Figures 20 and 24, pages 51 and 55).

**iv. Hawai`i Population**. The number of Hawaiian ducks on Hawai`i was estimated to be 200 by Engilis *et al.* (2002). The number of Hawaiian ducks counted on the biannual waterbird surveys is much lower (Figures 21 and 25, pages 52 and 56), but these surveys do not include montane stream habitat in Kohala where many ducks occur. Hawaiian ducks were reestablished on the island of Hawai`i between 1976 and 1982, when captive-bred birds were released in the Kohala Mountains. Some birds have dispersed from release sites and have been recorded up to 32 kilometers (20 miles) away (Giffin 1982). They have been observed using stock ponds in the Kohala Mountains, stream habitats of Pololū, Waimanu, and Waipio Valleys, and on Mauna Kea in stock ponds and larger montane streams. Successful breeding in the wild has been documented in the Kohala Mountains and at Hakalau Forest National Wildlife Refuge. Hawai`i's upper elevation Hawaiian duck population was thought to be genetically pure and isolated from lowland populations of mallards, but pair bonds between Hawaiian ducks and mallards have been observed in the Hilo area (Engilis *et al.* 2002), and more recently hybrid birds have been documented to occur on Hawai`i's lowland wetlands (Figure 21, page 52; A. Engilis, pers. comm. 2003).

(e) Life History. Hawaiian ducks breed year-round, but the majority of nesting records are from March through June (Engilis *et al.* 2002). In Kaua`i lowlands, Hawaiian ducks form pair bonds between November and May, with pairs dispersing to montane nesting localities. Hawaiian duck numbers

fluctuate seasonally at Hanalei National Wildlife Refuge, with the highest numbers in September and lowest numbers in June and July (A. Asquith, Hanalei National Wildlife Refuge, pers. comm. 1999). These seasonal changes may reflect dispersal into montane areas during the breeding season, perhaps indicating a later breeding period for these Kaua`i birds. Some pairs find suitable nesting habitat in lowland wetlands.

Nests are on the ground near water, but little else is known of their specific nesting habits. There have been few documented records of nesting in areas populated by humans, particularly where cats, dogs, or mongooses are common. Clutch size ranges from 2 to 10 eggs (mean = 8.3) (Swedberg 1967). Incubation lasts approximately 30 days, with most chicks hatching from April to June.

Hawaiian ducks are usually found alone or in pairs and are wary, particularly when nesting or molting. Hawaiian ducks may congregate in substantially larger numbers when loafing or exploiting rich food sources. Concentrations of 200 or more Hawaiian ducks have been observed at Hanalei National Wildlife Refuge. They are strong flyers and usually fly at low altitudes. Hawaiian ducks exhibit intra-island movement but dispersal tendencies are still unclear (Engilis *et al.* 2002).

Hawaiian ducks, like mallards, apparently are opportunistic feeders. Foods consumed include snails, insect larvae, earthworms, grass seeds, rice, green algae, and seeds and leaf parts of wetland plants (Swedberg 1967). Feeding in wetlands and streams typically occurs in water less than 24 centimeters (9.4 inches) deep (Engilis *et al.* 2002).

(f) Habitat Description. The Hawaiian duck historically used a wide variety of natural wetland habitats for nesting and feeding, including freshwater marshes, flooded grasslands, coastal ponds, streams, montane pools, and forest swamplands at elevations ranging from sea level to 3,000 meters (9,900 feet). Agricultural and artificial wetlands such as taro, lotus (*Nelumbo nucifera*), shrimp, fish, and sewage treatment ponds supplement natural wetland habitats and provide important feeding habitat for the Hawaiian duck. They may also use irrigation ditches, flooded ephemeral fields, reservoirs, and the mouths of larger streams for feeding or nesting.

Swedberg (1967) estimated that 90 percent of the Hawaiian duck population on Kaua`i lives along that island's extensive upland stream system, between 300 and 1,200 meters (1,000 to 4,000 feet) elevation. A typical stream used by the Hawaiian duck on the Big Island is 7 meters (23 feet) wide, swiftly flowing, strewn with boulders, and has heavily vegetated banks (Paton 1981). However, little information is available

on habitat use of upland stream systems by the Hawaiian duck.

Ephemeral wetlands are important habitat for the Hawaiian duck, although how they are used beyond foraging is unknown (Engilis *et al.* 2002). Hawaiian ducks move regularly between Ni`ihau and Kaua`i in response to above-normal precipitation and the flooding and drying of Ni`ihau's ephemeral wetlands (Engilis 1988; Engilis and Pratt 1993). More information is needed on movements of the Hawaiian duck in response to the availability of seasonal and permanent wetland habitats between the summer (dry) and winter (wet) seasons.

(g) Species-specific Threats. Hybridization with feral mallards is currently the primary threat to the recovery of the Hawaiian duck. Extensive hybridization has occurred on O`ahu and Maui, with limited hybridization on Kaua`i and Hawai`i. Hybridization is unlikely to occur with wild migratory mallards that winter or pass through the islands since migrants occur in Hawai`i during their non-breeding season. Damage to watersheds by pigs, goats, and other feral ungulates may pose direct impacts to nesting habitat. Other limiting factors that threaten all of Hawai`i's waterbirds are covered in the "Reasons for Decline and Current Threats" section of this recovery plan.

2. Hawaiian Coot or `Alae Ke`oke`o

(a) Taxonomy. The Hawaiian coot or `alae ke`oke`o (*Fulica alai*) is endemic to the Hawaiian Islands. In the past the Hawaiian coot was considered a subspecies of the American coot (*Fulica americana*) and was originally listed under the Endangered Species Act as such, but it is now regarded as a distinct species (AOU 1993). The Hawaiian coot is nonmigratory and presumably originated from stray migrants from continental North America that remained as residents in the islands (Brisbin *et al.* 2002).

(b) Species Description. The Hawaiian coot is smaller in body size than the American coot, and the bulbous frontal shield above the bill is distinctly larger than that of the American coot and is usually completely white (Shallenberger 1977; Pratt *et al.* 1987. A small percentage of the Hawaiian coot population has a red lobe at the top of the frontal shield and deep maroon markings at the tip of the bill, similar to the American coot (Pratt *et al.* 1987; Figure 5-A).

Figure 5-A. Color variation in frontal shields and bills of Hawaiian coots. Photo by Eric VanderWerf.

Figure 5-B. Hawaiian coot. Photo by Eric VanderWerf.

Adult coots are dark, slate-gray in color, with white undertail feathers. Male and female coots are similar in color. Coots have large feet with lobed toes, unlike the webbed feet of ducks (Figure 5-B). Immature coots are a lighter gray with buff-tipped contour feathers, smaller, dull white bills, and lack a well-developed frontal shield. Downy chicks have red skin and a bill with a yellow tip, similar to that of the American coot (Brisbin *et al.* 2002).

(c) Historical Range and Population Status. Hawaiian coots historically occurred on all of the main Hawaiian Islands except Lāna`i and Kaho`olawe, which lacked suitable wetland habitat. Coots have always been most numerous on O`ahu, Maui, and Kaua`i (Shallenberger 1977). It is likely that they were once fairly common in large natural marshes and ponds and used wetland habitats created by Hawaiians for taro cultivation and large scale fish production.

No population estimates are available prior to the 1950's, however Schwartz and Schwartz (1949) identified a decline and potential threat of extinction in the first half of this century. Censuses from the late 1950's to the late 1960's indicated a population of fewer than 1,000 birds, contributing to the Federal listing of the Hawaiian coot as endangered (USFWS 1978).

(d) Current Range and Population Status. Hawaiian coots currently inhabit all of the main Hawaiian Islands except Kaho`olawe. Based on winter counts from biannual waterbird surveys from 1998 through 2003 (2002 was excluded due to missing data), the coot population averaged 2,100 birds and fluctuated between 1,500 and 3,000 birds (HDLNR 1976-2003). Summer counts were generally more variable than winter counts due to the variability in hatch-year bird survival. As coots are conspicuous and often use open water areas, they are relatively easy to census, so these data are considered fairly accurate minimum population estimates. Not all wetlands are counted, but the population numbers at least 2,100 coots, with Kaua`i, Oahu, and Maui supporting 80 percent of these birds. Engilis and Pratt (1993) reported the statewide coot population to range from 2,000 to 4,000 birds.

Survey data from 1976 through 2003 reveal short-term population fluctuations, with a long-term slightly increasing population trend overall (Figures 6 and 7). Coots are known to

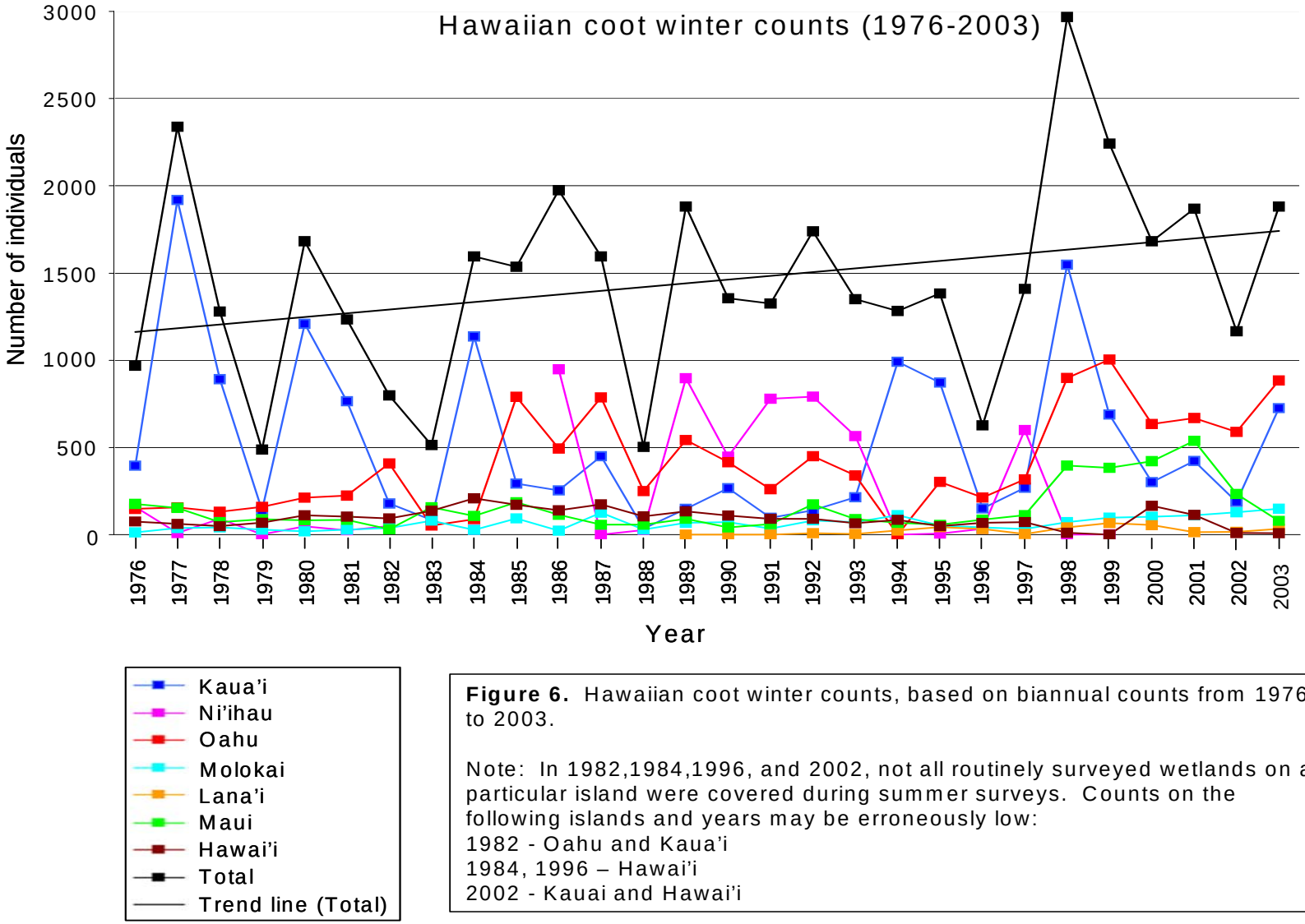

Figure 6. Hawaiian coot winter counts, based on biannual counts from 1976 to 2003.

Note: In 1982,1984,1996, and 2002, not all routinely surveyed wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982 - Oahu and Kaua'i
1984, 1996 – Hawai'i
2002 - Kauai and Hawai'i

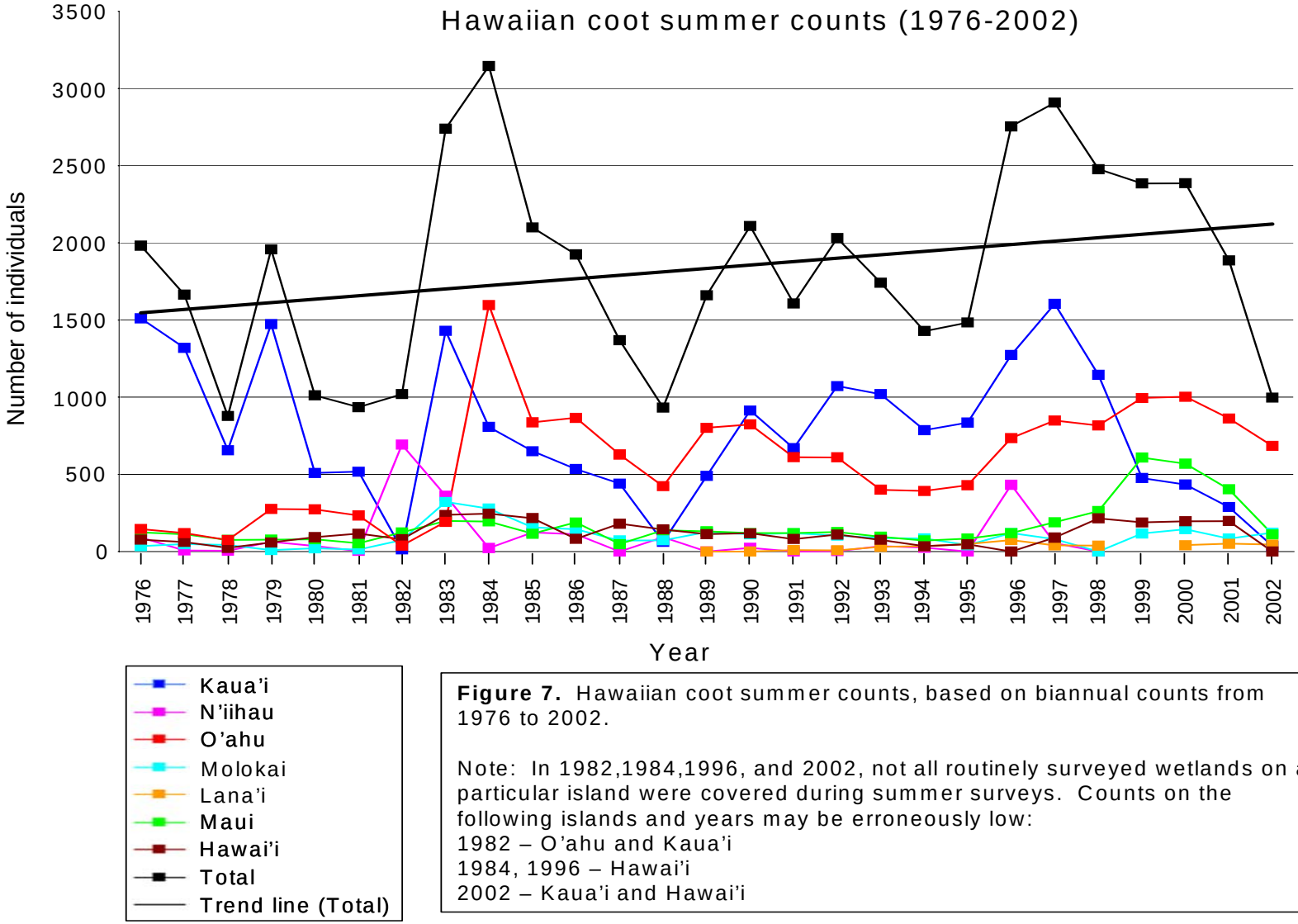

Figure 7. Hawaiian coot summer counts, based on biannual counts from 1976 to 2002.

Note: In 1982,1984,1996, and 2002, not all routinely surveyed wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982 – O'ahu and Kaua'i
1984, 1996 – Hawai'i
2002 – Kaua'i and Hawai'i

disperse readily and exploit seasonally flooded wetlands, thus their populations will naturally fluctuate according to climatic and hydrologic conditions (Engilis and Pratt 1993). The large playa lakes on Ni`ihau have supported large numbers of coots in wet years.

i. Kaua`i and Ni`ihau Populations. On Kaua`i, coots occur primarily in lowland valleys, such as Hanalei, Lumaha`i, and `Ōpaeka`a, and in reservoirs, but they have occasionally been observed in plunge pools at elevations above 1,500 meters (4,950 feet) (HDLNR 1989). Over the past 5 years (excluding 2002 due to missing data), the coot population on Kaua`i has fluctuated between 300 and 1,500 birds (HDLNR 1976-2003). Some of this variation is due to dispersal of coots to Ni`ihau in wet years. Several authors have speculated that annual migration occurs between Kaua`i and Ni`ihau, but statewide surveys indicate that these movements are less frequent, usually occurring when annual precipitation is above normal and Ni`ihau's ephemeral lakes become flooded (Engilis and Pratt 1993). Numbers of coots counted on Ni`ihau during wet winters include 949 birds in 1986 and 803 birds in 1996, but Ni`ihau has not been surveyed since 1999.

**ii. O`ahu Population**. On O`ahu, the coot population has fluctuated between approximately 500 and 1,000 birds in recent years (HDLNR 1976-2003). O`ahu's extensive coastal wetlands provide excellent habitat for Hawaiian coots, and the species occurs less frequently on interior reservoirs, such as Lake Wilson and Nu`uanu Reservoir. Large concentrations of coots occur at the Ki`i Unit of James Campbell National Wildlife Refuge, the Kahuku aquaculture ponds, the Kuilima wastewater treatment plant, Ka`elepulu Pond in Kailua, the Honouliuli Unit of Pearl Harbor National Wildlife Refuge, and the Hawai`i Prince Golf Course (Figure 14, page 33). Aquaculture ponds for shrimp and fish production provide year-round foraging habitat for coots; however, nesting opportunities are limited on these ponds as vegetation is generally controlled along the banks and predators (dogs, cats, and mongooses) can readily find nests around these ponds.

iii. Maui, Moloka`i, and Lāna`i (Maui Nui) Populations. The coot population on Maui Nui fluctuates between approximately 200 to 600 birds (HDLNR 1976-2003). The largest concentrations of coots occur at Kanahā and Keālia Ponds on Maui, the Kaunakakai Sewage Treatment Ponds on Moloka`i, and the Lāna`i Sewage Treatment ponds (Figures 15, 16 [pages 36, 39]). Waterbird survey data suggest that annual movements occur between Kanahā and Keālia Ponds, and also possibly among islands within Maui Nui. Monthly surveys of Kanahā and Keālia Ponds from 1995 to 1999 suggest that increased coot numbers at Keālia Pond are the result of influxes from other populations. This assumption is supported by counts at Keālia Pond

which exceed the combined total of Keālia and Kanahā Ponds from the previous monthly count (M. Nishimoto, Maui National Wildlife Refuge Complex, pers. comm. 2004). In addition to these wetlands, many of the remaining reservoirs associated with former sugar cane (*Saccharum officinarum*) production are frequented by coots.

The largest concentrations of coots on Moloka`i occur at the Kaunakakai Sewage Treatment Ponds and Kualapu`u Reservoir, but coots also occur on Molokai's coastal ponds and playa wetlands, particularly Paialoa Pond. There is some evidence from statewide waterbird surveys that coots move between Maui and Moloka`i. These movements are not seasonal, but are sporadic and seem to correlate with periods of heavy rainfall (Engilis and Pratt 1993). The playa habitats on Moloka`i are usually dry, but flood in wet winters. Coots have become permanent residents at the Lāna`i City wastewater treatment ponds since 1989 when these ponds became operational. During the 2002 summer waterbird counts, 45 birds were observed using this area. Coots have also been observed nesting at the wastewater treatment facility (HDLNR 1976-2003).

**iv. Hawai`i Population**. The Big Island, with its limited wetlands, supports only a small Hawaiian coot population, generally fewer than 100 birds (HDLNR 1976-2003). Four ponds on the island support the majority of these birds: `Aimakapā and `Ōpae`ula Ponds on the Kona Coast, and Waiakea and Loko Waka Ponds in Hilo. The latter two ponds are in an urban area. The Big Island's coot population shows little seasonal fluctuation. Numbers vary from year to year, suggesting birds disperse to and from other islands.

(e) Life History. Hawaiian coots nest on open fresh water and brackish ponds, taro ponds, shallow reservoirs, irrigation ditches, and in small openings of marsh vegetation (Udvardy 1960; Shallenberger 1977). They construct floating nests of aquatic vegetation in open water, or semi-floating nests anchored to emergent vegetation or in clumps of wetland vegetation (Byrd *et al.* 1985). Open-water nests typically are anchored on semi-floating mats of vegetation, usually constructed from water hyssop *(Bacopa monnieri*) and Hilo grass (*Paspalum conjugatum*). Nests in emergent vegetation are platforms constructed from buoyant stems of nearby vegetation, such as bulrush (*Scirpus* spp.) (Byrd *et al.* 1985). Nests have also been documented on shorelines or rocky islets (M. Morin, USFWS, pers. comm. 1994). Additional "false nests" may be constructed near the actual nest and are often used as loafing or brooding platforms.

Nesting occurs primarily from March through September, although some nesting occurs in all months of the year (Shallenberger 1977). Nesting occurred at `Aimakapā Fishpond,

Hawai`i, in all months except November and January (M. Morin, pers. comm. 1999). The timing of nesting appears to correspond with seasonal weather conditions (Byrd *et al.* 1985; Engilis and Pratt 1993). Water levels are critical for nest initiation and success. Taro ponds provide good nesting habitat because they are shallow and have limited water fluctuation compared to other sites. Clutch size ranges from 3 to 10 eggs, with an average of 5 eggs (Byrd *et al.* 1985). The incubation period is about 25 days (Shallenberger 1977; Bryd *et al.* 1985), and chicks are able to swim as soon as their down has dried (Brisbin *et al.* 2002).

Coots are generalist feeders, obtaining food near the surface of the water, diving, or foraging in mud or sand. They also graze on upland grassy sites such as golf courses that are adjacent to wetlands, especially during times of drought and when food is unavailable elsewhere (T. Telfer, pers. comm. 1999). Food items include seeds and leaves of aquatic plants, various invertebrates including snails, crustaceans, and aquatic or terrestrial insects, tadpoles, and small fish (Schwartz and Schwartz 1949). Coots typically feed close to their nesting areas but will travel long distances when food is not locally available (Shallenberger 1977). Intra-island movements occur when water levels are low and food sources become concentrated.

The Hawaiian coot is an active and at times gregarious species. Like its North American relative, the Hawaiian coot sometimes forms large flocks. This usually occurs in the summer, but some localities do not show a seasonal flocking pattern, such as the Hanalei National Wildlife Refuge where large coot flocks have been observed during all months.

Coot population fluctuations may be explained by inter-island dispersal in relation to rainfall patterns and are not the result of North American coots migrating to the Hawaiian Islands (Engilis and Pratt 1993). Statewide waterbird surveys from 1977 to 1986 indicate that coots migrate between islands in response to precipitation patterns. Periodic increases in coot numbers on Ni`ihau and Moloka`i presumably are the result of movement of birds from Kaua`i and Maui, respectively (Engilis and Pratt 1993). Population increases on Ni`ihau are correlated with the intermittent availability of wetlands resulting from high rainfall.

(f) Habitat Description. The Hawaiian coot is typically a species of the coastal plain, usually found below 400 meters (1,320 feet) elevation, and preferring wetland habitats with suitable emergent plant growth interspersed with open water. However, some birds use upland plunge pools above 1,500 meters (4,900 feet) on Kaua`i and montane stock ponds up to 2,000 meters (6,600 feet) on Hawai`i. Hawaiian coots prefer freshwater wetlands, but will use brackish wetlands, and rarely, saline

habitats. Coots forage in water less than 30 centimeters (12 inches) deep, but can dive in water up to 120 centimeters (48 inches) deep. They prefer more open water than do moorhens, particularly for feeding. Optimum nesting habitat for the North American coot (*Fulica americana*) is generally in a 50:50 to 75:25 mix of dense emergent vegetation and open water. Hawaiian coots may prefer a similar mix but research on nesting habitat is limited. Large, deep ponds appear to provide only limited habitat for coots, particularly in areas where strong winds can cause the formation of wavelets. Interspersion of robust emergent vegetation can help to reduce wind fetch.

Loafing sites include logs, rafts of vegetation, narrow dikes, mud bars, artificial islands, and "false nests." Coots also loaf on open bodies of water such as reservoirs. Because of their ability to disperse to find suitable foraging habitat, ephemeral wetlands play an important part in their annual life cycle. Ephemeral wetlands may support large numbers of coots during the nonbreeding season (*e.g.*, up to 25 coots per hectare [10 per acre] year-round on Moloka`i wetlands [Coleman 1978; Engilis 1988], and concentrations of 600 or more coots on Ni`ihau in winter [HDLNR 1976-2003]).

3. Hawaiian Common Moorhen or 'Alae 'Ula

(a) Taxonomy. The Hawaiian common moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*) is an endemic subspecies of the common moorhen (*Gallinula chloropus*) (AOU 1998). The Hawaiian subspecies is non-migratory and presumably originated from stray migrant birds that colonized Hawai`i from North America (Nagata 1983).

(b) Species Description. Although the Hawaiian common moorhen is recognized as distinct from its North American relative, there are no evident plumage, soft body coloration, or measurement differences from forms in North America (Wilson and Evans 1890 to 1899; Rothschild 1900). Hawaiian common moorhens superficially resemble the related Hawaiian coot, but they are noticeably smaller, possess a red shield over their red and yellow bill, and have a white flank stripe (Schwartz and Schwartz 1949; Bannor and Kiviat 2002). They are black above and slate blue below, with underwing coverts mostly white. Their legs and feet are yellowish green, and the feet are not lobed, as in the coot (Figure 8). The sexes are similar in appearance. Immature birds are olive-brown to grayish brown, with a pale yellow or brown bill.

Figure 8. Hawaiian common moorhen. Photo by Eric VanderWerf.

(c) Historical Range and Population Status. The Hawaiian common moorhen was found on all of the main Hawaiian Islands except Lāna`i and Kaho`olawe in 1891 (Munro 1960). However, by the late 1940's their status was considered "precarious," especially on O`ahu, Maui, and Moloka`i (Schwartz and Schwartz 1949). Moorhens disappeared from Moloka`i sometime after the 1940's and were reintroduced in 1983, but the population did not persist and the species currently is not known to occur on the island. Like the Hawaiian coot, the Hawaiian moorhen is predominantly a species of the coastal plains, generally found below 125 meters (410 feet) elevation.

The Hawaiian common moorhen is quite secretive and difficult to census, and even rough population estimates were lacking until the 1950's, so the long-term population trend is difficult to determine. Surveys in the 1950's and 1960's estimated no more than 57 individuals (Engilis and Pratt 1993). The spread of aquaculture on O`ahu in the late 1970's and 1980's probably led to an increase in the numbers of moorhens. In some locations aquaculture projects support some of the highest concentrations of moorhens in the State (Engilis 1988; M. Silbernagle, USFWS, pers. comm. 2000) although wetlands managed for moorhens have the potential to support high concentrations as well.

(d) Current Range and Population Status. Hawaiian common moorhens are currently found on the islands of Kaua`i and O`ahu. Biannual waterbird surveys provide a rough idea of recent population trends, but an accurate population estimate is not available due to the secretive nature of this species and its use of densely vegetated wetland areas. Counts of moorhens have been stable, but remain low, with average totals of 314 birds over the past 5 years (1998 to 2001 and 2003; Figures 9 and 10) (HDLNR 1976-2003). The inaccuracy of current methodology used in the biannual waterbird count, which involves relatively brief visits to each wetland (Griffin *et al.* 1989), is demonstrated by the extreme differences in numbers between summer and winter waterbird surveys of lotus fields on O`ahu. In the winter, after fields have been harvested and visibility is greater, numbers may be two to three times higher than the

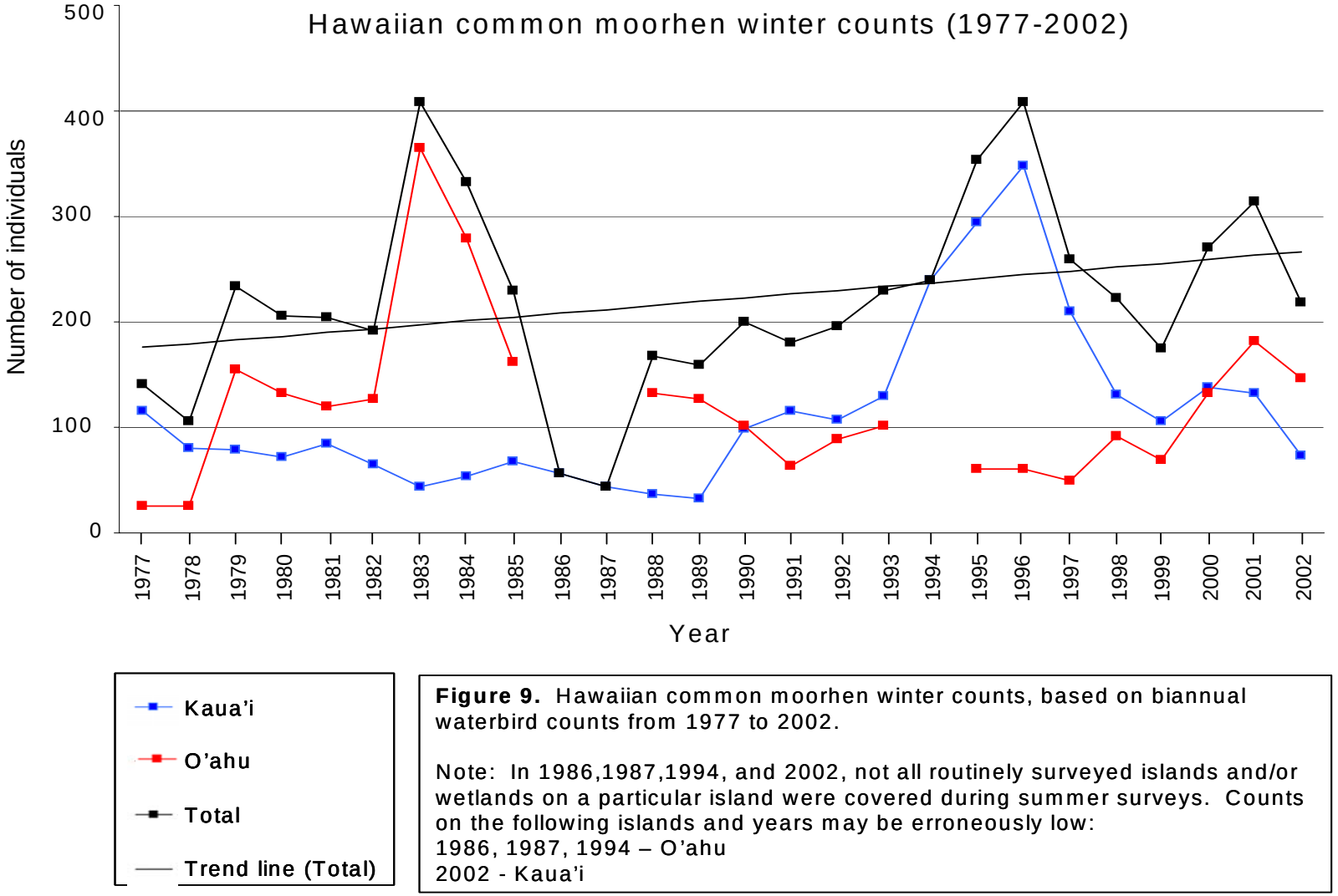

Figure 9. Hawaiian common moorhen winter counts, based on biannual waterbird counts from 1977 to 2002.

Note: In 1986,1987,1994, and 2002, not all routinely surveyed islands and/or wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1986, 1987, 1994 – O'ahu
2002 - Kaua'i

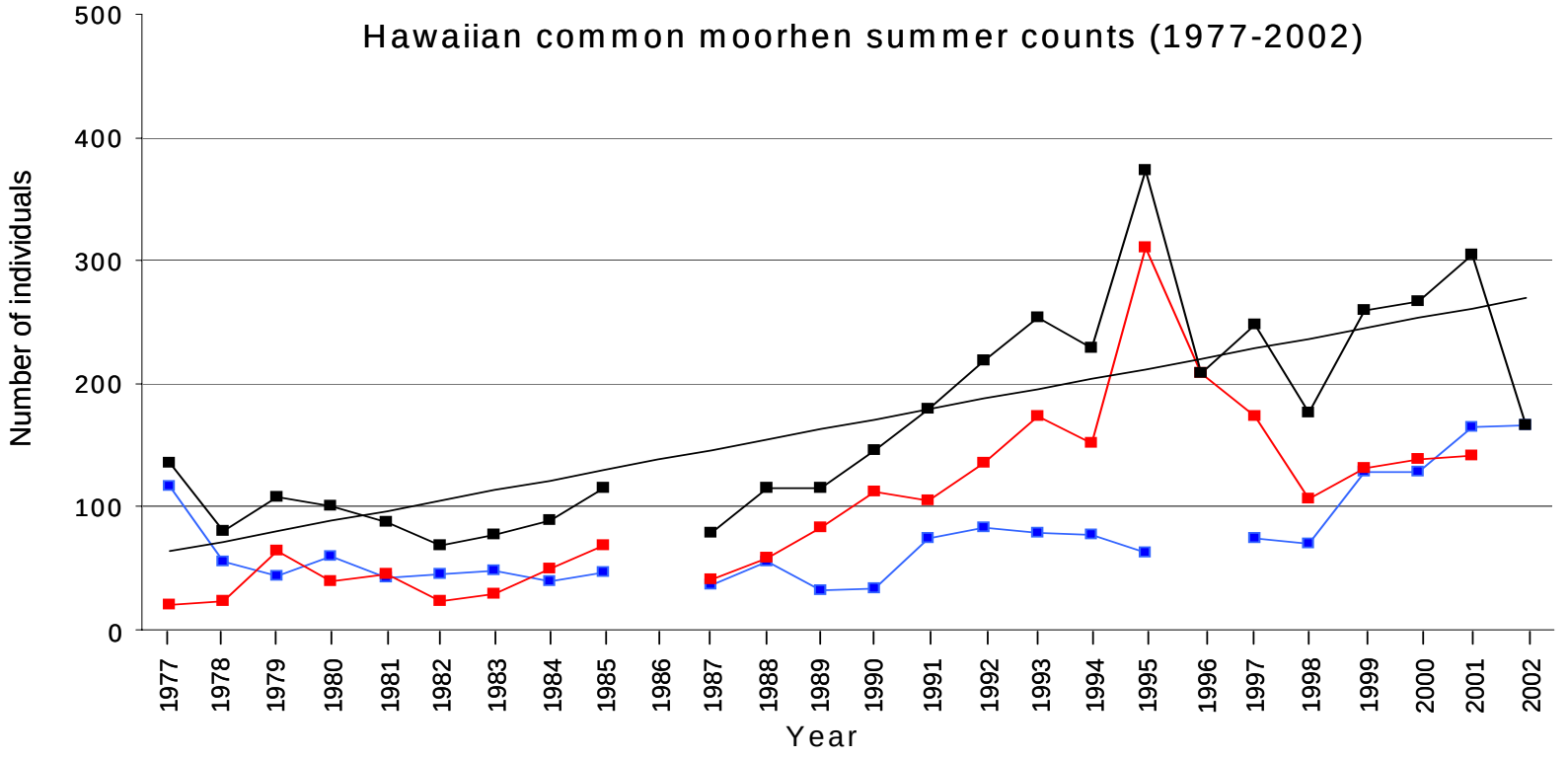

Figure 10. Hawaiian common moorhen summer counts, based on biannual waterbird counts from 1977 to 2002.

Note: In 1986,1987,1994, and 2002, not all routinely surveyed islands and/or wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1986, 1987, 2002 - Kaua'i and O'ahu
1996 - Kaua'i

numbers seen during the summer survey of the same areas. A more time-intensive point count method can provide accurate assessments of moorhens at a given site (Chang 1990), but this method requires a substantial commitment of resources. For example, the number of moorhens detected at Hamakua Marsh during waterbird counts is low (average of 3.8 moorhens from 2000 to 2002), but repeated careful observations by Smith and Polhemus (2003) for longer periods revealed 10 moorhen pairs at the same site. Another survey method that may enhance detection of moorhens during surveys is the use of tape playbacks, which have been used successfully for other moorhen species and subspecies (Brackney and Bookhout 1982; Ribic *et al.* 1999; Takano and Haig 2004a).

**i. Kaua`i Population**. Hawaiian common moorhens are widely distributed in lowland wetlands and valleys on Kaua`i (Figure 22, page 53). Sizable populations exist in the Hanalei and Wailua River valleys, Waiakalua Reservoir, and Wilcox Ponds. The irrigation canals on the Mānā Plain of western Kaua`i also support birds, but accurate counts have proven logistically difficult (T. Telfer, pers. comm. 1988). Dense vegetation around lowland reservoirs may also support moorhens, but nesting is limited by deep water and severe water level fluctuations. Moorhens are also found in wetland agricultural areas such as taro fields.

**ii. O`ahu Population**. Moorhens are widely distributed on O`ahu, but are most prevalent on the northern and eastern coasts between Hale`iwa and Waimānalo (Figure 14, page 33). Small numbers exist in Pearl Harbor, where foraging occurs in semi-brackish water. The population on the leeward coast is limited to Lualualei Valley. Based on biannual waterbird surveys during the past 5 years, O`ahu holds approximately half of the State's total population of moorhens (Figures 9 and 10).

**iii. Maui and Moloka`i Populations**. In the past, moorhens were observed regularly on Maui, with unsubstantiated reports of moorhen from the Ke`anae Peninsula (Shallenberger 1977). Six marked birds were released by U.S. Fish and Wildlife Service staff at Kakahai`a National Wildlife Refuge on Moloka`i in June 1983. At least two birds were still present in January 1984, but there have been no confirmed sightings since 1985 (USFWS, unpubl. data).

iv. Hawai`i Population. There are unsubstantiated reports of moorhen observed on the Big Island (HDLNR, unpubl. data), but no confirmed reports.

(e) Life History. Little is known of the Hawaiian common moorhen's breeding biology. Most nests are inconspicuously placed within dense emergent vegetation over shallow water. Moorhens generally nest in areas with standing freshwater less than 60 centimeters (24 inches) deep. The

emergent vegetation is folded over into a platform nest (Shallenberger 1977). Where emergent aquatic vegetation is insufficient, nests may be placed on the ground, but most have tall cover nearby. Apparently, the particular species of emergent plant used for nest construction by moorhens is unimportant as long as it is a robust emergent (Weller and Fredrickson 1973).

Like other common moorhen subspecies, the Hawaiian common moorhen is territorial. Territory size of nesting pairs at Hamakua Marsh on O`ahu ranged from 853 to 2,416 square meters (9,182 to 26,006 square feet) (Smith and Polhemus 2003). Nesting occurs year-round, but most activity extends from March through August and is influenced by water levels and vegetation growth (Shallenberger 1977; Byrd and Zeillemaker 1981; Chang 1990). Clutch size differed among 2 island investigations, where it averaged 4.9 eggs on Kaua`i (n = 87 nests) (Chang 1990) and 5.6 eggs on O`ahu (n = 64 nests; Byrd and Zeillemaker 1981). An average clutch size of 8.4 eggs was reported from seven North American moorhen sites (Byrd and Zeillemaker 1981). The incubation period ranges from 19 to 22 days (Byrd and Zeillemaker 1981). Moorhens are a precocial species; chicks are covered with down and are able to walk, but are dependent on the parents for several weeks. Renesting and multiple broods during one season have been observed (Byrd and Zeillemaker 1981). Brood sizes have been observed to range from 2 to 7 chicks (mean of 4.4 chicks per brood) at Hamakua Marsh, O`ahu (Smith and Polhemus 2003).

Little information is available on the feeding habits of the Hawaiian common moorhen. Food items consumed by this subspecies may include algae, aquatic insects, and mollusks (Schwartz and Schwartz 1949). Telfer (unpubl. data) found remains of snails, guava seeds, algae, and other plant material in stomachs of road-killed moorhens on Kaua`i. Seeds of grasses, parts of various plants, and other types of invertebrates are probably also included in the moorhen's diet. These birds are apparently opportunistic feeders, so the diet may vary with the particular habitat (Shallenberger 1977).

Hawaiian common moorhens are the most secretive of the native Hawaiian waterbirds, preferring to forage in dense emergent vegetation. Most birds feeding along the edge or in the open quickly seek cover when disturbed. Moorhens are good swimmers and often cross open water to reach foraging sites. They are generally sedentary; however, moorhens readily disperse in spring, presumably to breed (Nagata 1983). Dispersal may occur in relation to dry and wet periods (Engilis and Pratt 1993). This pattern also occurs in a similar island common moorhen subspecies, the Mariana common moorhen (*Gallinula chloropus guami*), where moorhens exhibited reduced breeding and natal site tenacity. This

was presumably in response to resource shifts caused by flooded habitat and creation of new seasonal habitat, and possibly behavioral changes as juveniles dispersed to other wetlands (Takano 2003). Mariana common moorhens have been also documented to move between islands in response to high rainfall during the wet season and creation of new habitat (Worthington 1998; Takano and Haig 2004b). Whether the Hawaiian common moorhen is capable of inter-island movement is unknown.

(f) Habitat Description. Hawaiian common moorhen habitat consists of freshwater marshes, taro patches, lotus fields, reedy margins of water courses (streams, irrigation ditches, etc.), reservoirs, wet pastures, and occasionally saline and brackish water areas. The conversion of aquaculture ponds in Kahuku, O`ahu, from fresh to salt water resulted in an observed decline in moorhen numbers (Engilis and Pratt 1993). The densest moorhen nesting areas are at the Hanalei National Wildlife Refuge and taro fields on the island of Kaua`i, and at the Kahuku and `Uko`a wetlands and Waialua lotus fields on O`ahu.

The key features of habitat areas for moorhens are: 1) dense stands of robust emergent vegetation near open water; 2) floating or barely emergent mats of vegetation; 3) water depth less than 1 meter (3.3 feet); and 4) fresh water as opposed to saline or brackish water. Interspersion of robust emergent vegetation and open water is important for common moorhens on the mainland, and presumably is also for the Hawaiian subspecies. The optimal overall ratio of emergent vegetation to open water is 50:50 (Weller and Fredrickson 1973). Continued management of wetland areas is necessary to maintain these habitat conditions.

4. Hawaiian Stilt or Ae`o

(a) Taxonomy. The Hawaiian stilt or ae`o (*Himantopus mexicanus knudseni*) is part of a cosmopolitan superspecies complex including the black-necked stilt (*Himantopus mexicanus*) of North and South America, the black-winged stilt (*H. himantopus*) of Eurasia and Africa, and pied stilt (*H. leucocephalus*) and black stilt (*H. novazelandiae*) from Australasia (Robinson *et al.* 1999). The Hawaiian stilt is clearly allied with the black-necked stilt and is considered a distinct subspecies (AOU 1998). Colonization of Hawai`i by stilts probably resulted from North American vagrants.

(b) Species Description. The stilt is a slender wading bird, black above (except for the forehead) and white below with distinctive long, pink legs (Figure 11-A). The Hawaiian stilt differs from North American black-necked stilts by having black extending lower on the forehead as well as around to the sides of the neck, and by having a longer bill, tarsus (lower leg), and tail (Coleman 1981; Robinson *et al.* 1999).

Figure 11-A. Adult male Hawaiian stilt. Photo by Eric VanderWerf.

Figure 11-B. Juvenile Hawaiian stilt. Photo by Eric VanderWerf.

Sexes are distinguished by the color of the back feathers (brownish in females, black in males) as well as voice (lower in females). Downy chicks are well camouflaged, tan with black speckling. Immatures have a brownish back and more extensive white on the cheeks and forehead (Pratt *et al*. 1987; Figure 11-B). Immature birds produce a sharp peeping call. The total length of adult Hawaiian stilts is about 40 centimeters (16 inches).

(c) Historical Range and Population Status. Hawaiian stilts were historically known from all of the major islands except Lāna`i and Kaho`olawe (Paton and Scott 1985). Prior to 1961, documented records of Hawaiian stilts on the island of Hawai`i were limited to three collected by S. B. Wilson in the late 1800's and possibly one collected by Collett prior to1893 (Banko 1979). As with the other Hawaiian waterbirds, there are no estimates of historical numbers. However, extensive wetlands and aquatic agricultural lands historically provided a fair amount of habitat. Loss of this habitat undoubtedly caused a decrease in stilt numbers. It has been suggested that the population had declined to approximately 200 birds by the early 1940's (Munro 1960). This number, however, may have been an underestimation of the population, as other estimates from the late 1940's place the population at approximately 1,000 birds (Schwartz and Schwartz 1949). This number may still be a low estimate, as a sizable number of stilts can be found seasonally on Ni`ihau, which was not surveyed in the 1940's. The Hawaiian stilt was a popular game bird, and hunting contributed to local population declines until waterbird hunting was prohibited in 1939 (Schwartz and Schwartz 1949).

(d) Current Range and Population Status. Hawaiian stilts are currently found on all of the main Hawaiian Islands except Kaho`olawe. The first stilts on Lāna`i were

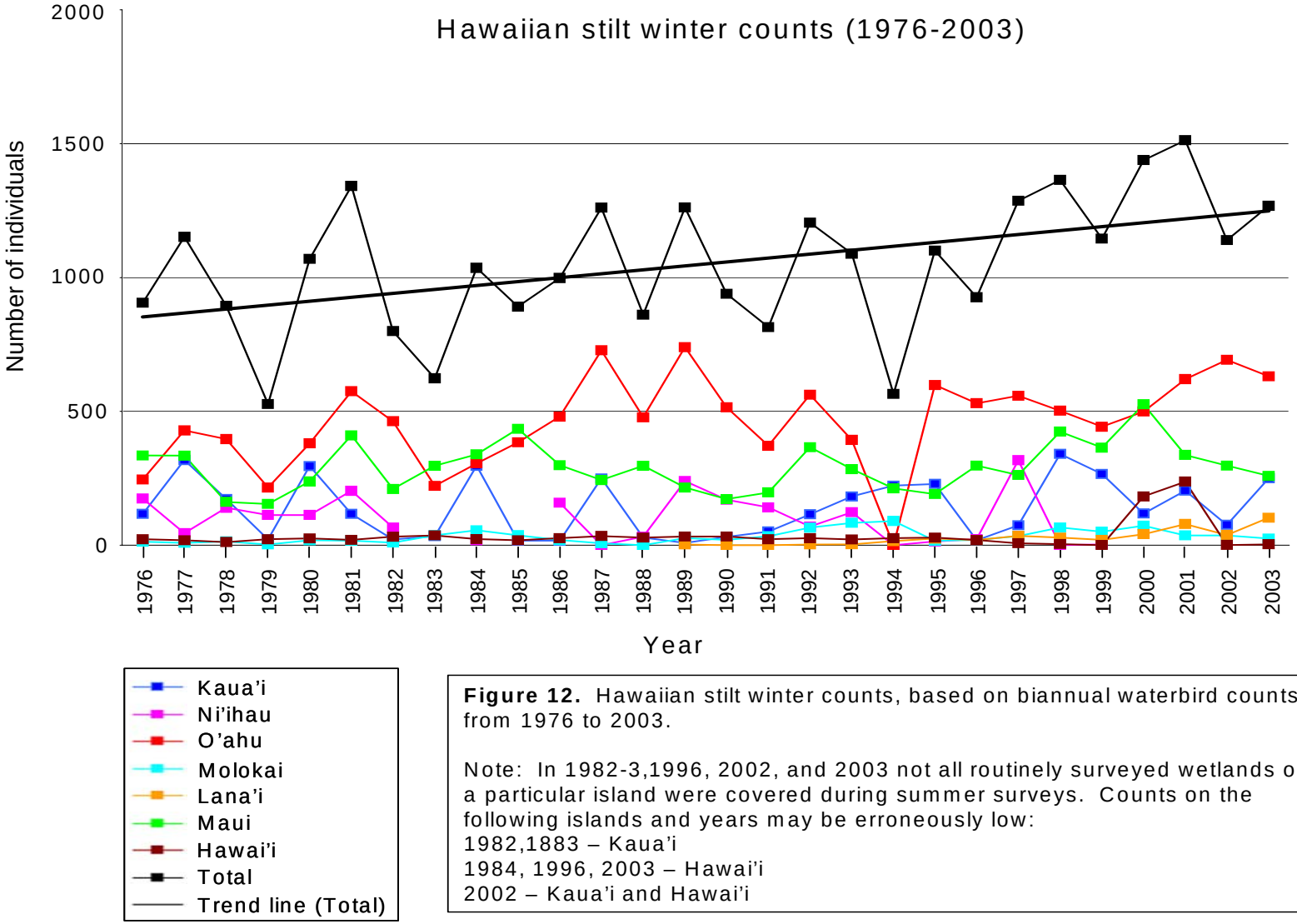

Figure 12. Hawaiian stilt winter counts, based on biannual waterbird counts from 1976 to 2003.

Note: In 1982-3,1996, 2002, and 2003 not all routinely surveyed wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982,1883 – Kaua'i
1984, 1996, 2003 – Hawai'i
2002 – Kaua'i and Hawai'i

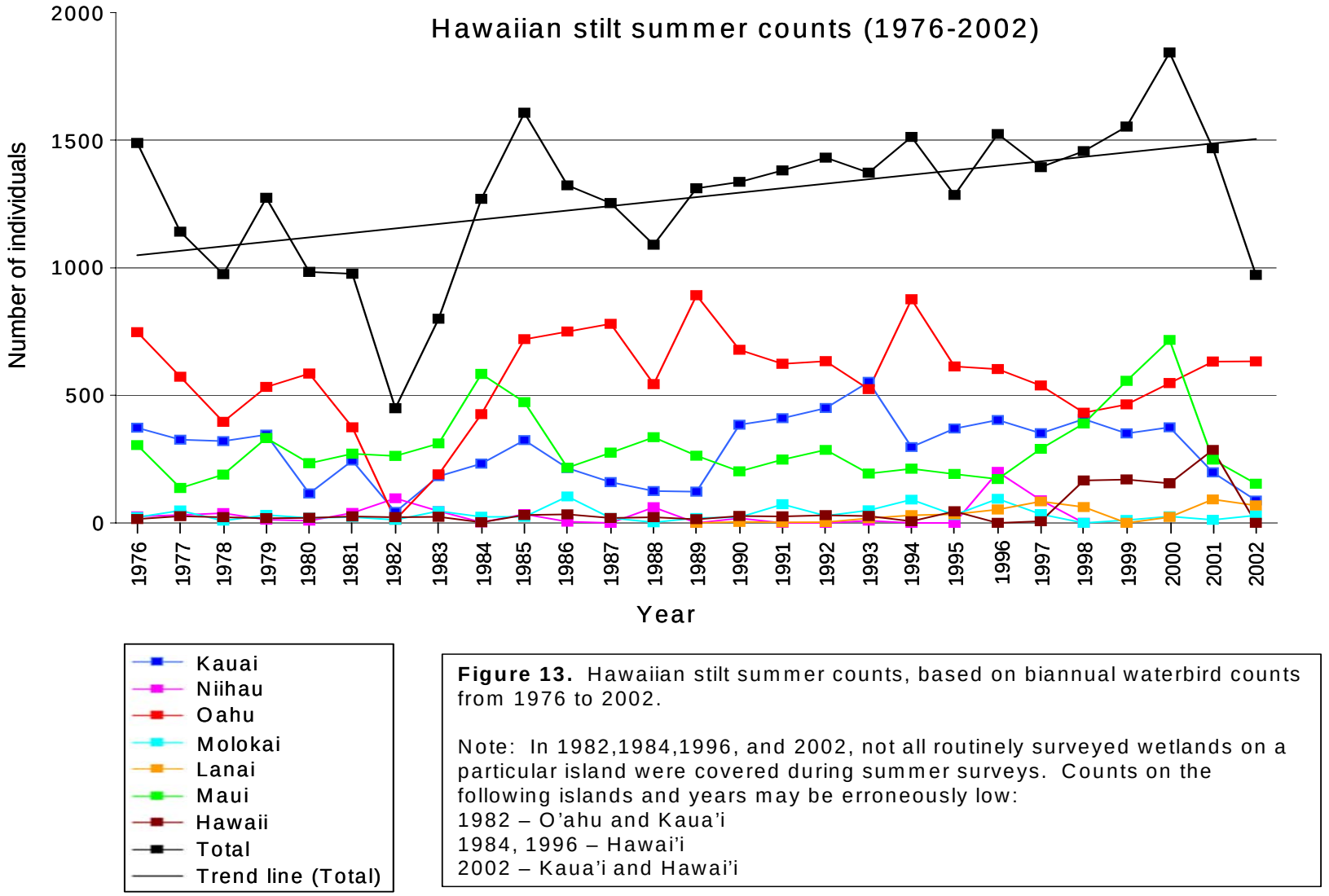

Figure 13. Hawaiian stilt summer counts, based on biannual waterbird counts from 1976 to 2002.

Note: In 1982,1984,1996, and 2002, not all routinely surveyed wetlands on a particular island were covered during summer surveys. Counts on the following islands and years may be erroneously low:
1982 – O'ahu and Kaua'i
1984, 1996 – Hawai'i
2002 – Kaua'i and Hawai'i

documented in 1989 at the Lāna`i City wastewater treatment ponds (Engilis and Pratt 1993; M. Ueoka, Hawai`i Division of Forestry and Wildlife, pers. comm. 1993). Based on biannual Hawaiian waterbird surveys from 1998 through 2003 (2002 was excluded because of missing data), the stilt population averaged 1,350 birds, but fluctuated between 1,200 and 1,500 birds (Figure 12; HDLNR 1976-2003). The census method used during these surveys appears to provide an accurate picture of the number of stilts at a site (Chang 1990). Summer counts were not averaged because these counts are generally more variable than winter counts due to the variability in hatch-year bird survival (Reed and Oring 1993).

Long-term census data indicate statewide populations have been relatively stable or slightly increasing for the last 30 years (Reed and Oring 1993; Figures 12, 13). As with coots, census data show year-to-year variability in the number of stilts observed. This variability can be partially explained by rainfall patterns and reproductive success (Engilis and Pratt 1993). Hawaiian stilts readily disperse between various islands and collectively the Hawaiian island populations constitute one metapopulation (Reed *et al*. 1994,1998).

i. Kaua`i and Ni`ihau Populations. Considerable movement of Hawaiian stilts occurs between these two islands, apparently in response to rainfall patterns and the flooding and drying of Ni`ihau's ephemeral lakes (Engilis and Pratt 1993). On Kaua`i, stilts are numerous in large river valleys such as Hanalei, Wailua, and Lumaha`i, and on the Mānā Plain (Figure 17, page 40). Stilts also frequent Kaua`i's reservoirs, particularly during drawdown periods, as well as sugarcane effluent ponds in Līhu`e and Waimea.

Over the past 5 years (excluding 2002 because of missing data), the stilt population on Kaua`i has fluctuated between approximately 125 to 350 birds (HDLNR 1976-2003). Ni`ihau can potentially support a large number of stilts when the extensive ephemeral lakes are flooded.

**ii. O`ahu Population**. O`ahu supports the largest number of stilts in the Hawaiian Islands (Engilis 1988; HDLNR 1976-2003). Large concentrations of stilts can be found at the James Campbell National Wildlife Refuge, the Kahuku aquaculture ponds, the Honouliuli and Waiawa units of the Pearl Harbor National Wildlife Refuge, and on Nu`upia Ponds in Kāne`ohe. Populations also exist at the Chevron Refinery, the fishponds at Kualoa Beach Park, at Salt Lake District Park, and at scattered locations along the northern and eastern coasts. Over the past 5 years, O`ahu accounted for 35 to 50 percent of the State’s stilt population, with approximately 450 to 700 birds counted during any single year (HDLNR 1976-2003).

iii. Maui, Moloka`i, and Lāna`i (Maui Nui) Populations. Maui's two large coastal wetlands, Kanahā and Keālia, support a significant number of Hawaiian stilts, with important nesting habitat at Keālia. Monthly counts indicate that birds freely move between these two wetlands, apparently in search of optimal foraging habitat (Ueoka 1979). A small number of stilts also frequent aquaculture areas on Maui. Over the past 5 years, stilt numbers have ranged from approximately 250 to 530 birds (HDLNR 1976-2003).

Molokai's south coast wetlands and playa lakes are, at times, important habitats for stilts, with large concentrations at the Kaunakakai Sewage Treatment Plant. There is some evidence of periodic movements of birds between Maui and Moloka`i, again probably in response to available foraging habitat (Engilis and Pratt 1993). Since 1968, statewide waterbird surveys have shown a significant increase in stilts on Moloka`i (Reed and Oring 1993). On Molokai, the stilt population has fluctuated between approximately 25 to 90 birds over the past 10 years.

Hawaiian stilts are now permanent residents at the Lāna`i City wastewater treatment pond. They have been recorded there annually since the ponds became operational in 1989 and numbers sometimes exceed 100 birds (HDLNR 1976-2003).

**iv. Hawai`i Population**. The Kona Coast from Kawaihai Harbor south to Kailua supports the largest number of stilts on the Big Island, with Makalawena and `Aimakapā Ponds being key breeding areas (Figure 18, page 43). Until recently, the Cyanotech Ponds were a key breeding area because management focused on providing adequate breeding habitat for stilts to minimize nesting attempts in hazardous areas (Waddington 2003). For a variety of reasons, these ponds are no longer available to stilts, and we are working with Cyanotech and the State to identify other suitable nesting habitats on Hawai`i for stilts displaced from Cyanotech (J. Kwon, USFWS, pers. comm. 2004).

Hawaiian stilts can also be found along the Hāmākua Coast and in the Kohala river valleys of Waipio, Waimanu, and Pololū (Figure 18). The scattered anchialine[2] ponds along the Kona Coast are important feeding sites. Hawaiian stilts have become numerous at the Kona (Kealakehe) wastewater treatment plant. The County of Hawai`i has designed wildlife habitat for Hawaiian stilts to fit within the 12-hectare (30-acre) perimeter around the Kona Wastewater Treatment Plant. Comprehensive surveys on Hawai`i have placed the Kona Coast population at 130 birds (Ducks Unlimited 1996 to

[2]land-locked brackish-water pools adjacent to the ocean, lacking surface connection to the ocean but with a subterranean connection and showing a damping tidal fluctuation in water level

1997). Based on biannual waterbird surveys (1999 to 2002; 2003 is excluded because of missing data), there are approximately 200 birds islandwide (HDLNR 1976-2003).

(e) Life History. Hawaiian stilts prefer to nest on freshly exposed mudflats interspersed with low growing vegetation. The nest itself is a simple scrape on the ground. They have also been observed using grass stems and rocks for nesting material (Coleman 1981; M. Morin, pers. comm. 1994). Nesting also occurs on islands (natural and manmade) in fresh or brackish ponds (Shallenberger 1977). Higher nesting densities are found on large mudflat expanses interspersed with vegetation. Stilts have also been observed successfully using manmade floating nest structures on Kaua`i (T. Telfer, pers. comm. 1988) and floating wooden platforms at `Aimakapā Fishpond in Kona, Hawai`i (Morin 1994, pers. comm. 1999). Stilts are territorial and maintain an area approximately 14 to 30 meters (46 to 98 feet) around nests (Robinson *et al.* 1999).

The nesting season normally extends from mid-February through August, but varies among years, perhaps depending on water levels. Stilts usually lay 3 to 4 eggs that are incubated for approximately 24 days (Coleman 1981; Chang 1990). Chicks are precocial, leaving the nest within 24 hours of hatching. Young may remain with both parents for several months after hatching (Coleman 1981). Parents are extremely aggressive toward foreign young (Robinson *et al.* 1999).

A hatching success of 54 percent (n = 243 nests, 833 eggs) was reported for Hawaiian stilts at the Ki`i Unit of the James Campbell National Wildlife Refuge (Chang 1990). Of the 243 total nests observed at Ki`i, 61 (25 percent) were lost to predation and 42 (17 percent) were lost to flooding or abandonment (Chang 1990). Robinson *et al.* (1999) reported 2.18 chicks hatched per nest and 0.93 fledged per brood for Hawaiian stilts. In a more recent study at the James Campbell National Wildlife Refuge, bullfrogs (*Rana catesbeiana*) were found to be the most important predators of young stilts based on tracking of birds fitted with radio transmitters (Eijzenga 2003).

Other predators of Hawaiian stilts include mongooses, black rats (*Rattus rattus*), feral cats, feral dogs, black-crowned night herons (*Nycticorax nycticorax)*, cattle egrets (*Bubulcus ibis*), Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*), and common mynas (*Acridotheres tristis*) (Robinson *et al.* 1999). Stilts have a variety of antipredator behaviors, including mobbing aerial predators, a "popcorn display" (birds hopping and flapping around a ground predator), and striking ground predators from behind with their legs (Robinson *et al.* 1999). Because of their exposed nest sites, stilts

appear to be more susceptible to avian predators than other Hawaiian waterbirds.

Stilts are opportunistic feeders. They eat a wide variety of invertebrates and other aquatic organisms as available in shallow water and mudflats. Specific organisms taken include water boatmen (insects in the family Corixidae), beetles (order Coleoptera), possibly brine fly (*Ephydra riparia*) larvae, polychaete worms, small crabs, fish (*e.g.*, Mozambique tilapia [*Oreochromis mossambica*] and mosquito fish [*Gambusia affinis*]), and tadpoles (*Bufo* spp.) (Shallenberger 1977; Robinson *et al.* 1999).

Feeding typically occurs in shallow flooded wetlands. These types of wetlands are ephemeral in nature and may appear at any time of year, but are primarily available in winter. Hawaiian stilts require specific conditions (water depths of 13 centimeters [5 inches] or less) for optimal foraging (Telfer 1973). Thus, intra- and inter-island movement is an important strategy for exploiting food resources and has been documented between O`ahu and Maui by statewide waterbird survey data and banding studies (Ueoka 1979; Engilis and Pratt 1993; Reed *et al.* 1994; Reed *et al.* 1998).

(f) Habitat Description. Hawaiian stilts use a variety of aquatic habitats but are limited by water depth and vegetation cover. Stilts require early successional marshlands with water depth less than 24 centimeters (9 inches) and favor perennial vegetation that is limited and low growing such as nonnative pickleweed, California grass, and seashore paspalum or knotgrass (*Paspalum* spp.), or exposed tidal flats. Native low-growing wetland plants associated with stilt nesting areas include water hyssop, sea purslane (*Sesuvium portulacastrum*), and the sedges makaloa (*Cyperus laevigatus*) and kaluha (*Bolboschoenus maritimus*) (Robinson *et al.* 1999). Stilts may also use taro ponds where the full-grown vegetation forms a protective canopy. Stilts are rarely found in wetlands above 200 meters (660 feet) elevation.

Ephemeral wetlands on Moloka`i, Maui, and Ni`ihau are important for stilts. Management techniques that mimic seasonal inundation and evaporation of freshwater mudflats are beneficial to nesting stilts and provide invertebrate forage for their young. Insular mudflats that are isolated from terrestrial predators are still susceptible to avian and amphibian predation. On the island of Hawai`i, anchialine ponds provide important foraging habitat for the Hawaiian stilt. Prawn farms, which have numerous ponds with changing water levels, provide excellent foraging habitat for adult birds.

Stilts generally forage and nest in different wetland sites, moving between these areas daily. Adults with 3-day-old chicks have been observed to move 0.5

kilometer (0.3 mile) from the nest site (Reed and Oring 1993). Nesting sites are adjacent to or on low-relief islands within bodies of fresh, brackish, or salt water. These include irrigation reservoirs and settling basins, natural or manmade ponds, marshes, taro patches, silted ancient fish ponds, salt evaporation pans, and other wetlands.

Feeding habitat consists of shallow water that is fresh, brackish, or saline. Freshwater sites include irrigation ditches, reservoirs, settling basins, taro patches, sewage ponds, and marshes. Brackish-water feeding habitat consists of coastal ponds, fish ponds, and estuaries. Saltwater feeding habitat includes inshore reefs, beach areas, and tidal flats. Loafing areas include open mudflats, pickleweed flats, and pasture lands where visibility is good and predator populations are low.

C. SPECIES DISTRIBUTION MAPS AND WETLAND IDENTIFICATION TABLES

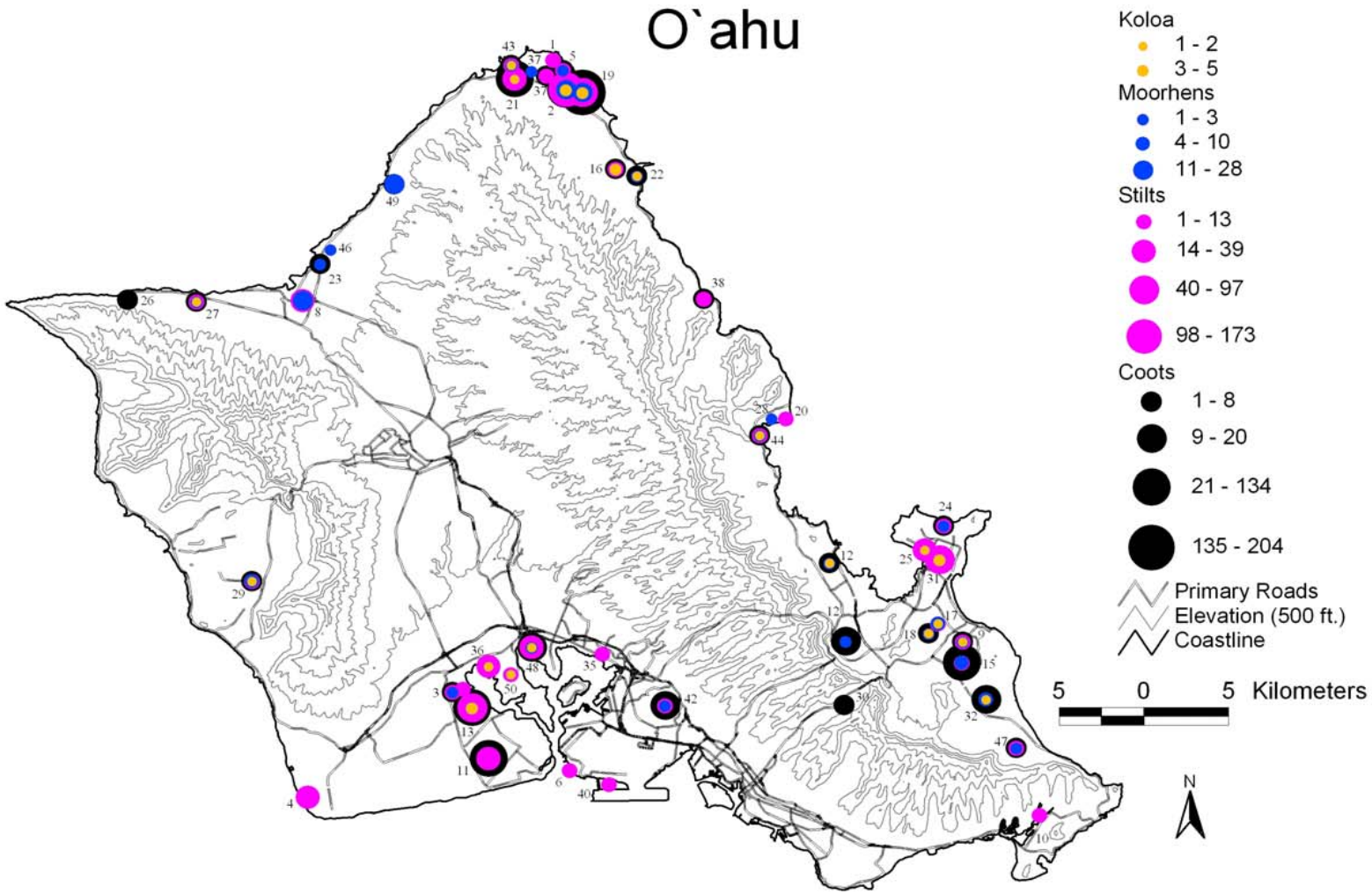

Figure 14. Waterbird populations at wetlands on O`ahu. Values are 5-year averages using winter counts of adults only from 1999 to 2003.

Table 1. Locations of numbered wetlands on O`ahu shown in Figure 14.

Wetland	Number on Map
Airstrip Ponds	1
Amorient (includes Ming + Romey's)	2
Apoka`a Pond	3
Chevron Refinery Ponds	4
Coconut Grove	5
Fort Kamehameha Reef Flats	6
Gavin's Pond (Waiawa NWR)	7
Haleiwa Lotus/Taro Fields	8
Hāmākua Marsh	9
Hawai`i Kai	10
Hawai`i Prince Golf Course	11
He`eia Marsh	12
Honouliuli Unit Pearl Harbor NWR	13
Ho`omaluhia Botanical Garden	14
Ka`elepulu Mitigation Pond (Enchanted	15
Kahuku Prawn Farm	16
Kawainui Levee	17
Kawainui Marsh	18
Ki`i Unit James Campbell NWR	19
Kualoa State Park (`Āpua Pond)	20
Kuilima Sewage Treatment Plant	21
Lā`ie Prawn Farm	22
Loko Ea Pond	23
MCBH Clipper Golf Course	24
MCBH Sewage Treatment Plant	25
Mokulē`ia Quarry	26
Mokulē`ia Ranch	27
Mōli`i Fish Pond	28
Niuli`i Reservoir	29
Nu`uanu Reservoir	30
Nu`upia Ponds	31
Olomana Golf Course	32
Oneawa Canal	33
Paikō Lagoon	34
PC Watercress Farm	35
Pouhala Marsh	36
Punaho`olapa Marsh	37
Punalu`u Prawn Farm	38
Punamanō Unit James Campbell NWR	39
Airport Reef Runway	40
Rubber Lined Pond	41

Table 1 (continued). Locations of numbered wetlands on O`ahu shown in Figure 14.

Wetland	Number on Map
Salt Lake	42
Turtle Bay Golf Course	43
UH Mariculture Research Center	44
UH Waiale`e Agricultural Research	45
`Uko`a Marsh	46
Unisyn	47
Waiawa Unit Pearl Harbor NWR	48
Waimea Falls Arboretum	49
Waipi`o Soccer Field Wetlands	50

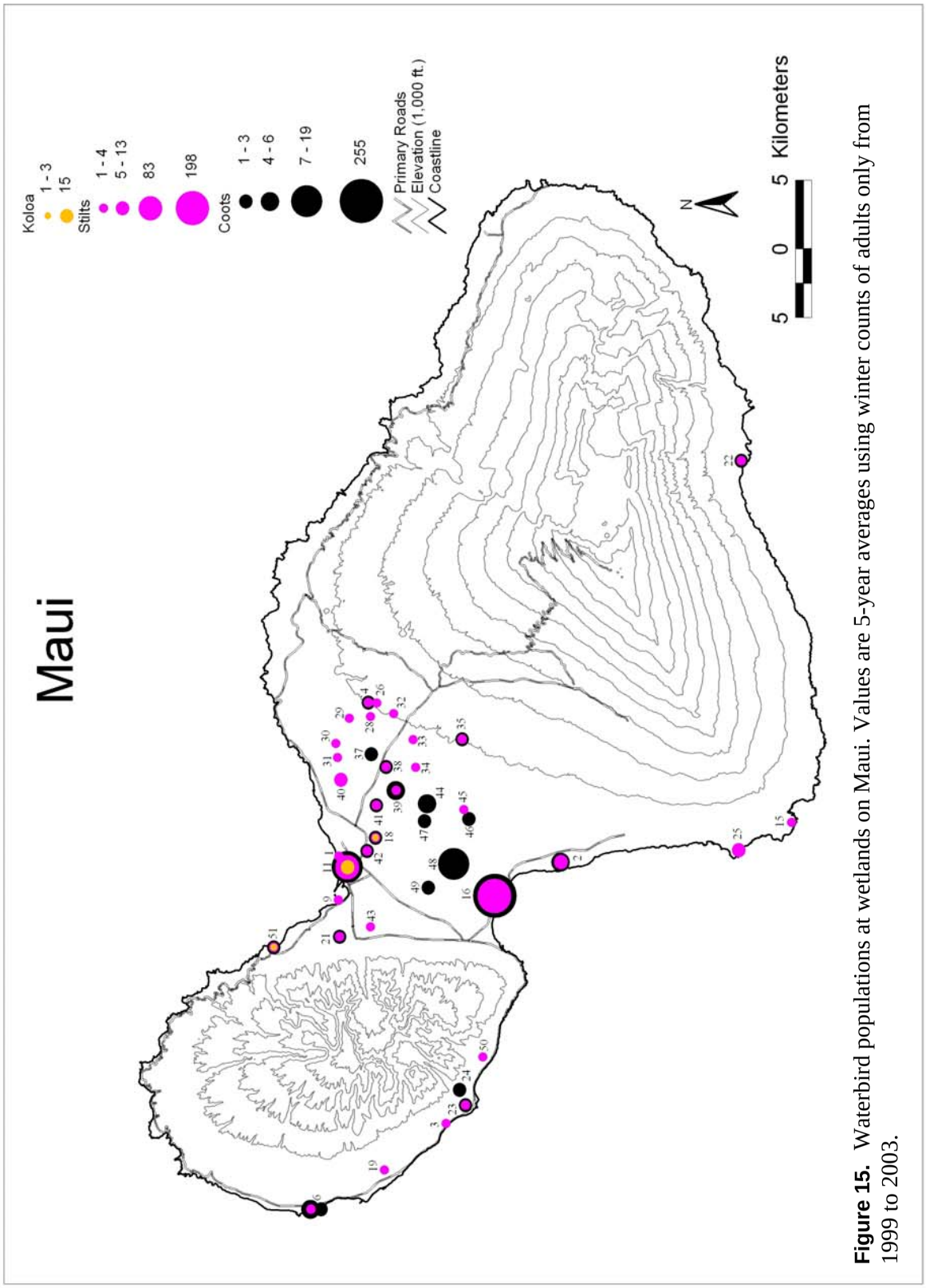

Figure 15. Waterbird populations at wetlands on Maui. Values are 5-year averages using winter counts of adults only from 1999 to 2003.

Table 2. Locations of numbered wetlands on Maui shown in Figure 15.

Wetland	Number on Map
Airport Drainage Ditch	1
Azeka Ponds 1 and 2	2
Cut Mountain	3
Hailiimaile Treatment Pond	4
Hansen Road Ponds (Reservoirs 70, 71)	5
Kā`anapali Golf Course Ponds	6
Kahului Fairgrounds Drainage	7
Kahului Oxidation Pond (HC&S Settling Pond)	8
Kahului Settling Pond	9
Kahului Sewage	10
Kanahā Pond Wildlife Sanctuary	11
Kapalua Bay	12
Kapalua Reservoir	13
Kapalua Village	14
Kauhi	15
Keālia Pond and Wetlands	16
Ke`anae Peninsula	17
K-mart Settling Pond	18
Lahaina Aquatic Center	19
Maluaka Pond	20
Mill Pond	21
Nu`u Pond	22
Olowalu Reservoir	23
Olowalu Reservoir 2	24
Pāniaka Pond	25
Reservoir 20	26
Reservoir 21	27
Reservoir 22	28
Reservoir 23	29
Reservoir 26	30
Reservoir 29	31
Reservoir 32	32
Reservoir 33	33
Reservoir 35	34
Reservoir 40	35
Reservoir 42	36
Reservoir 50	37
Reservoir 51	38
Reservoir 52	39

Table 2 (continued). Locations of numbered wetlands on Maui shown in Figure 15.

Wetland	Number on Map
Reservoir 60	40
Reservoir 61	41
Reservoir 72 (Ōma`opio)	42
Reservoir 73 (Wai`ale)	43
Reservoir 80	44
Reservoir 81	45
Reservoir 82	46
Reservoir 84	47
Reservoir 90 (Airport Village)	48
Reservoir 92	49
Ukumehame Settling Pond + Reservoirs	50
Waihe`e Wetlands	51

Table 3. Locations of numbered wetlands on Moloka`i (Mo) and Lāna`i (L) shown in Figure 16.

Wetland	Island	Number on Map
Kakahai`a NWR	Mo	1
Kaluaapuhi Fish Pond	Mo	2
Kaluako`i Golf Course	Mo	3
Kamalō Flats	Mo	4
Kaunakakai River	Mo	5
Kaunakakai Sewage Treatment Plant	Mo	6
Kualapu`u Reservoir	Mo	7
Maunaloa Sewage Treatment Plant	Mo	8
`Ōhi`apilo	Mo	9
Oliwai Sewage Treatment Plant	Mo	10
Paialoa Fish Pond	Mo	11
Lāna`i City Oxidation Ponds	L	1

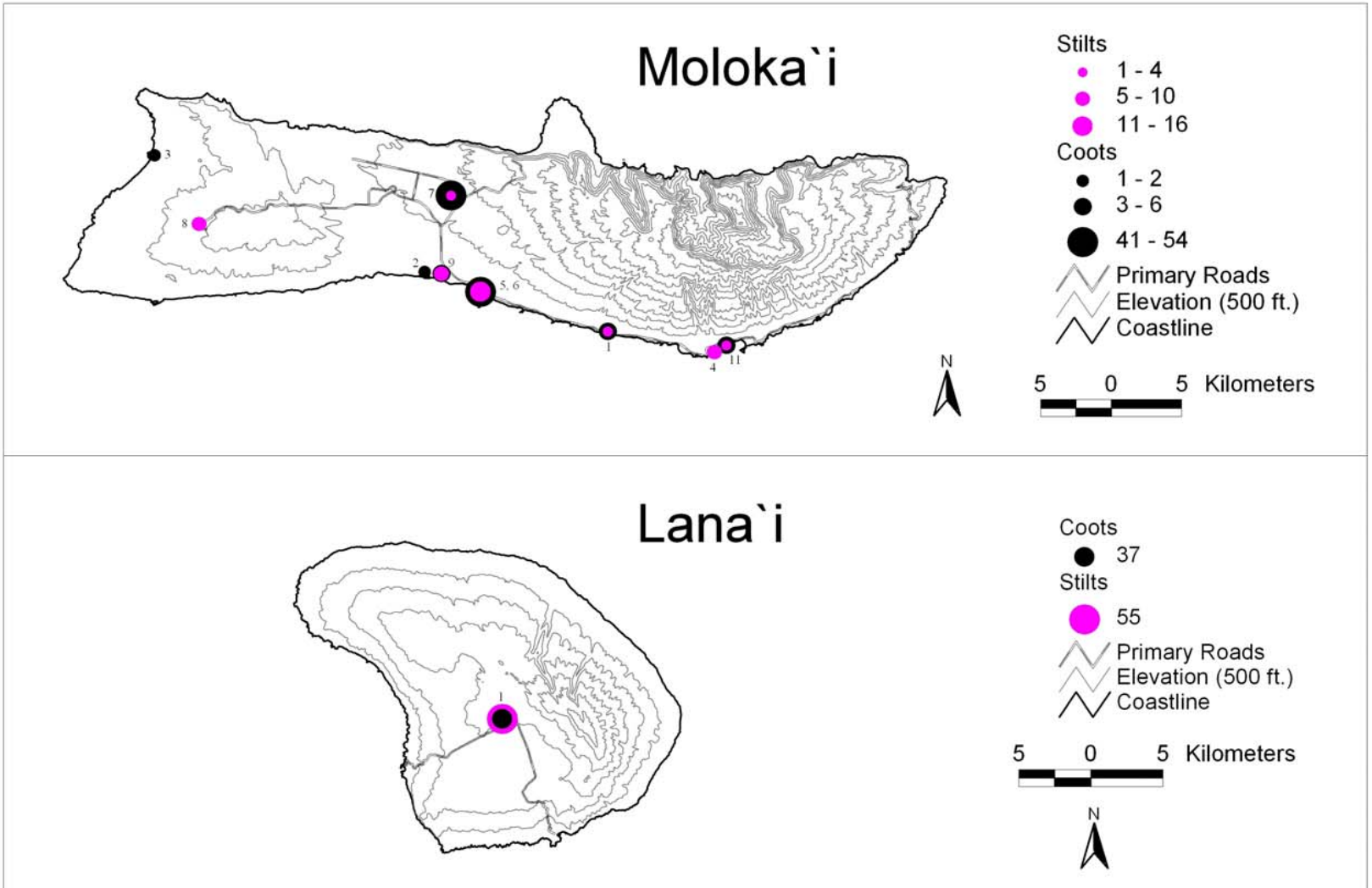

Figure 16. Waterbird populations at wetlands on Moloka`i and Lana`i. Values are 5-year averages using winter counts of adults only from 1999 to 2003.

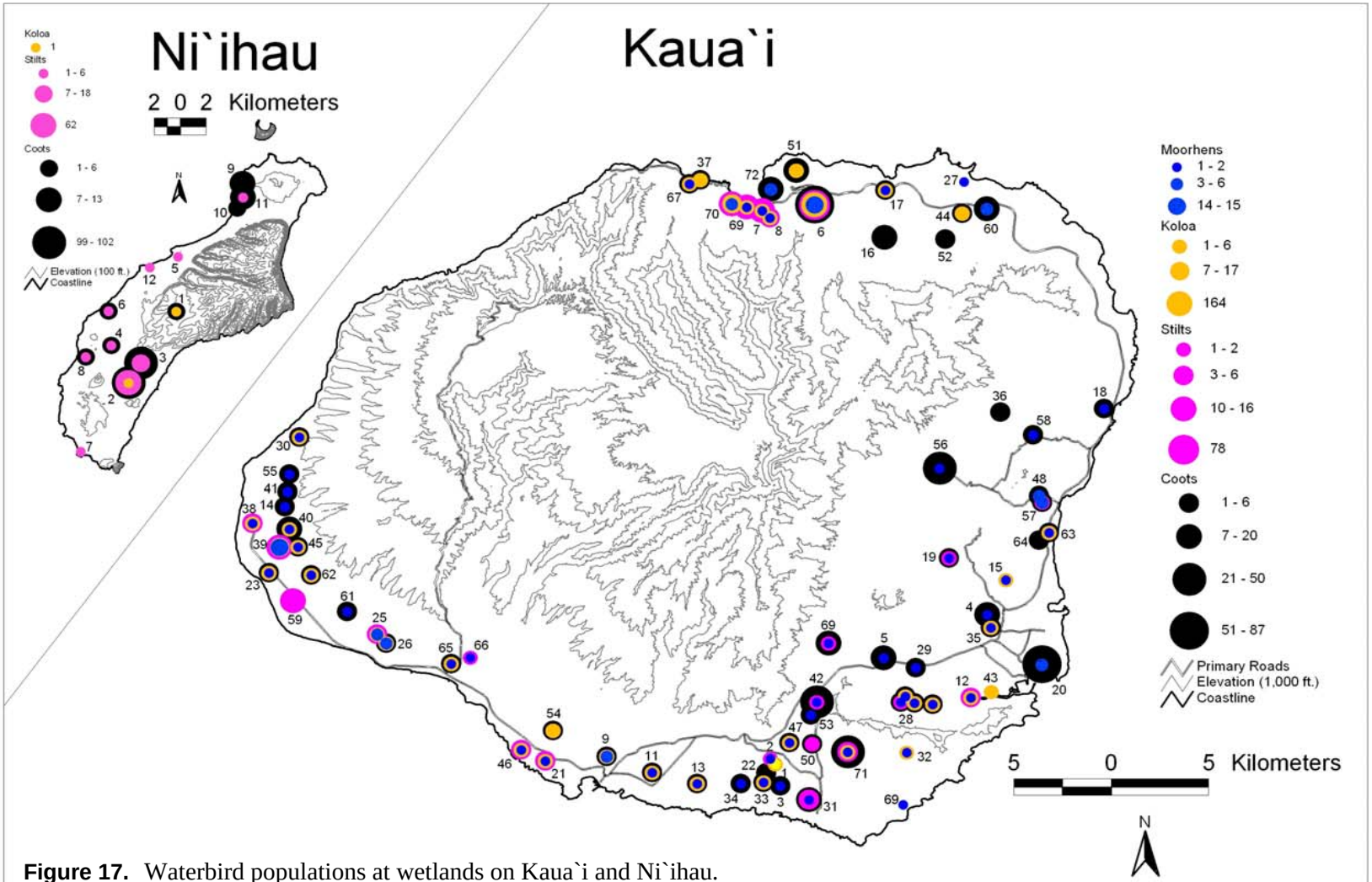

Figure 17. Waterbird populations at wetlands on Kaua`i and Ni`ihau.
Values are 5-year averages using winter counts of adults only from 1999 to 2003 for Kaua`i and 1993, 1995, 1996, 1997, and 1999 for Ni`ihau.

Table 4. Locations of numbered wetlands on Kaua`i (K) and Ni`ihau (N) shown in Figure 17.

Wetland	Island	Number on Map
Aeopoalua Reservoir	K	1
Aepo Reservoir	K	2
Aepoeha Reservoir	K	3
De Mello Reservoir	K	4
Halenānahu Reservoir	K	5
Hanalei N.W.R	K	6
Hanalei Post Office Taro Fields	K	7
Hanalei Trader Taro Fields	K	8
HanapēpēTaro Fields	K	9
Hanini Reservoir	K	10
Hukiwai Reservoir	K	11
Hulē`ia National Wildlife Refuge	K	12
Ioleau Reservoir	K	13
Kahelunui Reservoir	K	14
Kaili`iliainale (Okinawa) Res.	K	15
Kalihiwai Reservoir	K	16
Kalihiwai River Estuary	K	17
Kapa`a Stream Estuary	K	18
Kapaia Reservoir	K	19
Kaua`i Lagoons Westin	K	20
Kaumakani Gulch Pond	K	21
Kaupale Reservoir	K	22
Kawailele Sand Mine	K	23
Kekaha Landfill (Leachate) Pond	K	24
Kekaha Slaught. House Res	K	25
Kekaha Sugar Company Settling Basin	K	26
Kīlauea Stream Estuary	K	27
Kīpū Reservoirs 1-4	K	28
Kīpū Road Reservoir	K	29
Kolo Reservoir	K	30
Kōloa (Kukui`ula) Sewage Pond	K	31
Kōloakapohu Reservoir	K	32
Kumano Reservoir	K	33
Lauwai Reservoir	K	34
Līhu`e Settling Basin	K	35
Lono Reservoir	K	36
Lumaha`i River	K	37
Mānā Base Pond	K	38
Mānā Ditches & Drains	K	39
Mānā House Reservoir	K	40
Mānā Reservoir	K	41
Mauka Reservoir	K	42

Table 4 (continued). Locations of numbered wetlands on.Kaua`i (K) and Ni`ihau (N) shown in Figure 17.

Wetland	Island	Number on Map
Menehune Fish Pond	K	43
Morita Reservoir	K	44
Niu Valley Reservoir	K	45
Olokele Settling Basin Reservoir	K	46
`Ōma`o Reservoir	K	47
`Ōpaeka`a Valley	K	48
Pāpua`a Reservoir	K	49
Pia Mill Reservoir	K	50
Princeville Golf Course Ponds	K	51
Pu`u Ka Ele Reservoir	K	52
Pu`u O Hewa Reservoir	K	53
Pu`u O Papai Reservoir	K	54
Saki Mana Reservoir	K	55
Sloggett Reservoir	K	56
Smith's Tropical Paradise	K	57
Twin Reservoir	K	58
U.S. Navy Sewage Treatment Pond	K	59
Waiakalua Reservoir	K	60
Waiawa Reservoir	K	61
Wailau Siphon Reservoir	K	62
Wailua Golf Course Pond	K	63
Wailua Jail Swamp	K	64
Waimea Heights Reservoir	K	65
Waimea Taro Fields	K	66
Wainiha River Taro Fields	K	67
Waioli Taro Fields	K	68
Waiopili Spring Quarry	K	69
Waipa Taro Fields	K	70
Waitā Reservoir	K	71
Wilcox Ponds	K	72
`Āpana Reservoir	N	1
Halāli`i Ditches	N	2
Halāli`i Lake	N	3
Halulu Lake	N	4
Kaununui Ponds	N	5
Ki`eki`e Ponds	N	6
Lē`ahi Pond	N	7
Nonopapa Lake	N	8
Palikoa`e Ponds	N	9
Pōhueloa Valley Pond	N	10
Pu`u `Alala Pond	N	11
Pu`u Wai Pond	N	12

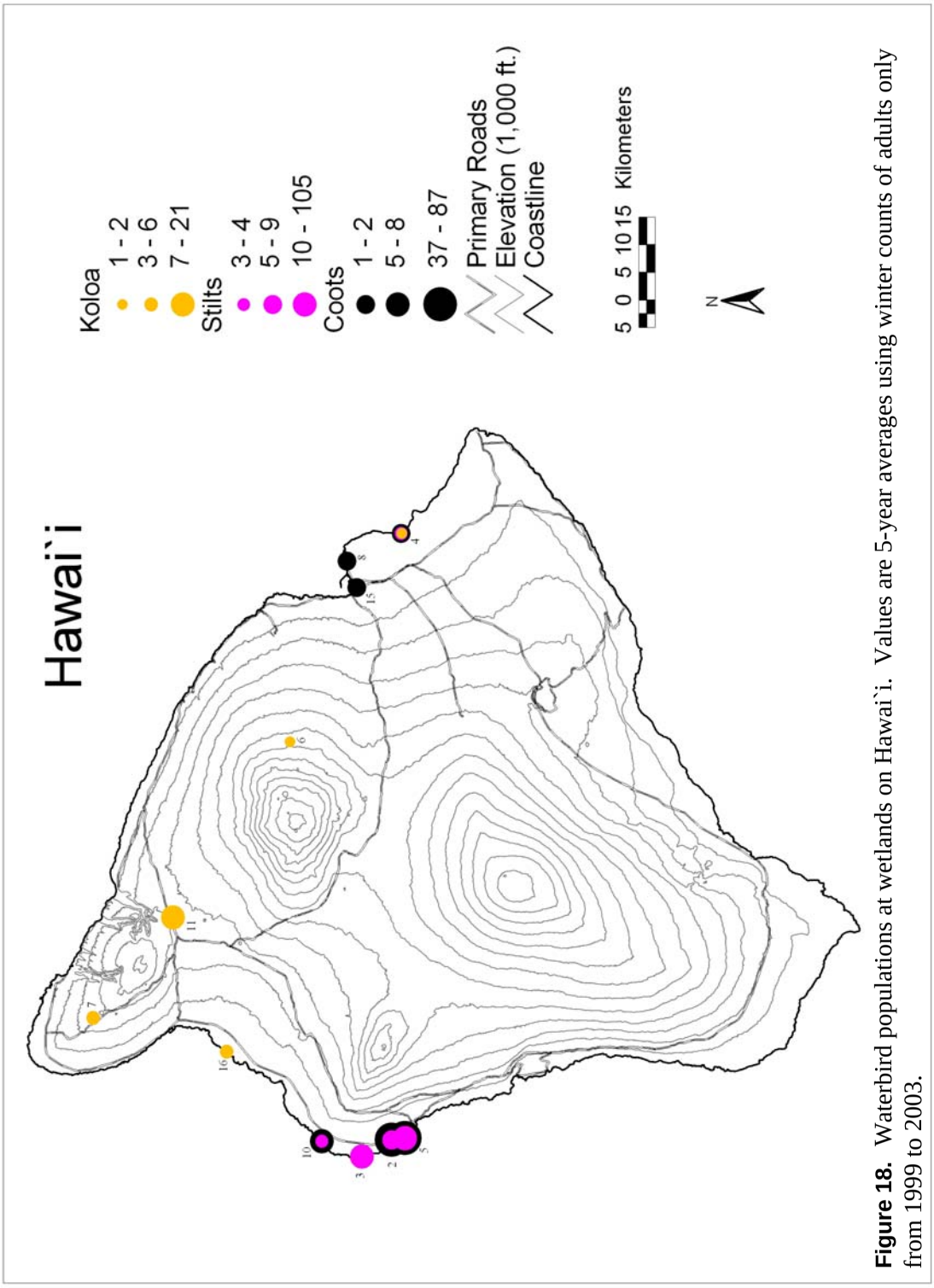

Figure 18. Waterbird populations at wetlands on Hawai`i. Values are 5-year averages using winter counts of adults only from 1999 to 2003.

Table 5. Locations of numbered wetlands on Hawai`i shown in Figure 18.

Wetland	Number on Map
Ahn's Pond	1
`Aimakapā Pond	2
Cyanotech	3
Kea`au Pond (Shipman)	4
Kealakehe (Kona) Sewage Treatment Plant	5
Keanakolu Road Stock Ponds	6
Kehena Reservoir and Ponds (1-5)	7
Loko Waka Pond	8
Nakagawa Pond	9
`Ōpae`ula Pond	10
Pāiakuli Reservoir	11
Punalu`u Pond	12
Pu`u Pū`lehu Reservoir	13
Slatter Pond	14
Waiākea Pond	15
Waipuhi Ponds (1 and 2)	16

D. REASONS FOR DECLINE AND CURRENT THREATS

The most important cause of decline of these four species of endangered Hawaiian waterbirds is loss of wetland habitat. Other factors that have contributed to population declines, and which continue to be detrimental, include predation by introduced animals, altered hydrology, alteration of habitat by invasive nonnative plants, disease, and possibly environmental contaminants. Hunting in the late 1800's and early 1900's took a heavy toll on Hawaiian duck populations, and to a lesser extent on populations of the other three species (Swedberg 1967). Currently, predation by introduced animals may be the greatest threat to the coot, moorhen, and stilt, and hybridization with feral mallards (*Anas platyrhynchos*) is the most serious threat to the Hawaiian duck.

The identified threats to the Hawaiian waterbirds are each classified according to the five factors identified under section 4(a)(1) of the Endangered Species Act in consideration for listing, delisting, and reclassification decisions. These five factors are as follows:

A — The present or threatened destruction, modification, or curtailment of its habitat or range;

B — Overutilization for commercial, recreational, scientific, or educational purposes;

C — disease or predation;

D — the inadequacy of existing regulatory mechanisms;

E — other natural or manmade factors affecting its continued existence.

1. Loss of Wetland Habitat (Factor A)

A significant amount of Hawai`i's wetlands have been filled or otherwise modified and are now occupied by hotels, housing developments, golf courses, shopping centers, landfills, military installations, highways, former sugarcane fields, and industrial sites. Hawai`i contains approximately 44,320 hectares (110,800 acres) of wetlands and deep freshwater habitats, of which 81 percent are classified as palustrine scrub-shrub forest habitats, which are not used by Hawai`i's four endangered waterbirds. This wetland class is located at mid- to high elevations and occurs as bogs and rainforest ecosystems. The waterbirds addressed in this recovery plan primarily utilize wetlands that exist within the coastal plains of Hawai`i, of which an estimated 8,990 hectares (22,475 acres) existed circa 1780 (USFWS 1990). By 1990, however, only an estimated 6,190 hectares (15,474 acres) of these wetlands remained, a decrease of 31 percent (Dahl 1990).

Wetland agriculture (taro, lotus, and rice) has provided additional managed wetlands for waterbirds since the arrival of the first Polynesians (Stone 1989). As early as the 1850's, significant losses of this type of habitat began with the partial replacement of taro by other agricultural crops (*e.g.*, sugarcane) and by development for an expanding industrial society (Bostwick 1982). This gradual loss of natural and agricultural wetlands has continued to the present. Sugar plantations provided a limited amount of habitat via settling basins and reservoirs. The collapse of the sugarcane industry has resulted in the draining of many of these reservoirs and basins, which were widely utilized by resident waterbirds, migratory waterfowl, and migratory shorebirds.

Hawaiian common moorhens have become dependent in some areas upon modern aquacultural wetlands (used for raising, for example, taro or shrimp) for their survival (Engilis and Pratt 1993), and many other bird species also use these wetlands. The majority of aquacultural wetlands occur on O`ahu. The industry reached its peak in the mid-1980's and is now declining. Waterbirds are occasionally implicated as a cause of depredation on taro and prawn farms. Suspected depredation may result in efforts by farmers to place exclusion devices around ponds that would effectively eliminate some habitat presently utilized by waterbirds.

Many of Hawai`i's wetlands occur in coastal areas that are highly valued for development and are becoming increasingly urbanized. This urban encroachment raises concerns regarding human disturbance, urban runoff impacts on water quality, and an increased incidence of domestic cats and dogs in wildlife areas (Brown and Dinsmore 1986; Reid 1993). Development pressure in wetland areas has been most prevalent on the islands of O`ahu and Maui, but is increasing on all islands. Urban development has encroached upon both Kanahā and Keālia Ponds on Maui, and the Honouliuli Unit of Pearl Harbor National Wildlife Refuge is now surrounded by urban development. If

hotels and golf courses on the Kahuku Plain of O`ahu expand, ephemeral wetlands that are utilized by waterbirds will be lost to development.

2. Hunting (Factor B)

Indiscriminate hunting of migratory waterfowl in the late 1800's and early 1900's took a heavy toll on Hawaiian duck populations. During this period, as habitat size and quality decreased, direct pressure on waterbird populations increased. When bag limits were introduced, they were generous (25 ducks, including both Hawaiian ducks and mainland duck migrants, per day over a 4-month season) and difficult to enforce. In 1925, the Territorial Fish and Game Commission closed the Hawaiian duck season, but because of their similarity to female mallards and pintails, Hawaiian ducks probably received little protection (Swedberg 1967). A total ban on waterfowl hunting, initiated in 1939 and which is still in effect today, provided important protection for the remaining Hawaiian ducks (Bostwick 1982). Although overhunting contributed to the historical decline of the Hawaiian duck, it is not considered a current threat to the species.

3. Predators (Factor C)

The introduction of alien predators has had a negative impact on populations of all four endangered waterbirds (Griffin *et al.* 1989). Birds on the Hawaiian Islands evolved in the absence of mammalian predators, and are consequently highly vulnerable to these introduced animals. Mongooses were first introduced to the island of Hawai`i in 1883, subsequently to Maui, Moloka`i, and O`ahu, and it is possible an incipient population exists on Kaua`i (K. Gundersen, Kaua`i Invasive Species Committee, pers. comm. 2004). Mongooses have become a serious threat to waterbirds throughout these islands, taking eggs, young birds, and nesting adults. Feral cats became established in Hawai`i shortly after European contact and were common in O`ahu forests as early as 1892 (Tomich 1969). Cats range from sea level to at least 2,900 meters (9,500 feet) on the Big Island (Hu *et al.* 2001) and 3,055 meters (10,000 feet) on Maui (Hodges and Nagata 2001). The proliferation of feral cat feeding stations near parks and other areas that support waterbirds may have a significant effect on waterbird recovery in these areas. Dogs have become a serious problem in some wetlands, particularly near urban areas. Although direct evidence is lacking, rats most likely have a negative effect on the waterbirds as well (Atkinson 1977). Rats are known to be one of the primary predators on the eggs and goslings of the endangered nēnē (USFWS 2004c).

Other introduced species, such as the cattle egret, bullfrog, and barn owl (*Tyto alba*), also have had negative impacts on waterbirds. The introduced bullfrog is a voracious predator of all small animals, and is known to eat young Hawaiian ducks (R. Walker, USFWS, pers. comm. 1982) and young stilts (Robinson *et al.* 1999; Eijzenga 2003). Barn owls have been observed taking adult stilts and are presumed to take chicks as well (K. Viernes, USFWS, pers. comm. 1994). Cattle

egrets play an unquantified role as a predator of nestling birds. Other predators on Hawaiian stilts include the alien common myna (Robinson *et al.* 1999) and perhaps the native Hawaiian short-eared owl or pueo.

In addition, both native and nonnative fish may prey upon endangered waterbirds. It is suspected that large fish in the `Aimakapā Fishpond in Kona may be a source of mortality for coot chicks (Morin 1994). It is believed introduced tilapia degrade waterbird feeding habitats by depleting the invertebrate prey base used by these birds (C. Swenson, USFWS, pers. comm. 2004). Native barracuda (*Sphyraena barracuda*) in Nu`upia Ponds on O`ahu are suspected of eating young stilts (C. Swenson, pers. comm. 2004).

The problems posed by these predators are magnified by a severe shortage of protected nesting areas. The importance of core wetland areas, permanent habitat that supports substantial numbers of Hawaiian waterbirds, is most evident during drought periods when waterbird populations become concentrated. These sites must be protected and managed to recover Hawai`i's waterbirds. During drought periods, nesting, foraging, and loafing sites become limited and overcrowding can result. Predator numbers then rapidly increase in response to this concentrated food source. This type of predator response has been well documented in North America and is summarized by Sargeant and Raveling (1992).

4. Alteration of Hydrology (Factor A)

Hydrologic alterations of wetlands, such as flood control and channelization, often make habitat less suitable or unusable for native waterbirds because they alter both water depth and timing of water level fluctuations. Hawaii's waterbirds may be unable to adjust their breeding behavior to accommodate these modifications, possibly resulting in decreased reproductive success. In addition, the depletion of freshwater aquifers causes salt water intrusion into coastal ground water, altering the salinity levels in associated wetlands. Although stilts and coots will use brackish water, moorhens and Hawaiian ducks do so only rarely. In addition, fluctuations in salinity levels alter the species composition of the vegetation and arthropod communities, thus impacting food availability for the waterbirds. At Nu`upia Ponds on O'ahu, mean salinity varied from 35 to 64 ppt (parts per thousand) (Hawai`i Division of Forestry and Wildlife 1978), and in a study on Kaua`i, salinity ranged from a low of 4 ppm (parts per million) to a high of 68 ppm (Coleman 1981). Such changes in hydrology highlight the need for secure water sources for both the core and supporting wetlands identified in this recovery plan (see Recovery Strategy, page 65). Analysis and management of hydrology are vital to managing waterbird habitat.

5. Invasion of Habitat by Nonnative Plants (Factor A)

The alteration of wetland plant communities due to invasion by nonnative plants can greatly reduce the usefulness of wetland areas for native waterbirds. Nonnative plant control is a key problem facing wetland managers in the State of Hawai`i. Managers are constantly faced with the challenge of developing techniques and then securing enough staff and funding to implement management. Species such as California grass (*Brachiaria mutica*), pickleweed (*Batis maritima*), water hyacinth (*Eichornia crassipes*), Indian fleabane (*Pluchea indica*), and mangrove (*Rhizophora mangle*) present serious problems in most Hawaiian wetlands by outcompeting native species and eliminating open water, exposed mudflats, or shallows (Shallenberger 1977).

6. Hybridization (Factor E)

The most serious threat specifically affecting Hawaiian ducks is genetic introgression (the introduction of a gene from one gene complex into another) through interbreeding with feral mallards (*i.e.* domesticated mallards that have escaped and now breed in the wild). Wild, migratory mallards also occur in Hawai`i (Pyle 2002) but generally leave the islands before the breeding season starts and thus are not thought to interbreed with Hawaiian ducks. Reduction of wetland habitat may increase opportunities for hybridization as populations of Hawaiian ducks and feral mallards are forced to share smaller wetland areas. The distribution and abundance of Hawaiian ducks and mallard-Hawaiian duck hybrids is not clear in some areas, particularly O`ahu and Maui, due to difficulties in identification and inconsistency in attempting to distinguish hybrids. Determination of the population status of Hawaiian ducks and whether there are any pure Hawaiian ducks left on O`ahu will require simultaneous genetic testing and morphological characterization to develop reliable morphological criteria for distinguishing Hawaiian ducks, female mallards, and hybrids. Once such criteria are available they can be used to identify birds for removal in order to reduce interbreeding and introgression. The number of hybrids apparently has increased rapidly on some islands in recent years (Figures 19 through 26); this pattern is no doubt real, but it is possible that hybridization has been occurring for some time and the apparently rapid increase is due to greater realization of the hybridization problem and more careful identification of Hawaiian duck-like birds.

Kaua`i has by far the largest Hawaiian duck population and is thought to be largely free of hybrids, making it extremely valuable as a potential source of individuals for translocation or captive breeding and reintroduction to other islands. However, hybridization appears to be beginning on Kaua`i, and a few Hawaiian duck-mallard hybrids have been recorded at Smith's Tropical Paradise (Paradise Pacific) in the Wailua River bottoms, and possibly at Hanalei National Wildlife Refuge (Figure 22). Mallards and known hybrids should be

removed from these and other sites immediately to stop hybridization and prevent introgression into the Hawaiian duck gene pool on Kaua`i. Because Kaua`i represents the core of the species distribution and is the only island that likely could provide birds for reintroduction to other islands, removal of feral mallards and hybrids on Kaua`i is of the highest priority.

On O`ahu, Hawaiian ducks are still reported in small numbers at some sites (Figures 19 and 23), but whether these birds are actually Hawaiian ducks or hybrids is not clear. Many areas on O`ahu now have numerous feral mallards and mallard-Hawaiian duck hybrids, with the largest concentrations in Kawainui Marsh, Oneawa Canal, Kaelepulu (Enchanted Lake), Ho`omaluhia, and the Hawai`i Prince Golf Course. Although hybridization is most severe on O`ahu, removal of feral mallards from O`ahu is a lower priority than on other islands because few or no pure Hawaiian ducks are left.

On Maui, most feral mallards are found in the Ka`anapali area, with smaller numbers in the numerous reservoirs of the central valley (Figure 20). All Hawaiian duck-like birds on Kanahā Pond recently have been recorded as Hawaiian ducks, while all those at Keālia Pond have been recorded as hybrids, but it seems unlikely that this apparent segregation is real; ducks could move easily between these sites, and the difference is probably due to the difficulty of identification in the field. Feral mallards have not been reported on Moloka`i or Lāna`i. Efforts should be made to prevent their arrival.

On the island of Hawai`i, the largest concentration of feral mallards is at Waiakea Pond in Hilo, which also supports many other exotic waterfowl and may serve as a source of feral mallards that disperse across the island (Figure 21). Substantial numbers of Hawaiian ducks exist in the Kohala area, but hybrids have been reported recently in stock ponds on Kohala and Mauna Kea (Figure 21; K. Uyehara, Ducks Unlimited [formerly], pers. comm. 2003). Hybridization appears to be limited on Hawai`i at this point, and management of feral mallards and known hybrids is a high priority before the problem worsens.

7. Avian Disease (Factor C)

The most prevalent disease affecting waterbirds is avian botulism, which has been documented at Ōhi`apilo Pond on Molokai, Hanalei National Wildlife Refuge, Kaua`i, `Aimakapā Pond on Hawai`i, and at Keālia Pond National Wildlife Refuge on Maui. It is caused by a toxin produced by anaerobic bacteria (*Clostridium botulinum* type C_a) in stagnant water. The disease may reappear annually and can affect all native and migratory waterbirds, causing flaccid paralysis which is evidenced by staggering and the eventual loss of use of legs. Tracking of the location and timing of avian botulism outbreaks might reveal patterns that could be used to avoid environmental conditions that lead to outbreaks.

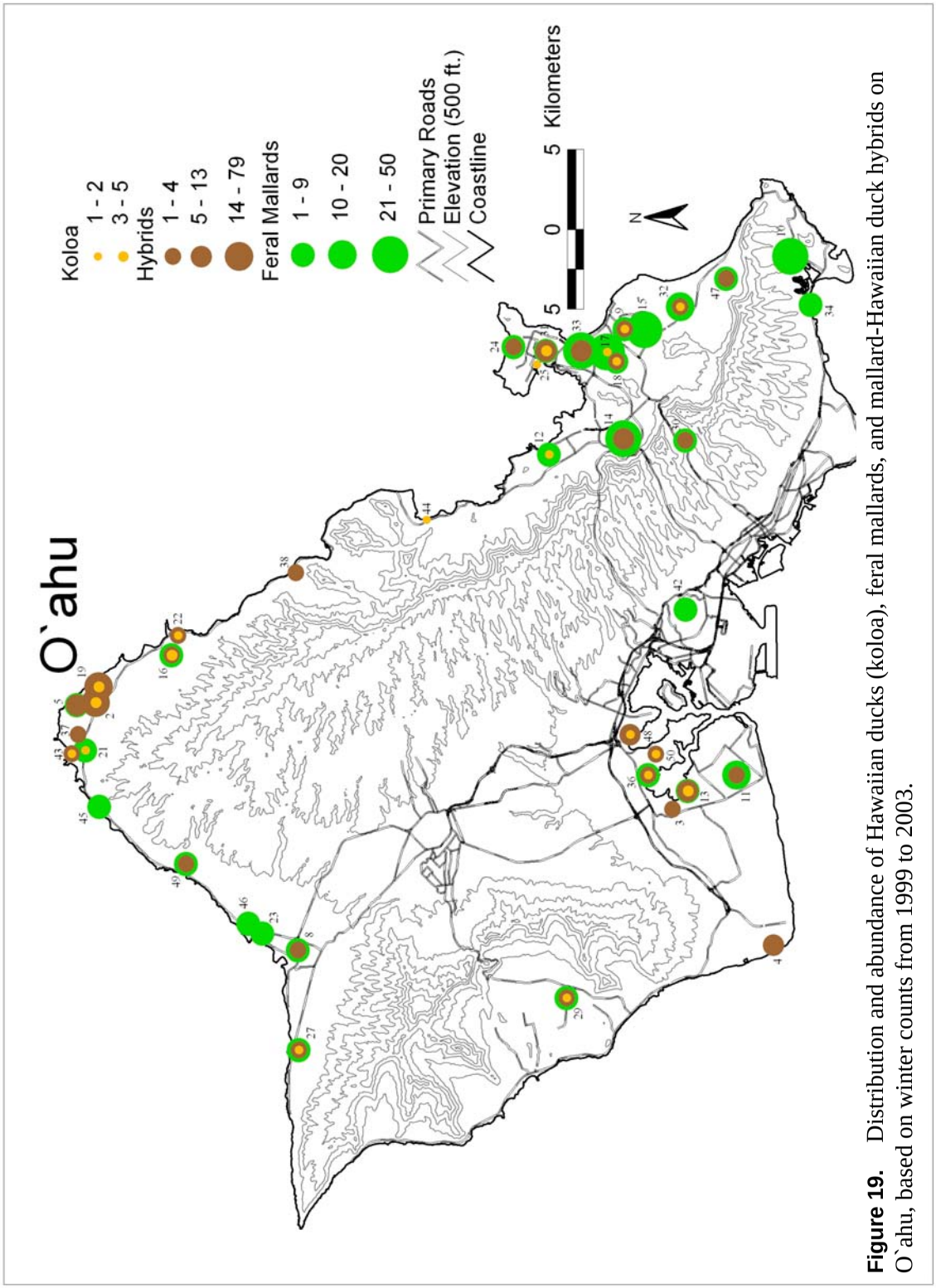

Figure 19. Distribution and abundance of Hawaiian ducks (koloa), feral mallards, and mallard-Hawaiian duck hybrids on O`ahu, based on winter counts from 1999 to 2003.

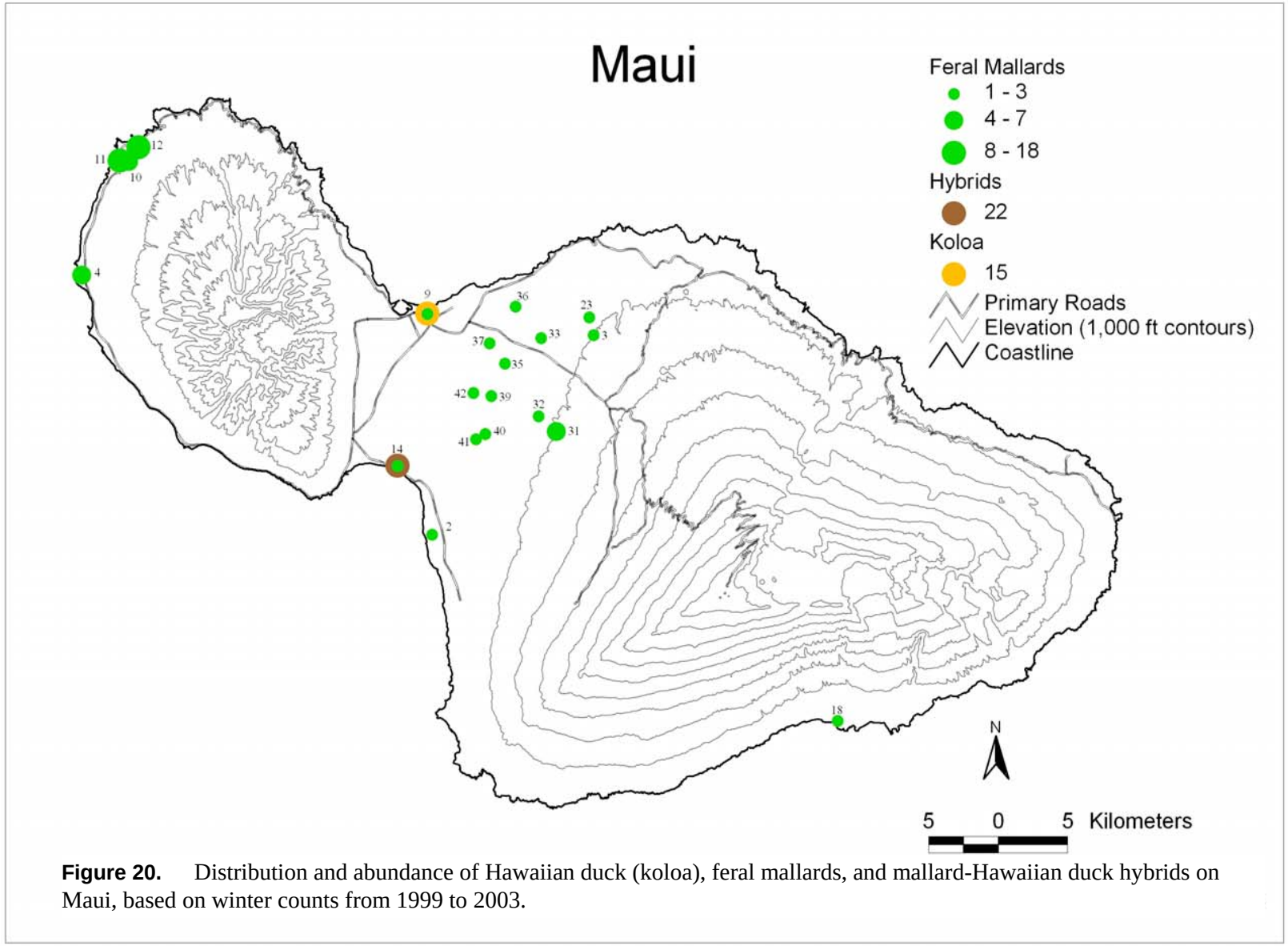

Figure 20. Distribution and abundance of Hawaiian duck (koloa), feral mallards, and mallard-Hawaiian duck hybrids on Maui, based on winter counts from 1999 to 2003.

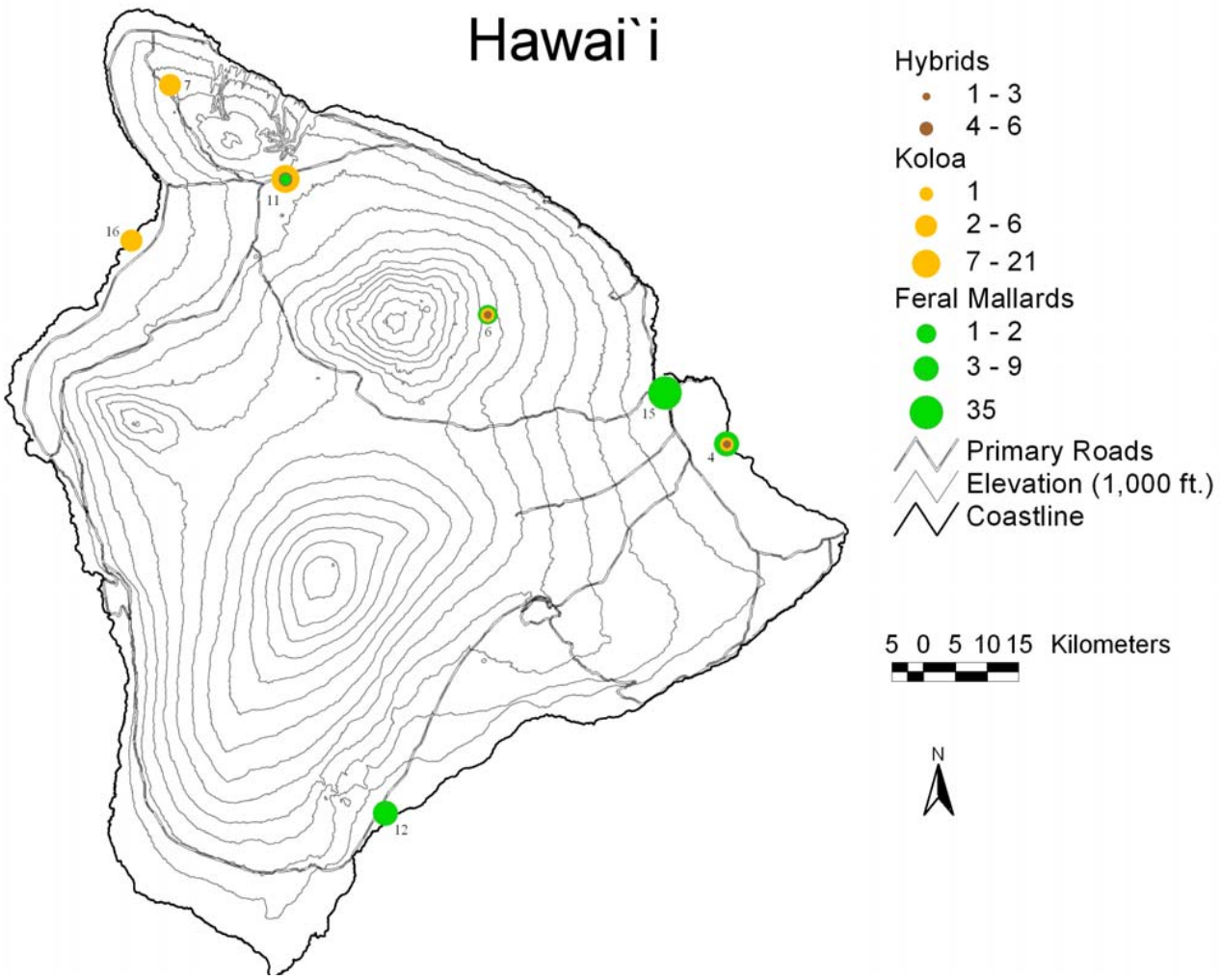

Figure 21. Distribution and abundance of Hawaiian duck (koloa), feral mallards, and mallard-Hawaiian duck hybrids on Hawai`i, based on winter counts from 1999 to 2003.

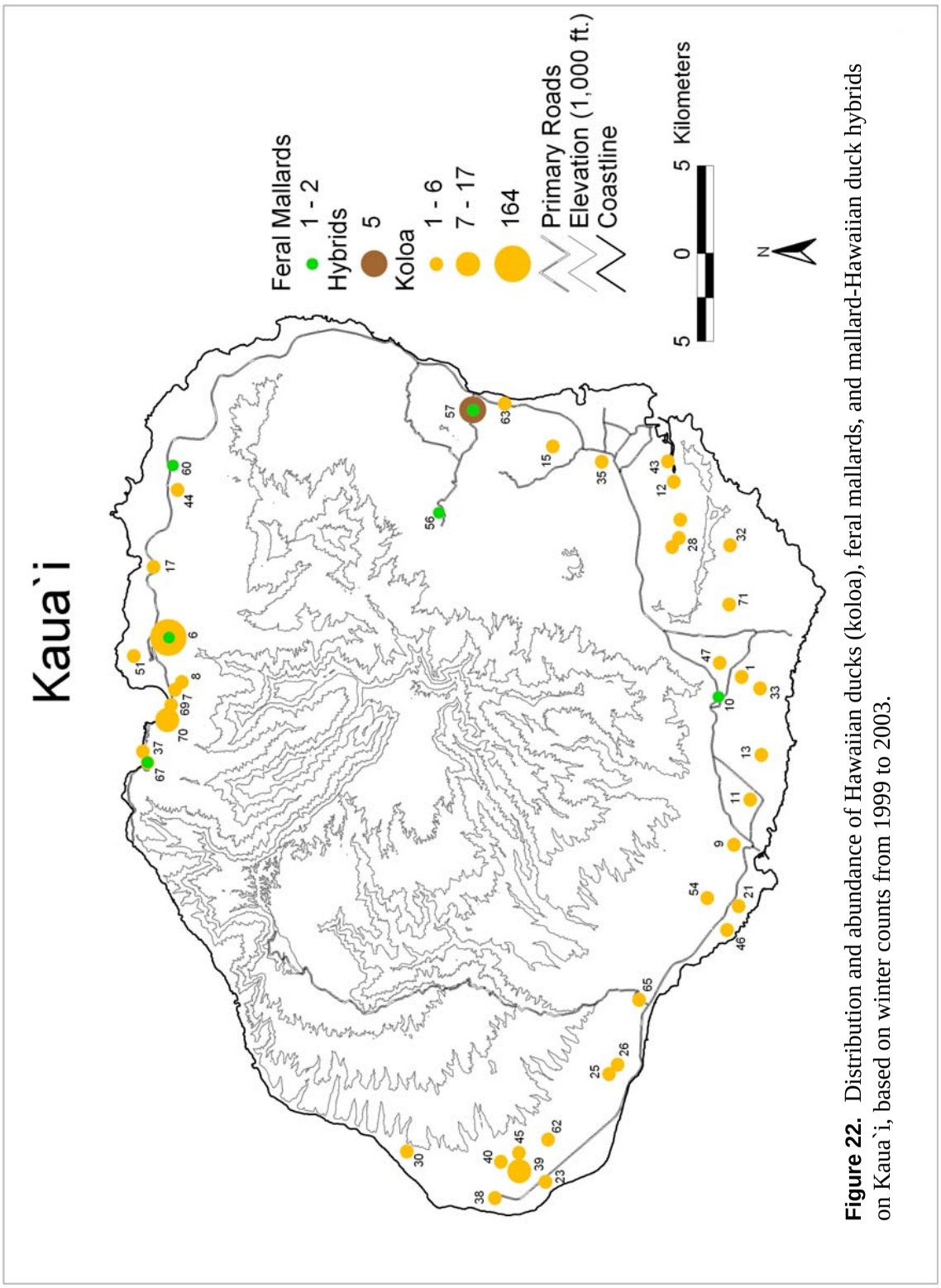

Figure 22. Distribution and abundance of Hawaiian ducks (koloa), feral mallards, and mallard-Hawaiian duck hybrids on Kaua`i, based on winter counts from 1999 to 2003.

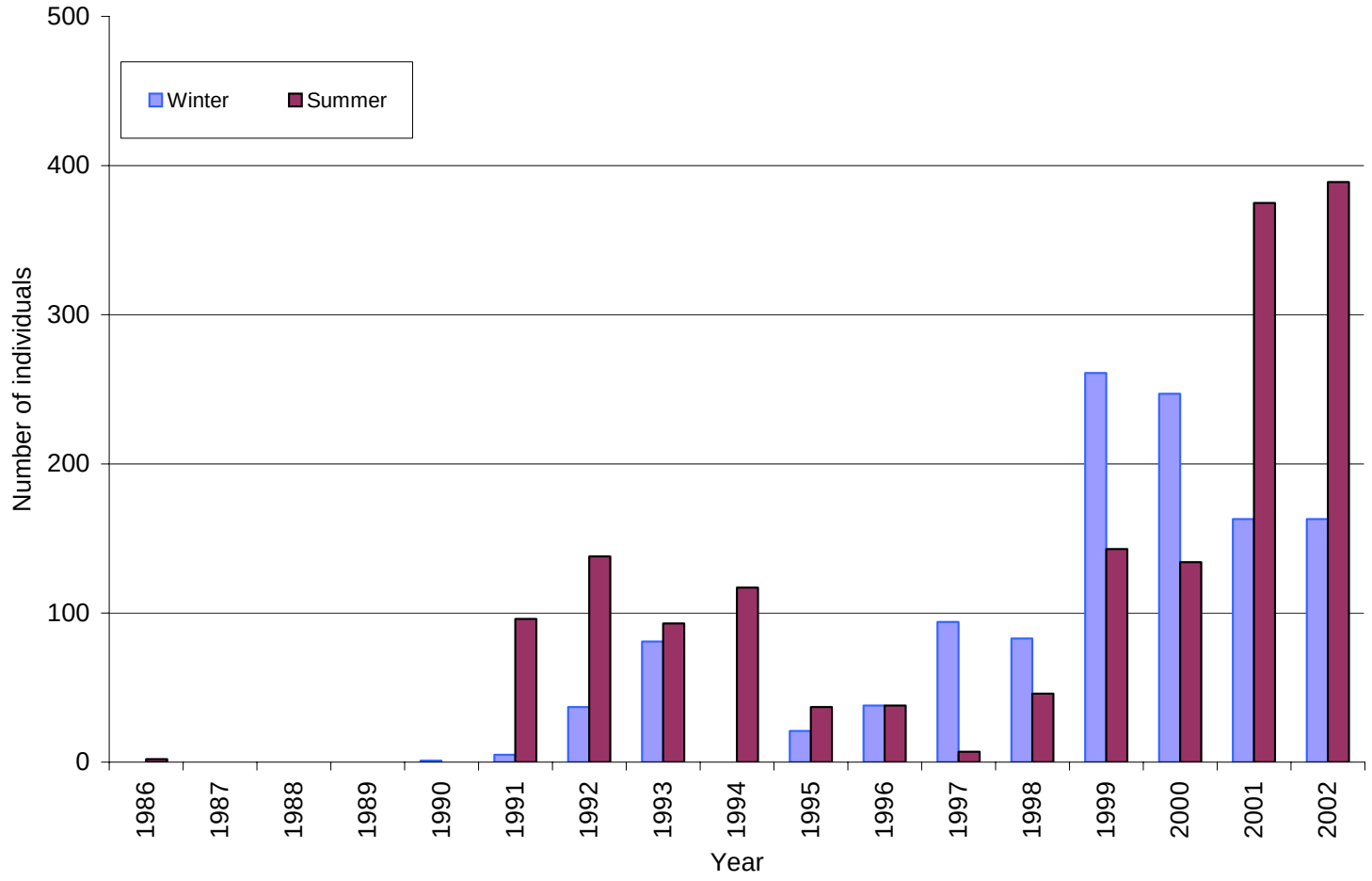

Figure 23. Mallard-Hawaiian duck hybrid winter and summer counts on O`ahu, based on biannual waterbird counts from 1986 to 2002.

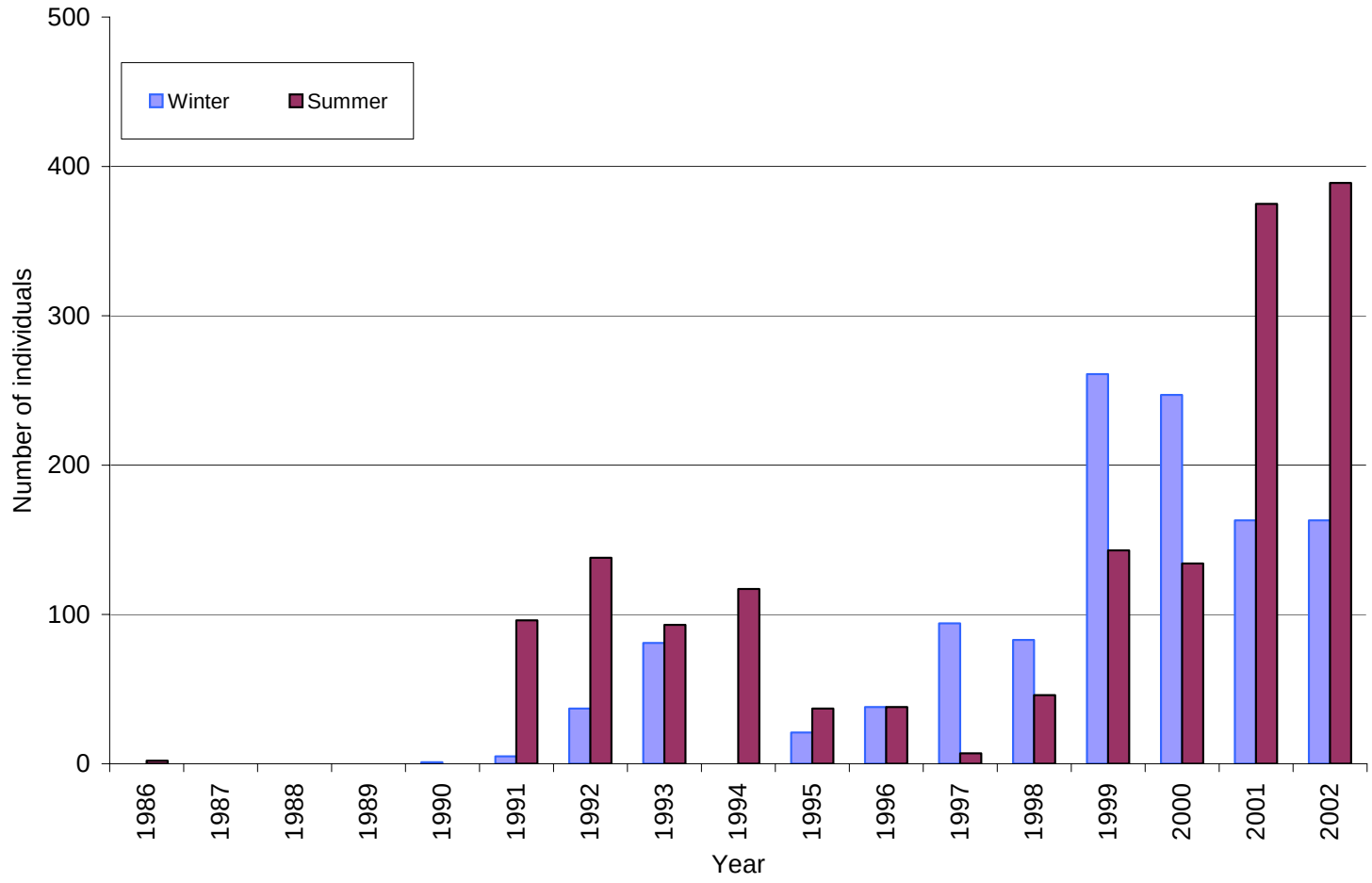

Figure 24. Mallard-Hawaiian duck hybrid winter and summer counts on Maui, based on biannual waterbird counts from 1999 to 2003.

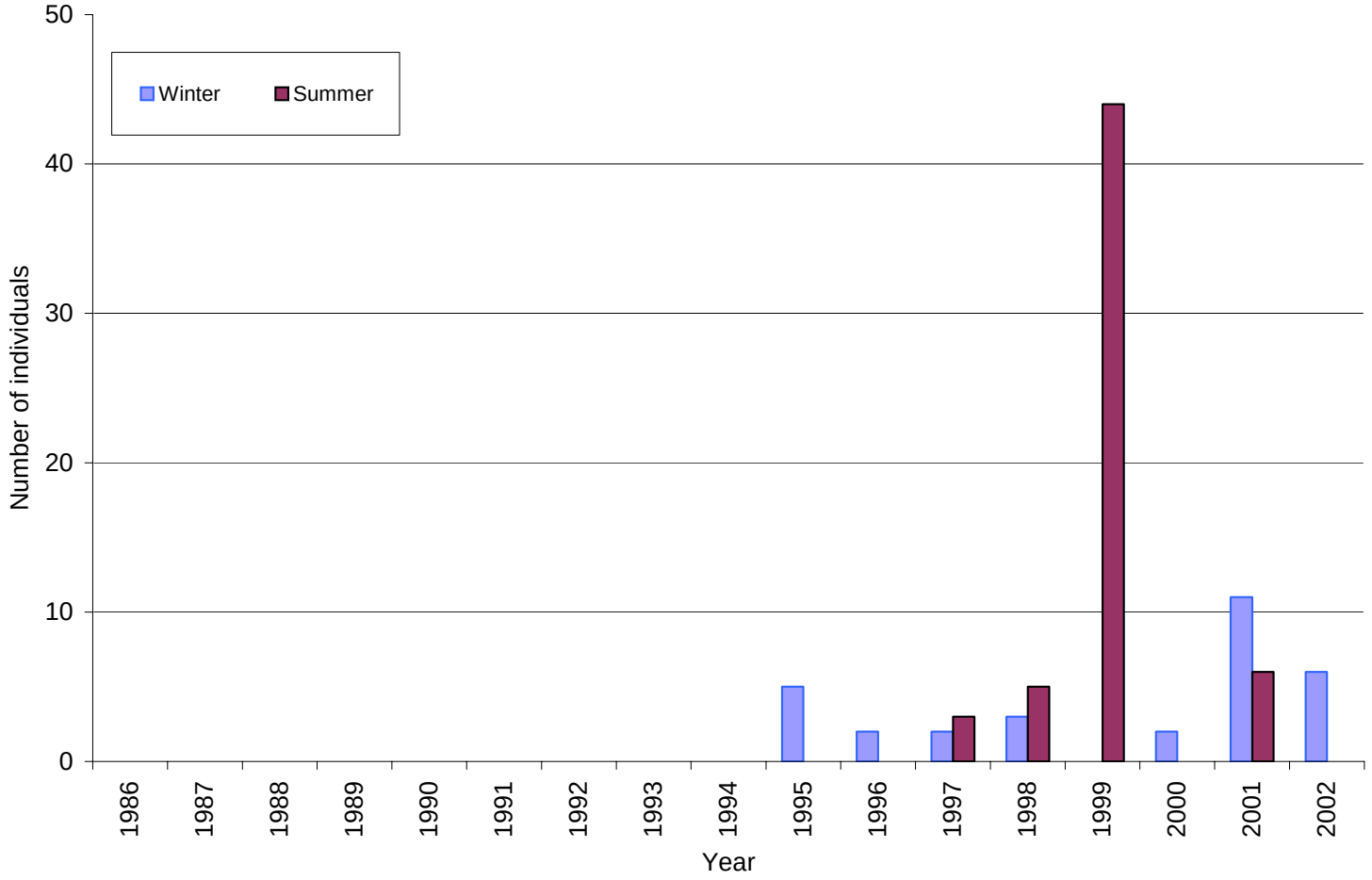

Figure 25. Mallard-Hawaiian duck hybrid winter and summer counts on Hawai`i, based on biannual waterbird counts from 1986 to 2002.

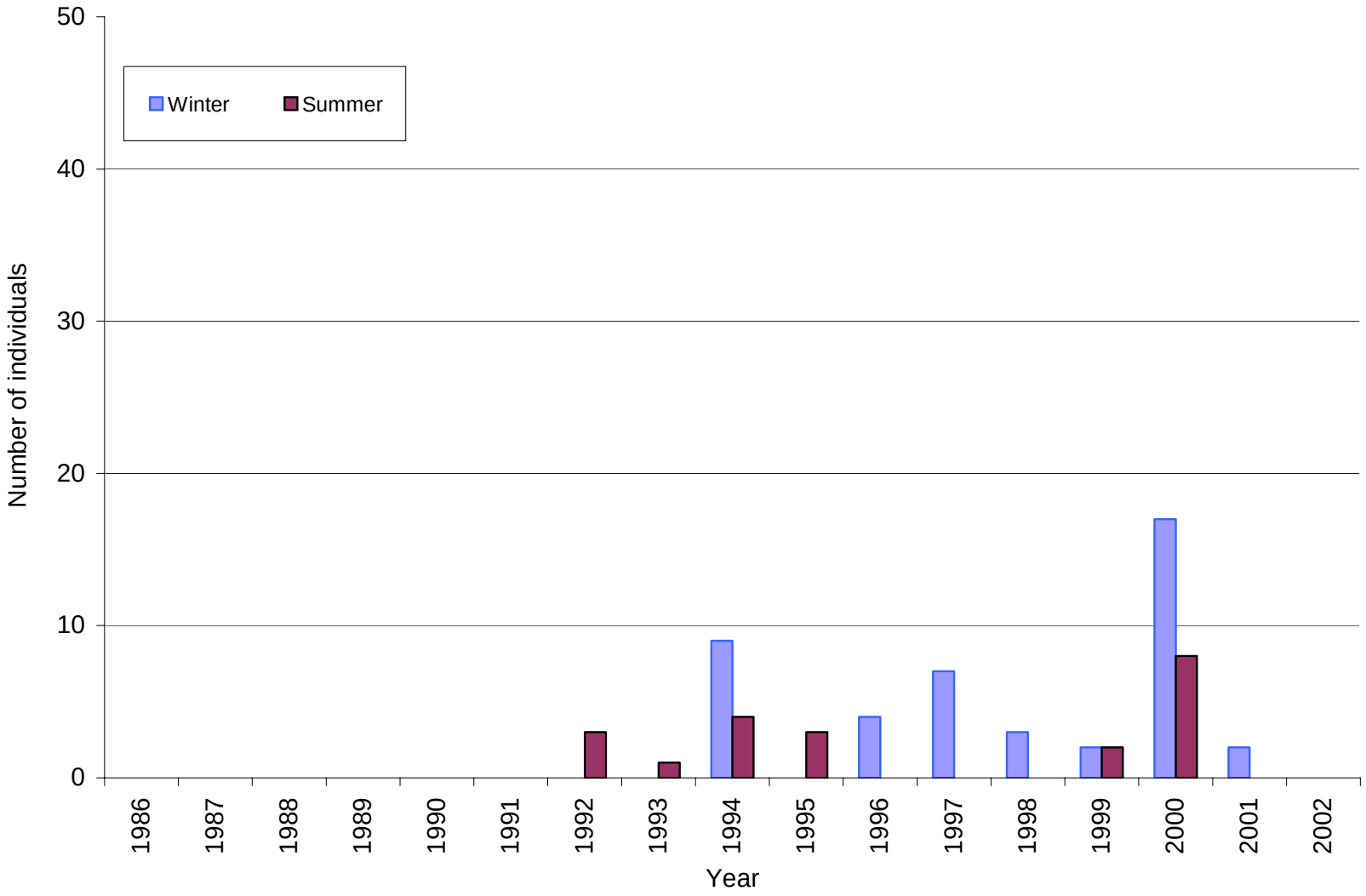

Figure 26. Mallard-Hawaiian duck hybrid winter and summer counts on Kaua`i, based on biannual waterbird counts from 1986 to 2003.

8. Environmental Contaminants (Factor E)

Environmental contaminants in wetlands are of concern to waterbird recovery because the general diet of these birds makes them susceptible to toxins accumulated in the food chain (Rattner 2000). In 1988, a fuel spill in Pearl Harbor caused direct mortality and nest abandonment of native waterbirds at the Honouliuli Unit of Pearl Harbor National Wildlife Refuge (J. Leinecke, USFWS, pers. comm. 1993). In 1996, an oil spill in Pearl Harbor imperiled the Hawaiian stilt as well as marine fisheries (Pearl Harbor Natural Resource Trustees 1999). Degradation of water quality from urban encroachment on wetlands also has the potential to negatively affect waterbirds.

E. CONSERVATION MEASURES

A variety of conservation measures have been implemented to protect Hawaii`s endangered waterbirds. These efforts include a long-term hunting ban, protection of habitat through establishment and management of refuges and sanctuaries, population monitoring, research projects, release of captive-bred Hawaiian ducks, and restrictions on importation of mallards. Federal, State, and private entities have all contributed to Hawaiian waterbird recovery. The major contributions of these entities are summarized below.

1. Federal and State Actions

Indiscriminate hunting of migratory waterfowl in the late 1800's and 1900's took a heavy toll on waterbird populations, especially for the Hawaiian duck because of their similar appearance to mallards and pintails. When bag limits were introduced they were generous and difficult to enforce. All Hawaiian waterbird species continued to be hunted for several more decades. In 1925, the Territorial Fish and Game Commission closed the Hawaiian duck season, but because of their similarity to female mallards and pintails, Hawaiian ducks probably received little protection (Swedberg 1967). A total ban on waterfowl hunting in 1939, which is still in effect today, provided important protection for the remaining Hawaiian ducks (Bostwick 1982).

In 1952, the State designated Kanahā Pond on Maui as the first State wildlife sanctuary. Other State sanctuaries include Kawai`ele on Kaua`i, and Hāmākua Marsh, Paikō Lagoon, and Pouhala Marsh on O`ahu. In 1964, the U.S. Fish and Wildlife Service (then called the Bureau of Sport Fisheries and Wildlife) and the Hawai`i Department of Land and Natural Resources initiated studies of Hawaiian stilts and other waterbirds at Kanahā Pond.

Additional legal protection was afforded these waterbirds with the passage of Federal legislation for endangered species, including the Endangered Species Preservation Act of 1966, the Endangered Species Conservation Act of 1969, and the Endangered Species Act of 1973. The Hawaiian duck and the Hawaiian common moorhen were declared Federal endangered species in 1967 (USFWS 1967). The Hawaiian coot and

stilt were added to the Federal endangered species list in 1970 (USFWS 1970).

The State Division of Forestry and Wildlife (then called the Division of Fish and Game) initiated Hawaiian duck restoration efforts in 1956 when they brought Hawaiian ducks from Kaua`i into captivity at Pohakuloa, Hawai`i, to create a captive breeding population for use in reestablishing the species on other islands. The first release of 26 captive-bred Hawaiian ducks occurred in 1958 at Kahua Ranch, Hawai`i (Engilis *et al.* 2002). Releases of captive-bred birds continued on Hawai`i from 1968 through 1979, with 361 birds released at Kahua Ranch and 58 released in the Hilo Forest Reserve. On O`ahu, 350 Hawaiian ducks were released from 1968 through 1982 (Engilis and Pratt 1993). Feral mallards were not removed from the reintroduction sites on Oahu prior to the releases, however, resulting in extensive hybridization and genetic introgression of mallards into the reestablished Hawaiian duck population on that island. Hawaiian ducks were also released on Maui from 1989 to 1990, resulting in the establishment of a small population, although hybridization with feral mallards has proven problematic there as well (Ducks Unlimited 1998).

In 1970, State and Federal biologists published an assessment of wetland habitats for endangered waterbirds (USFWS and HDLNR 1970). An important summary of the status of Hawai`i's wetlands followed this assessment (Shallenberger 1977). Since 1972, six National Wildlife Refuges have been established for the protection of waterbirds and their habitats: Hanalei and Hulē`ia on Kaua`i, James Campbell and Pearl Harbor on O`ahu, Kakahai`a on Moloka`i, and Keālia Pond on Maui. Two sanctuaries have also been designated on military lands for the conservation of Hawaiian waterbirds: Niuli`i Ponds in Lualualei Naval Magazine and Nu`upia Ponds on Kaneohe Marine Corps Base, both on O`ahu. State and Federal efforts have now protected 1,711 hectares (4,230 acres) or 27 percent of the remaining 6,190 hectares (15,475 acres) of coastal wetlands in Hawai`i.

In 1975, we established the Hawaiian Waterbird Recovery Team. The mission of this team was to evaluate available data and develop a plan for the recovery of the Hawaiian coot, moorhen, and stilt (the Hawaiian duck was not included in this original recovery plan). Limited information was available to the team due to the lack of statewide surveys and research on each of the species.

The team recognized that the availability of optimum habitat for the waterbirds was key to maintaining self-sustaining populations of these species. Population target levels were based on expected habitat carrying capacity and best professional judgement. The first Hawaiian Waterbirds Recovery Plan was completed in 1978 (USFWS 1978). The primary objective of this recovery plan, as defined by the team, was to maintain self-sustaining populations of at least 2,000 individuals of each species throughout the island distributions and habitats existing in 1976. Upon the

accomplishment of this objective, downlisting and then delisting of the waterbirds could be considered if the birds maintained these target population sizes and distributions for 3 and then 6 years, respectively. Specific recommendations discussed in the original recovery plan included: 1) providing optimum habitat throughout the state for each endangered species to complete their life cycle (accomplished through preservation and enhancement of primary habitat and development and enhancement of secondary and former habitats); 2) reducing adverse factors affecting waterbirds and their habitat, such as predation and/or encroachment of wetlands by invasive nonnative plants, to the lowest possible level; 3) preventing or moderating disasters adversely affecting the species in primary habitats, including habitat management to avoid disease; 4) monitoring populations to determine numbers, status, and distribution and to determine the progress of the statewide recovery program; 5) fostering public awareness and support of recovery plan implementation through an education and information program; and 6) investigating the possibility of captive rearing and release of moorhens on Maui, Moloka`i, and Hawai`i (USFWS 1978).

The recovery plan was revised and updated in 1985 to include the Hawaiian duck (USFWS 1985). While the primary recovery objectives and time frames remained the same, there were some modifications in the primary habitats identified as needing protection or management, based on changes in habitat status. Specific recommendations of the first revised recovery plan included: 1) providing protection of suitable habitat in sufficient abundance and distribution throughout the State for each of the four taxa of waterbirds; 2) maximizing productivity and survival of adults and young; 3) conducting management-related research to fill the gaps in required information; 4) continuing monitoring of all populations of waterbirds; 5) maintaining pure genetic stocks of Hawaiian ducks; 6) supplementing existing or historical populations of waterbirds, as needed; and 7) generating public awareness and support for the waterbird recovery program through education and information.

This second draft of the second revised recovery plan builds upon the previous efforts. The goal of this second draft revised recovery plan is to identify actions needed to downlist Hawai`i's four endangered waterbirds from endangered to threatened status and, ultimately, to remove them from the Federal list of threatened and endangered species (delisting). Steps necessary for the recovery of the four endangered waterbirds include: increasing population numbers to a statewide baseline level; establishing multiple self-sustaining breeding populations throughout each species' historical range; establishing a network of wetlands on the main Hawaiian islands that are protected and managed for waterbirds, including management actions aimed at eradicating or controlling threats such as introduced predators, disease, and contaminants; and for the Hawaiian duck in particular,

removing the threat of hybridization with feral mallards. The time frame for achieving these objectives has been modified in this revision of the plan from 3 and 6 years for downlisting and delisting, respectively, to 5 and 10 years. The following section outlines the strategy and criteria for recovery leading to the downlisting and eventually delisting of these endangered species.

Studies initiated since the first recovery plan was published have allowed the authors to modify population target levels and identify more specific recommendations for each species. In this recovery plan, population target levels are based upon State waterbird biannual survey data collected from 1976 through 2002, as well as a population viability analysis for the Hawaiian stilt. While the statewide survey data provides information about population trends, a population viability analysis is needed for the other three species to develop population targets that may serve as more accurate predictors of long-term recovery.

Over the past decades, State and Federal land managers have tested a number of experimental management techniques that increase waterbird productivity, including development of artificial nesting islets, floating nest structures, and eradication of the invasive red mangrove (*Rhizophora mangle*) using mechanical clearing and herbicide treatments. These experiments show promise for increasing productivity of endangered waterbirds in habitats currently lacking adequate nesting and foraging habitat. Use of windmills for water manipulation, fencing and trapping to control predators, and controlling human disturbance are additional successful management techniques that have increased waterbird numbers.

Managers have also studied the connectivity between wetland habitats, such as the study commissioned by the Marine Corps Base Hawai`i as part of the implementation of their Integrated Natural Resources Management Plan. This study (Rauzon *et al.* 2002) examined wetland use by the Hawaiian stilt in the windward O`ahu Ko`olaupoko District. The goal of this study was to increase understanding of current and potential habitat enhancements for the Hawaiian stilt on windward O`ahu and distribute this information to help regional stakeholders improve programs and activities that might improve Hawaiian stilt recovery efforts there. Over the past two decades, the Marine Corps Base has worked to maintain Hawaiian stilt habitat on its properties and facilitated events that promote Hawaiian stilt conservation and involve both the public and military personnel. Their overall goal is to contribute to regional recovery efforts of the Hawaiian stilt, with a view to building regional partnerships and strengthening the stilt population outside of the core habitat on Marine Corps Base Hawai`i.

Additional research is needed to develop appropriate census techniques, determine those parameters that characterize a viable self-sustaining breeding population, and to understand

the behavior and biology of these endangered waterbirds to allow us to effectively manage for these species.

2. Private Actions

Significant research on the endemic waterbirds of Hawai`i began in 1962 with a study of Hawaiian ducks on Kaua`i supported by the World Wildlife Fund. From 1980 to the present, research has been conducted to improve our biological knowledge of Hawai`i's endangered waterbirds (Coleman 1981; Nagata 1983; Griffin *et al.* 1989; Chang 1990; Engilis and Pratt 1993; Browne *et al.* 1993; Reed and Oring 1993; Reed *et al.* 1994, 1998; Eijzenga 2003; Smith and Polhemus 2003; Gee 2004). The University of Hawai`i conducts research on wetland biology and ecology and offers Sea Grant extension services on aquaculture and coastal conservation. Research on anchialine pools has been conducted by the Oceanic Institute. The University of Hawai`i also administers the Hawai`i Natural Heritage Program as part of the Center for Conservation and Training. The Hawai`i Natural Heritage Program maintains a database of natural communities and rare and endangered species and has been instrumental in summarizing biannual waterbird counts for the State. These research projects and data summaries have enhanced our knowledge of Hawai`i's waterbirds; however, many gaps still exist in our understanding of these species.

A variety of non-governmental organizations have also been instrumental in protecting Hawai`i's wetlands and endangered waterbirds. Ducks Unlimited, a private wetlands conservation organization, works cooperatively with State and Federal agencies, as well as with private landowners and local corporations, on wetlands conservation and habitat restoration and protection efforts. In 1997, Ducks Unlimited developed a comprehensive, cooperative plan to protect and restore wetlands used by native waterbirds in Hawai`i. Ducks Unlimited has signed a Memorandum of Understanding with the Natural Resources Conservation Service to undertake Wetlands Reserve Program projects statewide.

In addition to Ducks Unlimited's efforts, a variety of other conservation organizations are contributing to the recovery of Hawai`i's endangered waterbirds. The Nature Conservancy manages several ecological preserves in the state. The Hawai`i Audubon Society and the Sierra Club advocate on behalf of wetland protection. The National Audubon Society organizes the annual Christmas Bird Count, which provides another tool for monitoring waterbird populations. The Kawai Nui Heritage Foundation is a watchdog organization that oversees the future of Kawainui Marsh on O`ahu.

3. Partnerships

The recovery of Hawai`i's endangered waterbirds cannot occur without the formation of strong partnerships among Federal, State, local, and private groups. A variety of partnerships have been formed to protect and manage waterbird habitat. Examples of such partnership

opportunities include our Pacific Coast Joint Venture, Partners for Fish and Wildlife Program, Coastal Program, and Habitat Conservation Plan and Safe Harbor Agreement Programs; the multi-agency Coastal America program; restoration plans for hazardous materials spills that target waterbird habitat; and the Natural Resources Conservation Service's Wildlife Habitat Incentive Program (WHIP). Partnerships aim to encourage landowners and private citizens to protect and preserve waterbirds and their habitats through cooperative agreements, funding, or habitat restoration or creation projects. Partnerships with private landowners and conservation groups can assist land managers in acquiring and maintaining wetland habitats and developing and implementing public awareness programs.

Examples of ongoing partnerships are agreements with Chevron Refinery on O`ahu and `Umikoa Ranch on the island of Hawai`i. From 1993 to 2003, Chevron Refinery and the U.S. Fish and Wildlife Service implemented the terms specified in a Cooperative Agreement to manage Rowland's Pond as temporary nesting habitat for Hawaiian stilts, including predator control and vegetation management at Rowland's Pond, the impounding basin, and oxidation ponds. As a result of this agreement, a total of 361 stilt chicks fledged at Chevron over the 10-year period (L. Gibson, USFWS, pers. comm. 2004). The Safe Harbor Agreement for `Umikoa Ranch included the creation and maintenance (*e.g.*, fencing to exclude cattle and predator control) of 10 ponds for the Hawaiian duck and Hawaiian goose over a period of 20 years (J. Kwon, USFWS, pers. comm. 2004).

F. MONITORING

After World War II, State biologists, with Federal assistance, began an investigation of migratory waterfowl in the belief that wintering populations might support a continued hunting program. Although hunting was never reopened, this early study became the foundation of a continuing program of biannual statewide waterfowl surveys, which was later expanded to include all endemic and migratory waterbirds.

Biannual counts, organized by the Hawai`i Division of Forestry and Wildlife, have been conducted statewide since the mid-1950's, but coverage of certain areas was somewhat inconsistent until about 1976. Data from these surveys were recently compiled by the Hawai`i Natural Heritage Program (under contract from the State of Hawai`i) and by the U.S. Fish and Wildlife Service, making it possible to examine a comprehensive data set of waterbird abundance for population trends from 1976 through 2003.

The biannual waterbird surveys consist of visits to wetlands on all islands on a single day each winter and summer, reducing the possibility of counting birds more than once as they move among sites. In addition to recording the number of individuals of all waterbird species at each wetland, surveyors collect information on water level, vegetation cover, weather conditions, and human disturbance.

These surveys include the majority of wetlands on each island, but a few locations that support waterbirds are not covered. The numbers resulting from these surveys are thus minimum values and likely underestimate the actual population by an unknown amount. These counts are probably fairly accurate population estimates for coots and stilts in most years because these species are relatively conspicuous and often use open water areas. Hawaiian common moorhens and Hawaiian ducks, however, may be seriously undercounted since they are secretive and often hide in densely vegetated areas, in the case of the moorhen, or use montane stream habitats that are not covered in the biannual survey, in the case of the Hawaiian duck. Ni`ihau has not been covered in surveys since 1999 but supports many coots and stilts in wet years. Returning Ni`ihau to the surveys would increase their accuracy and utility.

The biannual waterbird count is the best tool available for estimating the relative abundance of waterbirds and is extremely valuable for monitoring their populations. The overall goal and methodology of the count are sound, but improvements could include greater standardization and consistency among islands in the identification of Hawaiian ducks, mallards, and hybrids; more consistent coverage of wetlands each year to increase comparability over time; development of more accurate methods of surveying Hawaiian common moorhens, possibly including playbacks; and inclusion of montane stream habitats to provide a more thorough estimate of the Hawaiian duck population. Efforts are underway to improve the utility of the count for monitoring populations of migratory shorebirds (Engilis and Naughton 2004), including more thorough instructions for counters and a photographic guide (E. VanderWerf, USFWS, pers. comm. 2004; Appendix E).

Population values presented in this plan are based on 5-year averages of winter counts from the biannual waterbird survey (Figures 3, 4, 6, 7, 9, 10, 12, 13). In most cases data from 1999 to 2003 were used to calculate this 5-year average, but in a few cases data from 1998 to 2003 were used because data from 2002 were missing. Although data from both summer and winter counts are presented, we used the winter counts to examine population trends because summer counts tend to be more variable due to annual variation in survival of hatch-year birds.

When compiling this data, we found numerous differences between the numbers recorded on the original data sheets obtained from the State and the summary values reported in previous versions of the recovery plan for Hawaiian waterbirds (USFWS 1999).

The population data reported in this plan are based on the original data recorded wetland by wetland on each island, are verifiable, and are therefore regarded as correct. Values in the previous draft plan could not be verified, and were not consistently higher or lower. Researchers and managers using previously available data are urged to confirm that the information they have is correct.

II. Recovery

A. RECOVERY STRATEGY

The recovery of Hawai`i's endangered waterbirds focuses on attaining adequate population sizes and distribution of multiple self-sustaining populations throughout the historical range of each species. These foci are based upon two widely recognized and scientifically accepted goals for promoting viable self-sustaining populations: 1) the creation or maintenance of multiple populations so that a single or series of catastrophic events will not result in the extinction of the species; and 2) increasing the population size of each species throughout its range to a level where the threats of genetic, demographic (population dynamics), and normal environmental uncertainties are diminished (Mangel and Tier 1994; National Research Council 1995; Tear *et al.* 1995; Meffe and Carroll 1996). Furthermore, for these population and distribution goals to ensure the long-term viability of the species requires the successful control or elimination of the threats identified in this plan. By maintaining minimum population numbers and self-sustaining breeding populations at multiple sites on multiple islands, the endangered waterbirds have a greater likelihood of achieving long-term survival and recovery.

The population size and distribution prescribed for recovery of the Hawaiian stilt are based on a population viability analysis conducted by Reed *et al.* (1998), which estimated that stilts would increase in number to a mean of 1,901 (SD = 88) individuals in 200 years based on current habitat conditions and other limiting factors. That number, rounded up to 2,000 to be conservative, was used as the basis for estimating the population size required for recovery because apparently it is the carrying capacity of the existing habitat. Furthermore, since population viability analyses or other quantitative means of establishing population requirements have not yet been developed for the Hawaiian duck, coot, or moorhen, the population size requirements for these species are also based on the research on the Hawaiian stilt and current population estimates from the biannual statewide waterbird survey, which represent the best information available to date. The population size requirements for these species should therefore be viewed as starting points for the establishment of recovery targets and are subject to revision based on future research and statistical analyses, as recommended in this recovery plan.

Wetland protection and management is crucial to maintain self-sustaining breeding populations of waterbirds. This recovery plan identifies a number of actions for important wetlands used by the Hawaiian coot, duck, moorhen, and stilt. The recovery strategy for the endangered waterbirds relies on a combination of **core** and **supporting** wetlands, as defined below:

Core Wetlands are areas that provide habitat essential to larger populations of Hawaiian waterbirds that comprise the bulk of the numbers prescribed for recovery. These sites must be protected and managed to recover Hawai`i's waterbirds. Appendix A provides a brief description of the core wetlands identified in this plan.

Supporting Wetlands are additional areas that provide habitat important for smaller waterbird populations or that provide habitat needed seasonally by segments of the waterbird populations during part of their life cycle. Protection and management of these or similar wetlands is required to recover Hawai`i's waterbirds, but there is room for some flexibility in regard to which sites must be managed, and it is possible that other sites may fulfill the same needs as those listed here. Appendix B provides a brief description of the supporting wetlands listed in this plan.

The core and supporting wetlands identified in Tables 6 through 9 are currently thought to be the sites on each island that provide the greatest potential for recovery of Hawaiian waterbirds. However, it is possible that in the future some of these sites, particularly those on private land, may become unsuitable for waterbirds due to changes in land use practices. Similarly, additional sites that are not currently suitable for waterbirds may become so following restoration efforts. The implementation of recovery actions for Hawaiian waterbirds must be flexible and often depends on opportunities provided by interested parties. The recovery criteria for these species thus also should be flexible, so that future changes in land use and unexpected opportunities for recovery can be accommodated. Therefore, it may be possible to substitute other wetlands for the supporting wetlands, as long as they provide a similar amount of habitat that can be expected to support a similar number of birds. We will use the best available information and update the supporting wetland list as necessary. Appendix C provides a more comprehensive list of wetlands on each island.

For core wetlands it will be difficult to substitute an alternate site that provides the same function because they are among the largest wetlands and support the greatest abundance of each species. An exception among the core wetlands may be the Playa Lakes on Ni`ihau, which in some years provide seasonally important habitat for large numbers of stilts and coots, but are located on private land where it may be difficult to ensure protection of the habitat. If similar habitat can be restored in a supporting location, such as the Mānā Plain, which once contained extensive seasonal wetlands, then that site could be substituted for the Playa Lakes as a core wetland.

Core and supporting wetlands include Federal, State, and private lands. Most sites are natural wetlands, but some are of human origin, such as aquaculture ponds, agricultural areas, sewage treatment ponds, and reservoirs. While these sites generally are not managed for waterbirds, resource management and regulatory agencies should seek the development of cooperative agreements,

Table 6. Core and supporting wetlands on Kaua`i (K) and Ni`ihau (N) identified for protection and management in order to recover the Hawaiian duck, Hawaiian coot, Hawaiian common moorhen, and Hawaiian stilt.

Island	Wetland	Status	Ownership
N	Playa Lakes	Core	Private
K	Hanalei NWR	Core	USFWS[1]
K	Hulē`ia NWR	Core	USFWS[1]
K	Kawai`ele Waterbird Sanctuary	Core	HDLNR[2]
K	Lumaha`i Wetlands	Core	Private
K	Hanalei Taro Fields and River	Supporting	Private/State
K	Hanapēpē Salt Ponds	Supporting	Private/HDLNR[2]
K	Mānā Base Wetlands	Supporting	Private/HDLNR[2]
K	Mānā Wetlands	Supporting	Private/State
K	Ōpaeka`a Marsh	Supporting	Private/HDLNR[2]
K	Smith's Tropical Paradise	Supporting	Private/State
K	Wailua River Bottoms	Supporting	Private/State
K	Waimea River System	Supporting	Private/State
K	Wainiha Valley Taro Fields and River	Supporting	Private/County
K	Waitā Reservoir	Supporting	Private

[1]USFWS = U.S. Fish and Wildlife Service

[2] HDLNR = Hawai`i Department of Land and Natural Resources

Table 7. Core and supporting wetlands on O`ahu identified for protection and management in order to recover the Hawaiian duck, Hawaiian coot, Hawaiian common moorhen, and Hawaiian stilt.

Wetland	Status	Ownership
James Campbell National Wildlife Refuge	Core	USFWS[1]
Kawainui Marsh	Core	HDLNR[2]
Nu'upia Ponds	Core	MCBH[3]
Pearl Harbor National Wildlife Refuge	Core	USFWS[1]
Pouhala Marsh Waterbird Sanctuary	Core	HDLNR[2]
Kahuku aquaculture farms	Supporting	Private
Kuilima (Turtle Bay) Sewage Treatment Plant	Supporting	Private
Halei'wa Lotus Fields	Supporting	Private/County
Hāmākua Marsh Wildlife Sanctuary	Supporting	HDLNR[2]
He'eia Marsh	Supporting	HDLNR[2]
Ka'elepulu Pond	Supporting	Private
Lā'ie Wetlands	Supporting	Private
Niuli'i Ponds (RTF Lualualei)	Supporting	USN[4] /USFWS[1]
Punaho`olapa Marsh	Supporting	Private
`Uko`a Marsh	Supporting	Private
Waialua Lotus Fields	Supporting	Private
Waihe`e Marsh	Supporting	Private

[1]USFWS = U.S. Fish and Wildlife Service

[2] HDLNR = Hawai`i Department of Land and Natural Resources

[3] MCBH = Marine Corps Base Hawai`i

[4] USN = U.S. Navy

Table 8. Core and supporting wetlands on Maui (M), Moloka`i (Mo), and Lāna`i (L) identified for protection and management in order to recover the Hawaiian duck, Hawaiian coot, Hawaiian common moorhen, and Hawaiian stilt.

Island	Wetland	Status	Ownership
M	Kanahā Pond Wildlife Sanctuary	Core	HDLNR[2]
M	Keālia Pond National Wildlife Refuge	Core	USFWS[1]
M	Ke`anae Point	Supporting	State
M	Waihe`e Preserve (coastal dunes and wetlands)	Supporting	Private
Mo	Kakahai`a National Wildlife Refuge	Core	USFWS[1]
Mo	Kaunakakai Sewage Treatment Pond	Supporting	County
Mo	Kualapu`u Reservoir	Supporting	State
Mo	`Ōhi`apilo Wetland	Supporting	County
Mo	Paialoa Fish Pond	Supporting	Private
L	Lāna`i Sewage Treament Ponds	Supporting	County

[1]USFWS = U.S. Fish and Wildlife Service

[2] HDLNR = Hawai`i Department of Land and Natural Resources

Table 9. Core and supporting wetlands on Hawai`i island identified for protection and management in order to recover the Hawaiian duck, Hawaiian coot, Hawaiian common moorhen, and Hawaiian stilt.

Wetland	Status	Ownership
`Aimakapā/Koloko Pond	Core	NPS[5]
Loko Waka Pond	Core	Private/State
Waiakea Pond	Core	State/County
Ke`anae Pond (Kea`au)	Supporting	Private
Kohala Stock Ponds	Supporting	Private
Mauna Kea Stock Ponds	Supporting	Private
Kona (Kealakehe) Sewage Treatment Plant	Supporting	County
`Ōpae`ula Pond	Supporting	Private
Parker Ranch Ponds	Supporting	Private
Waimanu Valley	Supporting	County
Waipi`o Valley	Supporting	County/Private

[5] NPS = National Park Service

Habitat Conservation Plans, Safe Harbor Agreements, conservation easements, or other protective measures to restore, enhance, or create wetland sites that provide important habitat for waterbirds. Such actions may provide long-term protection of these sites or encourage habitat improvements.

The distribution of core and supporting habitat allows for multiple breeding localities on the main Hawaiian islands within each species' historical distribution. Such a distribution should enhance recovery by minimizing the impact of random environmental events and catastrophes that can adversely affect the viability of these endangered waterbirds (Meffe and Carroll 1996; Shaffer 1996).

Actions identified in this plan to protect and manage both core and supporting wetlands include efforts to directly address many of the threats identified for the endangered waterbirds, as detailed below. Some of the recommended actions are site-specific, such as establishing protected land status and writing management plans, while other actions, such as population monitoring, assessing reproductive success, and increasing public awareness should be implemented on a statewide basis. The basic steps detailed in this recovery plan are as follows:

1) Protect and manage core and supporting wetland habitats in order to maximize productivity and survival of endangered waterbirds. This management would include the following actions: develop written management plans; secure water sources; manage water levels; manage vegetation; control predation; monitor waterbird populations and reproductive success; remove the threat of mallard-Hawaiian duck hybridization; minimize human disturbance; and monitor and control avian diseases and environmental contaminants (Tables 10 and 11, pages 93 and 95). Some of these wetland habitat areas already have protected status but need to be more actively managed.

2) Conduct research to better understand factors limiting Hawaiian waterbird population numbers, refine recovery objectives, and improve management techniques.

3) Establish a Hawaiian duck population on one additional island and moorhen populations on two additional islands.

4) Plan and implement an education program to increase landowner and land manager knowledge of waterbird needs and increase public support for waterbird recovery.

5) Reevaluate recovery objectives as additional information becomes available.

The key to the success of this general recovery strategy will be the formation of productive partnerships among Federal, State and local agencies, private organizations, and individuals. Partnerships have been instrumental in achieving past conservation efforts and are essential to protect and manage existing wetlands. Such partnerships also result in greater community support to insure long-term wetland and waterbird protection. Each of the basic steps identified above will succeed only with the active participation of a variety of entities.

B. GOAL AND OBJECTIVES

The ultimate goal of the recovery program is to restore and maintain multiple self-sustaining populations of these Hawaiian waterbirds within their historical ranges, which will allow them to be reclassified to threatened status and eventually removed from the Federal list of endangered species.

The recovery of the endangered waterbirds focuses on the following objectives:

1) increasing population numbers to statewide baseline levels;

2) establishing multiple, self-sustaining breeding populations throughout each species' historical range;

3) establishing and protecting a network of wetlands that are managed as habitat suitable for waterbirds, including the maintenance of appropriate hydrological conditions and control

of invasive nonnative plants;

4) for all four species, eliminating or controlling the threats posed by introduced predators, human disturbance, avian diseases, and contaminants; and

5) for the Hawaiian duck, removing the threat of hybridization with feral mallards.

C. RECOVERY CRITERIA

Downlisting or delisting is warranted when a listed species no longer meets the definition of threatened or endangered under the Endangered Species Act (Box 1). We set recovery criteria to serve as objective, measurable guidelines to assist us in determining when a species has recovered to the point that the protections afforded by the Endangered Species Act are no longer necessary. However, the actual change in listing status is not solely dependent upon achieving the recovery criteria set forth in a recovery plan; it requires a formal rulemaking process based upon an analysis of the same five factors considered in the listing of a species (see page 44). The recovery criteria presented in this recovery plan thus represent our best assessment of the conditions that would most likely result in a determination that downlisting or delisting of each of the four Hawaiian waterbirds is warranted as the outcome of a formal five factor analysis in a subsequent regulatory rulemaking.

The successful elimination or control of the threats that originally led to the need for protection under the Endangered Species Act is a key component of recovery. In this recovery plan, hybridization with feral mallards is a threat unique to the Hawaiian duck, and this threat is therefore addressed separately for this species. Other identified threats to the four endangered waterbirds, including introduced predators, altered hydrology, nonnative plants, avian disease, and contaminants, are specifically addressed by the management actions recommended in this plan (see Narrative Outline of Recovery Actions, page 79) and are incorporated in the Recovery Criteria through Criteria 1 and 2 for each species, which call for the protection and management of wetlands in accordance with the management practices outlined in this recovery plan.

Box 1. Definitions according to section 3 of the Endangered Species Act.

Endangered Species
Any species that is in danger of extinction throughout all or a significant portion of its range.

Threatened Species
Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

1. Downlisting Criteria

To consider downlisting the four species to threatened status, the following criteria should be met:

(a) Hawaiian Duck downlisting criteria

Criterion 1. All core wetlands listed in Table 10 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2. Of the supporting wetlands listed in Table 11 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i, at least 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3. The statewide Hawaiian duck population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years;

Criterion 4. There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Maui, and Hawai`i; and

Criterion 5. The threat of hybridization with feral mallards is removed from all islands.

(b) Hawaiian Coot downlisting criteria

Criterion 1. All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide coot population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i.

(c) Hawaiian Common Moorhen downlisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i and O`ahu are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i and O`ahu, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide moorhen population shows a stable or increasing

trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i and O`ahu, and on Maui/Moloka`i and/or Hawai`i.

(d) Hawaiian Stilt downlisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 25 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide stilt population shows a stable or increasing trend at a number greater than 2,000 birds for at least 5 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, including populations on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i.

2. Delisting Criteria

To consider delisting the four species, the following criteria must be met:

(a) Hawaiian Duck delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i, O`ahu, Maui, and Hawai`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide Hawaiian duck population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years;

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Maui, and Hawai`i; and

Criterion 5: The threat of hybridization with feral mallards is removed from all islands.

(b) Hawaiian Coot delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide coot population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/ Lāna`i.

(c) Hawaiian Common Moorhen delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i and O`ahu are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i and O`ahu, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide moorhen population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i, O`ahu, Hawai`i, and Maui/Moloka`i.

(d) Hawaiian Stilt delisting criteria

Criterion 1: All core wetlands listed in Table 10 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i, are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 2: Of the supporting wetlands listed in Table 11 on the islands of Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/Lāna`i, 75 percent are protected and managed in accordance with the management practices outlined in this recovery plan;

Criterion 3: The statewide stilt population shows a stable or increasing trend at a number greater than 2,000 birds for at least 10 consecutive years; and

Criterion 4: There are multiple self-sustaining breeding populations, with populations present on Kaua`i/Ni`ihau, O`ahu, Hawai`i, and Maui/Moloka`i/ Lāna`i.

D. STEP-DOWN OUTLINE OF RECOVERY ACTIONS

1. Protect (secure from development) and manage all core (100%) and supporting wetlands (25% for downlisting and 75% for delisting) listed in Tables 10 and 11 (pages 93 and 95).
   - 1.1 Develop management plans for core and supporting wetlands.
   - 1.2 Coordinate management of core and supporting wetlands with other agencies and organizations.
   - 1.3 Implement management plans for core and supporting wetlands.
     - 1.3.1 Secure water sources and manage water levels to maximize nesting success, brood survival, food availability, and recruitment of waterbirds.
     - 1.3.2 Manage vegetation to maximize nesting success, brood survival, food availability, and recruitment of waterbirds.
       - 1.3.2.1 Encourage desirable plant species.
       - 1.3.2.2 Control undesirable plant species.
       - 1.3.2.3 Prevent introduction of invasive nonnative plants.
     - 1.3.3 Eliminate or reduce and monitor predator populations.
       - 1.3.3.1 Prevent predator access.
       - 1.3.3.2 Control mongooses.
       - 1.3.3.3 Control feral cats.
       - 1.3.3.4 Control feral dogs.
       - 1.3.3.5 Control rats.
       - 1.3.3.6 Control cattle egrets.
       - 1.3.3.7 Control tilapia.
       - 1.3.3.8 Control bullfrogs.
     - 1.3.4 Prevent introduction of new nonnative predators, such as the brown treesnake (*Boiga irregularis*).
     - 1.3.5 Minimize human disturbance to waterbirds and their habitats.
       - 1.3.5.1 Assess and if necessary prevent intentional or accidental shooting of waterbirds.
       - 1.3.5.2 Control human access to waterbird habitats during breeding season.
       - 1.3.5.3 Resolve conflicts from actual or perceived depredation of aquaculture or agriculture products by waterbirds.
       - 1.3.5.4 Minimize influence of urban encroachment.
     - 1.3.6 Monitor and control avian disease.
       - 1.3.6.1 Monitor waterbird populations to detect disease outbreaks as soon as possible.
       - 1.3.6.2 Take immediate action to restrict the spread of disease outbreaks.
     - 1.3.7 Minimize contamination of waterbird habitat by toxic substances.
       - 1.3.7.1 Monitor water quality.
       - 1.3.7.2 Restrict introduction of contaminants into wetland systems.
       - 1.3.7.3 Assess nutrient levels and other parameters that influence core and supporting wetland productivity for waterbirds.

1.4 Monitor all populations of endangered waterbirds.
- 1.4.1 Continue standardized, biannual, statewide surveys for all endangered waterbirds.
- 1.4.2 Continue regular, standardized surveys on core and supporting wetlands.
- 1.4.3 Develop improved survey techniques for the Hawaiian duck and Hawaiian common moorhen.
- 1.4.4 Monitor reproductive success on core and supporting wetlands.
- 1.4.5 Monitor aquatic invertebrate prey species used by waterbirds and fish to determine whether they compete with waterbirds for aquatic invertebrates.

2. Remove the threat of mallard-Hawaiian duck hybridization on all islands where Hawaiian ducks occur and establish a self-sustaining population of Hawaiian ducks on Maui and/or Moloka`i.
   - 2.1 Conduct a public information and education program regarding the mallard-Hawaiian duck interbreeding problem and the need for the removal program.
   - 2.2 Develop methods for differentiating between Hawaiian ducks and mallard-Hawaiian duck hybrids.
   - 2.3 Implement a statewide program to humanely remove feral mallards and mallard-Hawaiian duck hybrids.
   - 2.4 Ensure new stocks of mallards and closely related ducks are not brought into the state.
   - 2.5 Establish a self-sustaining population of Hawaiian ducks on Maui and/or Moloka`i.
     - 2.5.1 Identify sites for reintroduction of the Hawaiian duck on Maui and Moloka`i.
     - 2.5.2 Investigate the pros and cons of captive propagation versus translocation for establishing additional Hawaiian duck populations and develop a reintroduction plan that includes the preferred method.
     - 2.5.3 Reintroduce either captive-bred or translocated Hawaiian ducks to protected and managed sites on Maui and Moloka`i and monitor their survival, dispersal, and reproduction.
3. Establish a self-sustaining population of Hawaiian common moorhen on the island of Hawai`i and either Maui or Moloka`i.
   - 3.1 Conduct thorough surveys of wetland areas on Maui, Moloka`i, and Hawai`i to confirm that a moorhen population does not already exist.
   - 3.2 If a population of moorhen is found on Maui, Moloka`i, or Hawai`i, protect and manage its wetland habitat.
   - 3.3 If no population of moorhen is found on Maui, Moloka`i, or Hawai`i, evaluate potential reintroduction sites.
   - 3.4 Investigate the pros and cons of captive propagation versus translocation for establishing additional moorhen populations and develop a reintroduction plan that includes the preferred method.

3.5 Reintroduce Hawaiian common moorhens to a protected and managed site on Hawai`i and either Maui or Moloka`i and monitor their survival, dispersal, and reproduction.

4. Conduct research to better understand population biology and limiting factors, evaluate recovery objectives, and improve management techniques.
   - 4.1 Increase understanding of Hawaiian waterbird population limiting factors.
     - 4.1.1 Investigate the effects of different predators on endangered waterbirds.
     - 4.1.2 Research improved predator control methods.
     - 4.1.3 Research improved methods to control nonnative plants and restoration of native plants.
   - 4.2 Conduct research to better understand Hawaiian waterbird population biology and recovery needs.
     - 4.2.1 Analyze existing survey data and estimate current population size and population trends.
     - 4.2.2 Determine carrying capacity of wetland habitats.
     - 4.2.3 Estimate reproductive parameters.
     - 4.2.4 Estimate mortality rates.
     - 4.2.5 Research movement of adults and natal dispersal.
     - 4.2.6 Determine the sex and age structure of populations.
     - 4.2.7 Investigate genetic population structure and potential inbreeding depression.
     - 4.2.8 Develop population viability analyses for the Hawaiian duck, coot, and moorhen.
   - 4.3 Research Hawaiian waterbird habitat needs and habitat manipulation.
5. Plan and implement a public information and education program to increase public awareness and support for waterbird recovery.
   - 5.1 Prepare and distribute television and radio spots, written information, slide programs, videos, films, posters, and displays.
   - 5.2 Coordinate with the Hawai`i Department of Education and private schools to incorporate wetland and waterbird information into school curricula.
   - 5.3 Develop and maintain interpretive displays of endangered waterbirds and wetlands.

E. NARRATIVE OUTLINE OF RECOVERY ACTIONS

1. Protect (secure from development) and manage all core (100%) and supporting wetlands (25% for downlisting and 75% for delisting) listed in Tables 10 and 11 (pages 93 and 95).

A network of protected and managed wetland habitats is the key element in the recovery strategy for all four taxa. Loss of habitat has been and continues to be a primary threat, thus maintenance of suitable habitat distributed over all the main islands is imperative for recovery of these waterbirds. Most core wetlands are protected except the Playa Lakes (Ni`ihau), Lumaha`i Wetlands (Kaua`i), Loko Waka Ponds (Hawai`i), and Waiākea Pond (Hawai`i). Agreements with the landowners should be developed to insure protection of these wetlands. Some of these areas are sufficiently managed, but most need increased levels of management to maximize waterbird production and survivability.

Supporting wetlands are additional areas that provide habitat important for smaller waterbird populations or that provide habitat needed seasonally by segments of the waterbird population during part of their life cycle. Protection and management of these or similar wetlands is required to recover Hawaii`s waterbirds, but there is room for some flexibility in which sites must be managed, and it is possible that other sites may fulfill the same needs as those listed here (Appendix C). Tools available to work with private landowners to provide habitat management and protection include Habitat Conservation Plans, Safe Harbor Agreements, Partners for Fish and Wildlife and Coastal programs, and conservation easements.

1.1 Develop management plans for core and supporting wetlands.

Management of the core and supporting wetlands is required to realize their full potential for providing waterbird nesting and/or feeding habitat. Management plans should be developed for core and supporting wetlands and actions to be implemented on these habitats will include, but are not limited to, the recommended recovery actions in Tables 10 and 11.

1.2 Coordinate management of core and supporting wetlands with other agencies and organizations.

Managers charged with the stewardship of refuges and sanctuaries have developed numerous methods of habitat management. These techniques vary among sites. Interagency management workshops, such as the Wetland and Predator Control Workshops organized by The Wildlife Society and the Hawai`i Department of Land and Natural Resources, or other forums for exchanging information have been held and should continue to be regularly conducted in Hawai`i. These meetings provide a professional forum for the presentation of management methodology practiced in Hawai`i and allow managers to present published and unpublished research results, develop new methods, and find solutions to shared management problems. A statewide

approach to wetland stewardship is important for successful management of core and supporting wetlands.

1.3 Implement management plans for core and supporting wetlands.
Wetland habitats in Hawai`i, including wildlife sanctuaries and refuges, have been altered or influenced to a varying extent by a number of factors. Providing these areas with the habitat components that allow waterbirds to survive and reproduce successfully requires active management. The steps necessary for enhancing habitat for Hawai`i's endangered waterbirds are outlined below. A number of these are already being implemented on protected wetland areas.

1.3.1 Secure water sources and manage water levels to maximize nesting success, brood survival, food availability, and recruitment of waterbirds.
Hydrology is key to ensuring the suitability of wetland habitat for these endangered waterbirds. An adequate water source must be ensured, and water levels must be managed so as to enhance productivity of wetland food sources and to provide suitable vegetative cover.

1.3.2 Manage vegetation to maximize nesting success, brood survival, food availability, and recruitment of waterbirds.
The composition and distribution of vegetation in a wetland ecosystem determines the habitat's value for waterbirds. Most of Hawai`i's wetlands have been extensively altered such that vegetation management is required to provide habitat for waterbirds.

1.3.2.1 Encourage desirable plant species.
Certain types of vegetation provide better feeding and nesting conditions for waterbirds. Habitat management should aim to develop the optimum distribution and density of these species, with an emphasis on enhancing native species. Desirable native plant species include, but are not limited to, *Bacopa monnieri* (`ae`ae, water hyssop); *Bolboschoenus maritimus* (kaluha, bulrush); *Cyperus javanicus C. laevigatus, C. polystachyos, and C. trachysanthos* (ahu`awa, makaloa, umbrella sedge); *Eleocharis obtusa* (kohekohe, spikerush); *Ludwigia octovalvis* (primrose willow); *Ruppia maritima* (ditchgrass, widgeongrass); *Schoenoplecus juncoides* and *S. lacustris* (`aka`akai); and *Sesuvium portulacastrum* (`akulikuli, sea purslane).

In some cases naturalized nonnative plants can provide important habitat components for waterbirds as well, serving as a source of food, cover, nesting material, and habitat for invertebrate prey.

Nonnative plants that serve these functions should not be eradicated before a suitable native plant species is identified that would provide equivalent resources. Nonnative plants that may provide beneficial resources for waterbirds include *Cyperus difformis* (variable flatsedge); *Echinochloa* spp. (cockspur, barnyard grass); *Eleocharis geniculata* (spikesedge); *Fimbristylis ferruginea* (West Indian fimbry); *Lemna* spp. (duckweed); *Leptochloa uninervia* (sprangletop); *Paspalum distichum* (knotgrass); and *Typha* spp. (cat-tails).

1.3.2.2 Control undesirable plant species.

Undesirable plants, mainly introduced species such as *Brachiaria mutica* (California grass), *Batis maritima* (pickleweed), *Eichornia crassipes* (water hyacinth), *Pluchea indica* (Indian fleabane), and *Rhizophora mangle* (red mangrove), make wetlands less useful or unusable for waterbirds. These plants should be eliminated, where feasible, or controlled. In many cases, water level management can be used to control noxious species. Some indigenous species might pose a problem as they overgrow wetlands and result in monocultures. Control methods that do not introduce environmental contaminants and that can be sustained over the long-term should be employed.

1.3.2.3 Prevent introduction of invasive nonnative plants.

Nonnative plants, particularly invasive species, can decrease wetland suitability for waterbirds. Measures should be taken to prevent accidental introduction of nonnative plants by people or equipment used in the management of wetlands and to prevent these plants from becoming established in wetland habitats. For example, equipment used on wetlands should be thoroughly cleaned before being used at a site.

1.3.3 Eliminate or reduce and monitor predator populations.

Predation is a major cause of waterbird mortality and nest failure. Introduced mammals such as mongooses, cats, dogs, and rats are the primary predators, but depredation by birds and bullfrogs has also been documented. Adult waterbirds are occasionally taken, but most depredation is of eggs and young. Long-term predator management at nesting sites is needed and may be more effective when control methods are used in conjunction with exclusion devices such as fences.

1.3.3.1 Prevent predator access.

One means of controlling predators is preventing their access to nesting habitat. This can be accomplished by the use of barriers, moats, or fences. Moats can be constructed around nesting habitat if sedimentation and vegetation are adequately controlled. Where appropriate and feasible, barriers and/or fences should be installed around important breeding sites to exclude as many species of predators as possible.

1.3.3.2 Control mongooses.

Mongooses are thought to be the most serious predator of Hawai`i's waterbirds in many areas. Removal of mongooses has been proven to increase waterbird reproduction and should be actively pursued using trapping and/or toxicants. Moats can be constructed around nesting islands if sedimentation and vegetation can be adequately controlled.

1.3.3.3 Control feral cats.

Feral cats are known to be predators of waterbirds and should be controlled. Feral cat feeding stations near waterbird habitat should be removed or relocated. Public education about the detrimental effects of feral cats is also important.

1.3.3.4 Control feral dogs.

Dogs are known to kill waterbirds and should be removed. Dogs often can be effectively excluded by fences.

1.3.3.5 Control rats.

Rats have been known to prey on waterbird chicks and eggs. The importance of rat predation should be assessed and control measures implemented as necessary.

1.3.3.6 Control cattle egrets.

Predation and competition for food resources by cattle egrets is poorly understood in Hawai`i, but we do know that cattle egrets prey on stilt chicks. Modified habitats and exposed nesting areas make young waterbirds more vulnerable to predation. These areas should be identified and improved. Control of cattle egrets in rookeries near, or in, refuges has proven effective and should be continued.

1.3.3.7 Control tilapia.

Tilapia modify the bottom of wetlands by creating circular nests and are suspected of depleting the invertebrate prey base used by

endangered waterbirds, thereby degrading waterbird feeding habitats. Tilapia should be controlled, possibly by manipulating water levels.

1.3.3.8 Control bullfrogs.

Bullfrogs are known to prey on juvenile Hawaiian ducks and stilts, and were identified as an important predator on radio-tracked stilt chicks at James Campbell National Wildlife Refuge (Eijzenga 2003). It may be possible to control bullfrogs by direct removal, or by strategic manipulation of water levels.

1.3.4 Prevent introduction of new nonnative predators, such as the brown treesnake (*Boiga irregularis*).

Nonnative predators are causing severe problems for native waterbirds. Introductions of new predators, such as the brown treesnake, must be prevented in the entire state. Special attention is needed to prevent the establishment of mongooses on Kaua`i, Lāna`i, and Ni`ihau.

1.3.5 Minimize human disturbance to waterbirds and their habitats.

Disturbance or loss of adult and young waterbirds is occasionally attributed to people. Although such losses are usually restricted to isolated incidents, measures should be taken to minimize this threat.

1.3.5.1 Assess and if necessary prevent intentional or accidental shooting of waterbirds.

The occurrence of shooting of waterbirds should be assessed and control measures taken as necessary to prevent such events through law enforcement and/or public education.

1.3.5.2 Control human access to waterbird habitats during breeding season.

Certain habitats and birds are more sensitive to human disturbance, especially during the breeding season. Restricting human access to sensitive habitat areas during certain times of the year may be needed.

1.3.5.3 Resolve conflicts from actual or perceived depredation on aquaculture or agriculture products by waterbirds.

Some waterbird habitat is also used for agriculture and aquaculture. This can result in conflicts due to actual and/or perceived depredation problems attributed to endangered waterbirds. Wildlife agencies need to respond to potential problems associated with waterbirds and minimize conflicts. Problems not associated with waterbirds can be explained and

solutions to problems associated with waterbirds can be sought before birds or nests are harmed. Open communication between agricultural and waterbird managers is necessary to minimize conflicts.

1.3.5.4 Minimize the influence of urban encroachment.
Urban encroachment is a significant threat to wetland areas in Hawai`i. Urban encroachment has increased because of the recent shift in land use from agriculture to housing developments. Issues such as predator control, water quality, and harassment are magnified in an urban setting. Refuges that were once surrounded by cane fields are now surrounded by housing tracts or resort developments. The establishment of buffer lands around protected wetlands through cooperative agreements or other measures is critical to the protection of these habitats. Buffer lands can also provide corridors between wetland refuges within a large complex.

1.3.6 Monitor and control avian disease.
Waterbirds and their habitat should be monitored for potential disease problems. When avian diseases are detected, control measures must be employed rapidly. Diseases that may affect endangered waterbirds include, but may not be limited to, avian botulism, cholera, malaria, pox, and West Nile virus.

1.3.6.1 Monitor waterbird populations to detect disease outbreaks as soon as possible.
Disease monitoring should be a part of wetland area management. A disease monitoring protocol should be developed, made available for wide use, and incorporated into management plans. Wildlife health professionals should be consulted to develop monitoring techniques.

1.3.6.2 Take immediate action to restrict the spread of disease outbreaks.
When a disease outbreak is identified, managers need to take immediate action to restrict the disease's spread and severity. Disease response protocols should be developed and incorporated into management plans.

1.3.7 Minimize contamination of waterbird habitat by toxic substances.
Contamination of wetlands with toxic substances is a potential threat. Because waterbirds are often concentrated in small areas, the localized contamination of water or food can affect a large number of birds.

1.3.7.1 Monitor water quality.
To minimize exposure of waterbirds to contaminants, environmental contaminant monitoring should be incorporated into management plans.

1.3.7.2 Restrict introduction of contaminants into wetland systems.
To minimize potential impacts to waterbirds, the introduction of chemicals to wetland areas, either directly or via water supplies, should be restricted as much as possible.

1.3.7.3 Assess nutrient levels and other parameters that influence core and supporting wetland productivity for waterbirds.
Wetland productivity for waterbirds varies annually. Measuring nutrient levels, food availability, and other parameters that influence productivity of wetlands for waterbirds will enhance our understanding of waterbird populations.

1.4 Monitor all populations of endangered waterbirds.
Monitoring populations of waterbirds is important for assessing the success of management activities.

1.4.1 Continue standardized, biannual, statewide surveys for all waterbirds.
The biannual statewide surveys provide valuable information for gauging the status of endangered waterbirds, particularly Hawaiian coots and stilts. These surveys should be continued to provide a long-term data set for examining population trends.

1.4.2 Continue regular, standardized surveys on core and supporting wetlands.
Regular, standardized surveys of core and supporting wetlands will provide valuable information on short-term population fluctuations and responses to management techniques. Monthly counts at core and supporting wetlands that include the evaluation of habitat parameters will provide valuable information on wetland biology.

1.4.3 Develop improved survey techniques for the Hawaiian duck and Hawaiian common moorhen.
Existing survey techniques are adequate for assessing Hawaiian coot and stilt populations, but improved methods are needed to accurately survey Hawaiian ducks and Hawaiian common moorhens. Because of their secretive behavior and use of densely vegetated and montane stream habitats, these birds are difficult to accurately survey.

1.4.4 Monitor reproductive success on core and supporting wetlands.
Surveys are needed to determine the reproductive success of endangered waterbirds. Hawaiian stilt recruitment survey techniques have already been developed, but methods for monitoring the reproductive success of the other species should be developed and implemented on core and supporting wetlands.

1.4.5 Monitor aquatic invertebrate prey species used by waterbirds and fish to determine whether they compete with waterbirds for aquatic invertebrates.
Monitoring seasonal densities of aquatic invertebrates that occur in the diets of waterbirds may identify periods when food sources are scarce. Fish should also be monitored to determine if they are competitors of aquatic invertebrate prey used by waterbirds. If nonnative fish such as tilapia are determined to be competitors, control measures and/or eradication of fish should be developed and implemented.

2. Remove the threat of mallard-Hawaiian duck hybridization on all islands where Hawaiian ducks occur and establish a self-sustaining population of Hawaiian ducks on Maui and/or Moloka`i.
Hybridization between Hawaiian ducks and mallards has resulted in a large population of hybrids and a scarcity of pure Hawaiian ducks on the island of O`ahu. This threat also occurs on Kaua`i, Maui, and Hawai`i, although to a lesser extent. Hybridization of the Hawaiian duck with mallards or other related waterfowl should be prevented.

Self-sustaining Hawaiian duck populations should be established on Maui and/or Moloka`i. Although a small population (fewer than 15 individuals) of Hawaiian ducks exist on Maui (F. Duvall, pers. comm. 2004), augmentation may be needed to increase the likelihood of its sustainability.

2.1 Conduct a public information and awareness program regarding the mallard-Hawaiian duck interbreeding problem and the need for a feral and hybrid duck removal program.
Eliminating hybridization will be controversial unless the public becomes aware of its importance. The public may be more supportive of programs to remove mallards, other closely related feral ducks, and mallard-Hawaiian duck hybrids from the islands if the program's role in preserving the native species is better understood.

2.2 Develop methods for differentiating between Hawaiian ducks and mallard-Hawaiian duck hybrids.
Methods for identifying mallard-Hawaiian duck hybrids need to be developed to insure that the correct birds are removed from the population. The

development of such identification criteria will require the simultaneous collection of genetic and morphological data. Genetic information can be used to confirm field identification of birds, thus protecting Hawaiian ducks. An identification guide outlining physical characteristics unique to pure Hawaiian ducks is currently under development to assist in differentiating between Hawaiian ducks and hybrids (A. Engilis, pers. comm. 2003).

2.3 Implement a statewide program to humanely remove feral mallards and mallard-Hawaiian duck hybrids.

A Hawaiian duck recovery implementation group that includes various resource agencies and researchers was recently established to address this problem. The group is working on developing a comprehensive statewide approach to the mallard-Hawaiian duck hybridization problem. Efforts to remove mallards and related waterfowl should be accomplished through approved duck trapping techniques and other humane methods.

2.4 Ensure new stocks of mallards and closely related ducks are not brought into the state.

Strict control over the entry of additional domesticated mallards or closely related ducks into Hawai`i should be enacted. Coordination with the Hawai`i Department of Agriculture will be necessary to maintain or improve importation controls.

2.5 Establish a self-sustaining population of Hawaiian ducks on Maui and/or Moloka`i.

Techniques for breeding the Hawaiian duck in captivity have been developed; however, translocation might also prove to be a useful method of reestablishing or augmenting populations.

2.5.1 Identify sites for reintroduction of the Hawaiian duck on Maui and Moloka`i.

Core wetlands that are protected and managed for waterbirds (Table 10) should be considered first as sites for Hawaiian duck reintroduction. If none of these areas are suitable, supporting wetlands (Table 11) should be considered before consideration of other areas (Appendix C).

2.5.2 Investigate the pros and cons of captive propagation versus translocation for establishing additional Hawaiian duck populations and develop a reintroduction plan that includes the preferred method.

The pros and cons of captive propagation versus translocation should be investigated to determine which method is likely to be more successful and efficient for reestablishing a Hawaiian duck population. A reintroduction plan should be developed using the preferred method.

2.5.3 Reintroduce either captive-bred or translocated Hawaiian ducks to protected and managed sites on Maui and Moloka`i and monitor their survival, dispersal, and reproduction.

Depending on the outcome of Recovery Actions 2.5.1. and 2.5.2, either captive propagation or translocation should be used to reestablish or, in the case of Maui, augment Hawaiian duck populations at protected and managed sites. Newly established Hawaiian duck populations should be monitored to evaluate the success of the reintroduction.

3. Establish a self-sustaining population of Hawaiian common moorhen on Hawai`i and either Maui or Moloka`i.

Hawaiian common moorhens formerly occurred on all of the main Hawaiian Islands except Lāna`i and Kaho`olawe, but now occur only on Kaua`i and O`ahu. Captive propagation and release, or translocation of moorhen should be conducted to help restore this species to its former range.

3.1 Conduct thorough surveys of wetland areas on Maui, Moloka`i, and Hawai`i to confirm that a moorhen population does not already exist.

It is possible that a population of moorhens already exists on the islands of Maui, Moloka`i, or Hawai`i. While this possibility is slim, all likely moorhen habitat areas should be thoroughly searched, reasons for the disappearance of moorhens identified, and the use of core and/or supporting wetlands for potential reintroduction sites assessed.

3.2 If a population of moorhens is found on Maui, Moloka`i, or Hawai`i, protect and manage its wetland habitat.

Hawaiian common moorhen populations found on the islands of Maui, Moloka`i, or Hawai`i should be increased through habitat protection and management.

3.3 If no population of moorhen is found on Maui, Moloka`i, or Hawai`i, potential reintroduction sites should be evaluated.

Habitat criteria for the reintroduction of moorhens need to be established. Core and supporting wetlands that are protected and managed should be considered first for moorhen reintroduction. If none of these areas are suitable, additional wetlands (Appendix C) that meet the habitat criteria should be considered.

3.4 Investigate the pros and cons of captive propagation versus translocation for establishing additional moorhen populations and develop a reintroduction plan that includes the preferred method.

Captive propagation and translocation are both useful methods for reintroducing species; however, the method most appropriate in a particular case depends on the ease of capturing, breeding, and maintaining the species

in captivity. A reintroduction plan should be developed using the preferred method.

3.5 Reintroduce Hawaiian common moorhens to a protected and managed site on Hawai`i and either Maui or Moloka`i and monitor their survival, dispersal, and reproduction.

Depending on the outcome of action 3.4, either captive propagation or translocation should be used to reestablish a moorhen population on Hawai`i and Maui or Moloka`i. Newly established Hawaiian common moorhen populations should be monitored to evaluate success of the reintroduction.

4. Conduct research to better understand population biology and limiting factors, evaluate recovery objectives, and improve management techniques.

Proper management requires the application of information obtained from research. Many of the successful waterbird management techniques currently in use were developed in response to research findings. Additional research is needed to better understand limiting factors, refine recovery objectives, and improve management techniques for Hawai`i's endangered waterbirds. Adaptive management should be implemented as management techniques evolve.

4.1 Increase understanding of Hawaiian waterbird population limiting factors.

A better understanding of the factors that limit the recovery of Hawai`i's waterbirds will allow more effective management techniques to be developed.

4.1.1 Investigate the effects of different predators on endangered waterbirds.

Waterbirds may be preyed on by a variety of animals, including dogs, cats, mongooses, bullfrogs, black-crowned night-herons, cattle egrets, owls, and possibly others. The relative importance of these predators may differ among sites and waterbird species. The frequency of predation, demographic effects, and efficiency of potential control programs should be investigated for each predator and at different sites.

4.1.2 Research improved predator control methods.

The effectiveness of predator control methods should be evaluated and improved methods should be developed if possible.

4.1.3 Research improved methods for nonnative plant control and restoration of native plants.

Improved methods for controlling nonnative plants and outplanting native plants should be developed to improve habitat suitable for waterbird use.

4.2 Conduct research to better understand Hawaiian waterbird population biology and recovery needs.

Scientific information is needed to better understand the population biology of these four species. This information can be used to more effectively manage the recovery program and support or modify the recovery criteria for the Hawaiian coot, duck, moorhen, and stilt.

4.2.1 Analyze existing survey data and estimate current population size and population trends.

Surveys to monitor waterbird populations have been conducted for many years. A great deal of information about the size and status of waterbird populations can be obtained by careful analysis of this data.

4.2.2 Determine the carrying capacity of wetland habitats.

Understanding the limits to the potential population density of the waterbird species at different types of wetlands will improve our ability to predict population sizes and whether additional management will allow for an increase in the population size.

4.2.3 Estimate reproductive parameters.

Collecting information on the reproductive parameters of all four waterbird species will increase our understanding of each species' biology. This research should focus on the following areas: age at first breeding, nest site and mate fidelity, length of nesting season, clutch size, hatching and feeding rates, and nesting attempts per pair.

4.2.4 Estimate mortality rates.

Determining the rates and sources of mortality will allow a better understanding of the threats and management needs for each species and facilitate a determination of the minimum reproductive rates needed to increase and stabilize populations.

4.2.5 Research on movement of adults and natal dispersal.

Investigate the movement patterns of adults and natal dispersal of juveniles. Evidence from banding studies and population fluctuations indicates there is some movement of waterbirds among and within islands (Engilis and Pratt 1993; Reed *et al.* 1998). More information of this kind will allow a better understanding of statewide population size and trends.

4.2.6 Determine the sex and age structure of populations.

Determine the sex and age structures of important populations (e.g., waterbird populations that use core wetlands) of all four endangered waterbird species.

4.2.7 Investigate genetic population structure and potential inbreeding depression.

Determine the genetic population structure and the potential for inbreeding depression in all four endangered waterbird species.

4.2.8 Develop population viability analyses for the Hawaiian duck, coot, and moorhen.

A population viability analysis has been completed for the Hawaiian stilt (Reed *et al.* 1994), and similar population viability analyses should be conducted for the Hawaiian duck, coot, and moorhen to help identify the population numbers and time spans that may serve as useful predictors of long term recovery. This exercise will also help identify those parameters that have the most impact on population viability through a sensitivity analysis.

4.3 Research Hawaiian waterbird habitat needs and habitat manipulation.

Determine the habitat requirements of each species for foraging, nesting, and loafing and develop management techniques to produce these habitat conditions. In particular, research is needed on the use of montane stream systems by the Hawaiian duck, especially the use of these streams as nesting sites. It is thought that many Hawaiian ducks nest on the banks of upland streams near pools of water. Surveys of montane stream habitat should be conducted on Kaua`i and Hawai`i to obtain a more accurate population estimate of the Hawaiian duck. In the past, selected samples of streams in upland habitat were surveyed and the results used to calculate an index of the number of Hawaiian ducks per linear mile of stream. This method, as well as other methods, should be evaluated to determine the best way to accurately estimate Hawaiian duck populations in montane stream habitats.

5. Plan and implement a public information and awareness program to increase public understanding and support for waterbird recovery.

The waterbird recovery program cannot be fully successful without a well informed and supportive public. Efforts need to be made to inform the public, increase public accessibility to waterbird areas, and provide information on the various programs outlined in this recovery plan.

5.1 Prepare and distribute television and radio spots, written information, slide programs, videos, films, posters, and displays.

Educational materials on waterbird conservation should be developed to implement a public awareness and information program to enhance recovery of endangered waterbirds.

5.2 Coordinate with the Hawai`i Department of Education and private schools to incorporate wetland and waterbird information into school curricula.

Efforts to teach wetland ecology and avian biology should be made within the public and private school systems. Wetland refuges and sanctuaries provide excellent opportunities for field trips and field studies.

5.3 Develop and maintain interpretive displays of endangered waterbirds and wetlands.

Interpretive displays should be developed and maintained at wetland habitat areas and at various community locations.

Table 10. Specific recovery actions recommended for core wetlands in the main Hawaiian Islands.

CORE WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[1]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
Ni`ihau												
Playa Lakes	769 (1900)	Private	No	X			X		X	X		
Kaua`i												
Hanalei National Wildlife Refuge	371 (917)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Hulē`ia National Wildlife Refuge	98 (241)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Kawai`ele Waterbird Sanctuary	14 (35)	HDLNR	Yes	X		X		X	X	X	X	X
Lumaha`i Wetlands	51 (125)	Private	No	X		X	X	X				X
O`ahu												
James Campbell National Wildlife Refuge	66 (164)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Kawainui Marsh	304 (750)	HDLNR	Yes	X	X	X	X	X	X		X	X
Nu`upia Ponds	196 (483)	MCBH	Yes	X		X	X	X	X	X		
Pearl Harbor National Wildlife Refuge	25 (61)	USFWS	Yes	X		X	X	X	X	X	X	X
Pouhala Marsh Waterbird Sanctuary	28 (70)	HDLNR	Yes	X		X	X	X	X		X	X

[1] Responsibility: HDLNR = Hawai`i Department of Land and Natural Resources, DU = Ducks Unlimited, MCBH = Marine Corps Base Hawai`i, NPS = National Park Service, USFWS = U.S. Fish and Wildlife Service, USN = U.S. Navy. , NWR = National Wildlife Refuge, Pvt = Private landowner.

[2] Protected refers to wetland habitats that are secure from development.

Table 10 (continued). Specific recovery actions recommended for core wetlands in the main Hawaiian Islands.

CORE WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[2]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
Moloka`i												
Kakahai`a National Wildlife Refuge	18 (45)	USFWS	Yes	X	X	X	X	X	X	X		X
Maui												
Kanahā Pond Wildlife Sanctuary	59 (145)	HDLNR	Yes	X	X	X	X	X	X	X	X	X
Keālia Pond National Wildlife Refuge	280 (692)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Hawai`i												
`Aimakapā/Kaloko Pond	22 (55)	NPS	Yes		X	X	X	X	X	X		
Loko Waka Ponds	10 (24.5)	Pvt/State	No	X	X	X	X	X	X		X	X
Waiakea Pond	16 (39.5)	State/County	Yes	X	X	X	X	X	X	X	X	X

[1] Responsibility: HDLNR = Hawai`i Department of Land and Natural Resources, DU = Ducks Unlimited, MCBH = Marine Corps Base Hawai`i, NPS = National Park Service, USFWS = U.S. Fish and Wildlife Service, USN = U.S. Navy. , NWR = National Wildlife Refuge, Pvt = Private landowner.

[2] Protected refers to wetland habitats that are secure from development.

Table 11. Specific recovery actions recommended for supporting wetlands in the main Hawaiian Islands.

SUPPORTING WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[1]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
Kaua`i												
Hanalei Taro Fields and River (that are not part of Hanalei National Wildlife Refuge)	40.4 (100)	Pvt/State	No	X		X	X	X	X		X	
Hanapēpē Salt Ponds	20 (49.4)	Pvt/HDLNR	No	X	X	X	X	X	X	X	X	
Mānā Wetlands	81 (200)	Pvt/State	No	X			X	X	X			X
Opaeka`a Marsh	20 (50)	Pvt/HDLNR	No	X	X	X	X	X	X	X		X
Smith's Tropical Paradise	1.9 (4.7)	Pvt/State	No	X	X	X	X	X	X	X	X	
Wailua River Bottoms	20 (8)	Pvt/State	No	X			X	X	X		X	
Waimea River System	64 (158)	Pvt/State	No	X			X	X	X		X	
Wainiha Valley Taro Fields and River	44 (109)	Pvt/County	No	X	X	X	X	X	X		X	
Waitā Reservoir	151 (373)	Private	No	X		X	X	X			X	X

[1] Responsibility: HDLNR = Hawai`i Department of Land and Natural Resources, DU = Ducks Unlimited, MCBH = Marine Corps Base Hawai`i, NPS = National Park Service, USFWS = U.S. Fish and Wildlife Service, USN = U.S. Navy. , NWR = National Wildlife Refuge, Pvt = Private landowner.

[2] Protected refers to wetland habitats that are secure from development.

Table 11 (continued). Specific recovery actions recommended for supporting wetlands in the main Hawaiian Islands.

SUPPORTING WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[1]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
O`ahu												
Ka`elepulu Pond	2.2 (5.6)	Private	No	X	X	X	X		X	X	X	
Kahuku aquaculture farms	41 (100)	Private	No	X		X	X	X	X			
Kuilima (Turtle Bay) Sewage Treatment Plant	5 (12.4)	Private	No	X			X	X	X	X		
Halei`wa Lotus Fields	4.2 (10.6)	Pvt/County	No	X			X	X	X		X	
Hāmākua Marsh WBS	9 (23)	HDLNR/DU	Yes	X	X	X	X	X	X	X	X	X
He`eia Marsh	162 (400)	DLNR	Yes	X	X	X	X	X	X	X		X
Lā`ie Wetlands	81 (200)	Private	No	X								X
Niuli`i Ponds, Lualualei	16 (40)	USN/USFWS	Yes	X	X	X	X	X	X	X	X	X
Paikō Lagoon WS	13 (33)	DLNR	Yes	X	X	X	X	X	X	X	X	X
Punaho`olapa Marsh	41 (100)	Private	No	X	X	X	X	X	X	X	X	X
`Uko`a Marsh	122 (300)	Private	No				X	X	X			X
Waialua Lotus Fields	30 (75)	Private	No	X	X	X	X	X	X			X
Waihe`e Marsh	10 (25)	Private	No	X	X	X	X	X	X			X

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[2] Protected refers to wetland habitats that are secure from development.

Table 11 (continued). Specific recovery actions recommended for supporting wetlands in the main Hawaiian Islands.

SUPPORTING WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[1]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
Moloka`i												
Kaunakakai Sewage Treatment Plant	1.5 (3.7)	Maui County	No	X		X	X	X	X	X		
Kualapu`u Reservoir	30 (74)	State	No	X		X	X	X	X	X		
`Ōhi`apilo Wetland	10 (25)	Maui County	Yes									
Paialoa Fish Pond	2 (5)	Private	No	X		X	X	X	X			X
Lana`i												
Lāna`i Sewage Treatment Plant	3 (7.4)	County	No	X		X	X	X	X	X		
Maui												
Ke`anae Point	1.5 (3.7)	State	No	X	X	X	X	X	X	X	X	
Waihe`e Preserve	101(250)	Private	Yes	X	X	X	X	X	X	X	X	
Hawai`i												
Ke`anae Pond (Kea`au)	2.9 (7.2)	Private	No	X	X	X	X	X	X	X	X	
Kohala Stock Ponds	*	Private	No	X	X	X	X	X	X			
Kona Sewage Treatment Plant	12 (30)	County	No	X		X	X	X	X	X		

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[2] Protected refers to wetland habitats that are secure from development.

Table 11 (continued). Specific recovery actions recommended for supporting wetlands in the main Hawaiian Islands.

SUPPORTING WETLANDS	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility[1]	Protected[2]	1.3	1.3.1	1.3.2	1.3.3	1.3.5	1.3.6	1.3.7	1.4	2
Hawai`i (continued)												
Mauna Kea Stock Ponds	*	Private	No	X	X	X	X	X	X			
`Ōpae`ula Ponds	3 (7.5)	Private	No	X	X	X	X	X	X			
Parker Ranch Ponds	18 (45)	Private	Yes	X	X	X	X	X	X			
Waimanu Valley	*	County	Yes	X	X	X	X	X	X	X	X	X
Waipi`o Valley	*	County	No	X	X	X	X	X	X	X	X	X

[1] Responsibility: HDLNR = Hawai`i Department of Land and Natural Resources, DU = Ducks Unlimited, MCBH = Marine Corps Base Hawai`i, NPS = National Park Service, USFWS = U.S. Fish and Wildlife Service, USN = U.S. Navy. , NWR = National Wildlife Refuge, Pvt = Private landowner.

[2] Protected refers to wetland habitats that are secure from development.

* = unknown.

III. Implementation Schedule

The Implementation Schedule outlines actions and estimated costs for the Hawaiian waterbirds recovery actions, as set forth in this recovery plan. It is a guide for meeting the recovery goals outlined in this plan. The Implementation Schedule includes the following elements:

A. ACTION PRIORITIES

The actions identified in the Implementation Schedule are those that, in our opinion, are necessary to bring about the recovery of these species. However, the actions are subject to modification as dictated by new findings, changes in species status, and the completion of reocvery actions. The priority for each action is given in the first column of the Implementation Schedule, and is assigned as follows:

Priority 1 — An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2 — An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 — All other actions necessary to meet the recovery objectives.

B. ACTION NUMBER AND DESCRIPTION

The action number and action description are extracted from the stepdown narrative of recovery actions found in part II-E of this plan. Please refer back to this narrative for a more detailed description of each action.

C. LISTING/DELISTING FACTORS

As discussed earlier, we evaluate five major factors when considering to list, delist, or reclassify a species:

A — The present or threatened destruction, modification or curtailment of its habitat or range;
B — Overutilization for commercial, recreational, scientific, or educational purposes;
C — Disease or predation;
D — Inadequacy of existing regulatory mechanisms; and
E — Other natural or man-made factors affecting its continued existence.

The Listing Factor column in the Implementation Schedule indicates which of the five factors the recovery action addresses in order to meet the recovery goals for the endangered waterbirds. The majority of recovery actions in the Implementation Schedule address threats to habitat (factor A), disease and predation (factor C), and other factors such as small population sizes and reduced distribution (factor E).

D. RESPONSIBLE PARTIES

In this table, we have identified agencies and other parties that we believe are primary stakeholders in the recovery process for the Hawaiian waterbirds. Stakeholders are those agencies who may voluntarily participate in any aspect of implementation of particular actions listed within this recovery plan. Stakeholders may willingly participate in project planning, funding, provide technical assistance, staff time, or any other means of implementation. The list of potential stakeholders is not limited to the list below; other stakeholders are invited to participate. In some cases, the most logical lead agency (based on authorities, mandates, and capabilities) has been identified with an asterisk (*).

The listing of an agency in the Implementation Schedule does not require, nor imply a requirement or an agreement, that the identified agency implement that action(s) or secure funding for implementing action(s). However, agencies willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover these four species. Also, section 7(a)(1) of the Endangered Species Act (Act) directs all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species.

We, the U.S. Fish and Wildlife Service, have the statutory responsibility for implementing this recovery plan. Only Federal agencies are mandated to take part in the effort. Recovery actions identified in this plan imply no legal obligations of the State and local government agencies or private landowners. However, the recovery of the Hawaiian coot, duck, moorhen, and stilt will require the involvement and cooperation of Federal, State, local, and private interests.

E. ACTION DURATION

The action duration column indicates the number of years estimated to complete the action if it is a discrete action, or whether it is a continual or ongoing action. Occasionally it is not possible to provide a reasonable estimate of either the time or cost to complete an action; these cases are denoted as To Be Determined (TBD). Continual and ongoing actions are defined as follows:

Continual (C) -— An action that will be implemented on a routine basis once begun.

Ongoing (O) -— An action that is currently being implemented and will continue until the action is no longer necessary.

F. COST ESTIMATES

The Implementation Schedule provides the estimated costs of implementing recovery actions for the first 5 years after the release of the recovery plan, the years 2005 through 2009. Estimates for recovery actions are based on average costs of similar actions implemented to date. For wetland management, these costs may vary considerably depending upon the condition of the wetland vegetation, hydrology, types of management actions, and actions already occurring in the area.

Annual cost estimates are as follows:

2005 = $2,442,000
2006 = $2,724,000
2007 = $2,507,000
2008 = $2,098,000
2009 = $1,598,000

The total cost to implement this plan for years 2005 through 2009 is $11,369,000. The total cost to implement this plan through the year 2015, the estimated recovery date, is $18,059,000.

G. ACRONYMS USED IN THE IMPLEMENTATION SCHEDULE

BRD	U.S. Geological Survey, Biological Resources Division
DOCARE	Hawai`i Department of Land and Natural Resources, Division of Conservation and Resources Enforcement
DU	Ducks Unlimited
FWS -ES	U.S. Fish and Wildlife Service, Ecological Services, Honolulu, Hawai`i
FWS -LE	U.S. Fish and Wildlife Service, Law Enforcement, Honolulu, Hawai`i
FWS -R	U.S. Fish and Wildlife Service, Refuges, Honolulu, Hawai`i
HDLNR	Hawai`i Department of Land and Natural Resources, Division of Forestry and Wildlife
HDOA	Hawai`i Department of Agriculture
HDOE	Hawai`i Department of Education
USDA	U.S. Department of Agriculture
USMC	U.S. Marine Corps
USN	U.S. Navy
WS	U.S. Department of Agriculture, Wildlife Services

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Revision

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
1	1	A	Protect (secure from development) core (100%) and supporting (at least 25% for downlisting and 75% for delisting) wetlands.	3	FWS-R	50	50	50			150
					HDLNR	50	50	50			150
1	1.1	A	Develop management plans for core and supporting wetlands.	2	FWS-R	50	50				100
					HDLNR	50	50				100
					USMC	10	10				20
					USN	5	5				10
1	1.2	A,E	Coordinate management of core and supporting wetlands with other agencies and organizations.	C	FWS-ES	5	5	5	5	5	50
					HDLNR	5	5	5	5	5	50
1	1.3.1	A, C, E	Secure water sources and manage water levels to maximize nesting success, brood survival, food availability, and recruitment of waterbirds.	C	FWS-R	25	25	25	25	25	250
					FWS-ES	5	5	5	5	5	50
					HDLNR	25	25	25	25	25	250

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
1	1.3.2.1	A	Encourage desirable plant species.	C	FWS-R	50	50	50	50	50	500
					HDLNR	50	50	50	50	50	500
					USMC	10	10	10	10	10	100
					USN	5	5	5	5	5	50
1	1.3.2.2	A	Control undesirable plant species.	C.	HDLNR	150	150	150	150	150	1,500
					FWS-R	150	150	150	150	150	1,500
					USMC	10	10	10	10	10	100
					USN	5	5	5	5	5	50
1	1.3.2.3	A	Prevent introduction of invasive non-native plants.	C	FWS-R	5	5	5	5	5	50
					HDLNR	5	5	5	5	5	50
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
1	1.3.3.1	C	Prevent predator access.	C	FWS-R	80	80	80	80	80	800
					HDLNR	80	80	80	80	80	800
					USMC	5	5	5	5	5	50
					USN	5	5	5	5	5	50

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
1	1.3.3.2	C	Control mongooses.	C	FWS-R	80	80	80	80	80	800
					HDLNR	80	80	80	80	80	800
					USMC	10	10	10	10	10	100
					USN	2	2	2	2	2	20
1	1.3.3.3	C	Control feral cats.	C	FWS-R	40	40	40	40	40	400
					HDLNR	40	40	40	40	40	400
					USMC	10	10	10	10	10	100
					USN	2	2	2	2	2	20
1	1.3.3.4	C	Control feral dogs.	C	FWS-R	10	10	10	10	10	100
					HDLNR	10	10	10	10	10	100
					USMC	2	2	2	2	2	20
					USN	2	2	2	2	2	20
1	1.3.3.5	C	Control rats.	C	FWS-R	30	30	30	30	30	300
					HDLNR	30	30	30	30	30	300
					USMC	5	5	5	5	5	50
					USN	2	2	2	2	2	20

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	1.3.3.6	C	Control cattle egrets.	C	FWS-R	10	10	10	10	10	100
					HDLNR	10	20	10	10	10	100
					USMC	2	2	2	2	2	20
					USN	1	1	1	1	1	10
2	1.3.3.7	C	Control tilapia.	C	FWS-R	30	30	30	30	30	300
					HDLNR	30	30	30	30	30	300
					USMC	5	5	5	5	5	50
					USN	2	2	2	2	2	20
1	1.3.3.8	C	Control bullfrogs.	C	FWS-R	10	10	10	10	10	100
					HDLNR	10	10	10	10	10	100
					USMC	2	2	2	2	2	20
					USN	1	1	1	1	1	10
1	1.3.4	C	Prevent introduction of new non-native predators such as the brown treesnake (*Boiga irregularis*).	C	FWS-ES	10	10	10	10	10	100
					HDLNR	10	10	10	10	10	100
					HDOA	10	10	10	10	10	100

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	1.3.5.1	E	Assess and if necessary prevent intentional or accidental shooting of waterbirds.	C	FWS-R	5	5	5	5	5	50
					FWS-LE	5	5	5	5	5	50
					*DOCARE	10	10	10	10	10	100
2	1.3.5.2	E	Control human access to waterbird habitats during breeding seasons.	C	FWS-R	5	5	5	5	5	50
					HDLNR	5	5	5	5	5	50
2	1.3.5.3	A, E	Resolve conflicts resulting from actual or preceived depredation by waterbirds on aquaculture and agriculture products by waterbirds.	C	FWS-ES	2	2	2	2	2	20
					FWS-R	3	3	3	3	3	30
					HDLNR	5	5	5	5	5	50
2	1.3.5.4	A	Minimize influence of urban encroachment.	C	FWS-ES	5	5	5	5	5	50
					FWS-R	5	5	5	5	5	50
					HDLNR	5	5	5	5	5	50
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
2	1.3.6.1	C	Monitor waterbird populations to detect disease outbreaks as soon as possible.	C	FWS-R	2	2	2	2	2	20
					HDLNR	2	2	2	2	2	20
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	1.3.6.2	C	Take immediate action to restrict the spread of the disease outbreaks.	C	FWS-R	TBD	TBD	TBD	TBD	TBD	TBD
					HDLNR	TBD	TBD	TBD	TBD	TBD	TBD
					USMC	TBD	TBD	TBD	TBD	TBD	TBD
					USN	TBD	TBD	TBD	TBD	TBD	TBD
2	1.3.7.1	A ,C	Monitor water quality.	O	HDLNR	5	5	5	5	5	50
					FWS-R	5	5	5	5	5	50
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
2	1.3.7.2	A	Restrict introduction of contaminants to wetland systems.	O	HDLNR	2	2	2	2	2	20
					FWS-R	1	1	1	1	1	10
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
3	1.3.7.3	A	Assess nutrient levels and other parameters that influence core and supporting wetlands productivity for waterbirds.	3	HDLNR	2	2	2			6
					FWS-R	2	2	2			6
					USMC	1	1	1			3

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	1.4.1	E	Continue standardized, biannual, statewide surveys for all endangered waterbirds.	O	*HDLNR	20	20	20	20	20	200
					FWS-R	10	10	10	10	10	100
					FWS-ES	3	3	3	3	3	30
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
2	1.4.2	E	Continue regular, standardized surveys on core and supporting wetlands.	C	HDLNR	5	5	5	5	5	50
					FWS-R	5	5	5	5	5	50
					USMC	1	1	1	1	1	10
					USN	1	1	1	1	1	10
2	1.4.3	E	Develop and improve survey techniques for the Hawaiian duck and Hawaiian common moorhen.	2	BRD	50	50				100
2	1.4.4	E	Monitor reproductive success on core wetlands.	C	FWS-R	10	10	10	10	10	100
					HDLNR	10	10	10	10	10	100
					USMC	5	5	5	5	5	50
					USN	1	1	1	1	1	10

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	1.4.5	E	Monitor aquatic invertebrate prey species used by waterbirds and fish to determine whether they compete with waterbirds for aquatic invertebrates.	3	*BRD	10	10	10			30
					FWS-R	5	5	5			15
					USMC	1	1	1			3
					HDLNR	5	5	5			15
1	2.1	E	Conduct public information and awareness program regarding mallard-Hawaiian duck interbreeding problem and the need for the removal program.	3	FWS-ES	5	5	5			15
					FWS-R	3	3	3			9
					HDLNR	5	5	5			15
1	2.2	E	Develop methods for differentiating between Hawaiian ducks and mallard-Hawaiian duck hybrids.	2	FWS-ES,	15	15				30
					FWS-R,	15	15				30
					BRD	20	20				40
1	2.3	E	Implement statewide program to humanely remove feral mallards and mallard-Hawaiian duck hybrids.	3	FWS-R	50	50	50			150
					FWS-ES	10	10	10			30
					HDLNR	50	50	50			150
					WS	50	50	50			150

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
1	2.4	E	Ensure new stocks of mallards and closely related ducks are not brought into the State.	C	*HDOA	5	5	5	5	5	50
					FWS-LE	5	5	5	5	5	50
2	2.5.1	E	Identify sites for reintroduction of the Hawaiian duck on Maui and Moloka` i.	1	HDLNR		4				4
					FWS-R		2				2
					FWS-ES		2				2
					BRD		4				4
2	2.5.2	E	Investigate captive propagation versus translocation for establishing additional Hawaiian duck populations and develop a reintroduction plan.	1	FWS-ES		5				5
					HDLNR		5				5
2	2.5.3	E	Reintroduce either captive-bred or translocated Hawaiian ducks to a protected and managed site on Maui.	2	HDLNR			30	30		60
					BRD			30	30		60
					FWS-ES			30	30		60
					FWS-R			30	30		60

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
3	3.1	E	Conduct thorough surveys of wetland areas on Maui, Moloka`i, and Hawai`i to confirm that a Hawaiian common moorhen population does not already exist.	1	HDLNR	10					10
					BRD	10					10
1	3.2	A,E	If a population of moorhen is found on Maui, Moloka`i, and Hawai`i, protect and manage its wetland habitat.	C	HDLNR		TBD	TBD	TBD	TBD	TBD
					FWS-ES		TBD	TBD	TBD	TBD	TBD
					BRD		TBD	TBD	TBD	TBD	TBD
3	3..3	A,E	If no population of moorhen is found on Maui, Moloka`i, or Hawai`i, habitat quality at potential reintroduction sites should be evaluated. A site meeting certain minimum criteria should be selected.	1	HDLNR		4				4
					FWS-ES		2				2
					FWS-R		2				2
					BRD		2				2
					DU		2				2

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
2	3.4	E	Investigate the pros and cons of captive propagation versus translocation as a reintroduction technique.	2	FWS-R		2	2			4
					HDLNR		2	2			4
					BRD		2	2			4
					DU		2	2			4
2	3.5	A,E	Reintroduce Hawaiian common moorhens to a protected and managed site on Maui, Moloka`i, or Hawai`i and monitor their survival, dispersal, and any reproduction.	2	FWS-ES				30	30	60
					FWS-R				30	30	60
					HDLNR				30	30	60
					BRD				30	30	60
1	4.1.1	C	Investigate the effects of different predators on endangered waterbirds.	4	FWS-R	20	20	20	20		80
					HDLNR	20	20	20	20		80
					BRD	20	20	20	20		80
1	4.1.2	C	Research improved predator control methods.	3	FWS-R		40	40	40		120
					HDLNR		40	40	40		120
					*BRD		40	40	40		120
					WS		40	40	40		120

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
3	4.1.3	C	Research improved methods for non-native plant control and restore native plants.	3	FWS-R	40	40	40			120
					HDLNR	40	40	40			120
					*BRD	40	40	40			120
2	4.2.1	E	Analyze existing survey data and investigate current population size, effective population size, and population trends.	3	*BRD	30	30	30			90
					HDLNR	20	20	20			60
					FWS-ES	20	20	20			60
3	4.2.2	E	Determine carrying capacity of wetland habitats.	3	*BRD			5	5	5	15
					FWS-ES			5	5	5	15
					HDLNR			5	5	5	15
					FWS-R			5	5	5	15
3	4.2.3	E	Estimate reproductive parameters.	3	BRD			5	5	5	15
					FWS-ES			5	5	5	15
					HDLNR			5	5	5	15
					FWS-R			5	5	5	15

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
3	4.2.4	E	Estimate mortality rates.	3	BRD			5	5	5	15
					FWS-ES			5	5	5	15
					HDLNR			5	5	5	15
					FWS-R			5	5	5	15
3	4.2.5	E	Conduct research on movement of adults and natal dispersal.	4	BRD	20	20	20	20		80
					HDLNR	20	20	20	20		80
					FWS-R	20	20	20	20		80
					FWS-ES	20	20	20	20		80
3	4.2.6	E	Determine the sex and age structure of populations.	3	BRD	5	5	5			15
					FWS-ES	5	5	5			15
					HDLNR	5	5	5			15
					FWS-R	5	5	5			15
3	4.2.7	E	Investigate genetic population structure and potential inbreeding depression.	4	*BRD		20	20	20	20	80
					FWS-ES		20	20	20	20	80
					HDLNR		20	20	20	20	80
					FWS-R		20	20	20	20	80

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
3	4.2.8	E	Conduct population viability analyses for Hawaiian duck, coot, and common moorhen.	2	BRD		10	10			20
					FWS-ES		10	10			20
3	4.3	E	Conduct research on habitat needs and habitat manipulation.	4	BRD	20	20	20	20		80
					FWS-ES	20	20	20	20		80
					HDLNR	20	20	20	20		80
					FWS-R	20	20	20	20		80
3	5.1	E	Prepare and distribute educational materials.	2	FWS-ES	10	10				20
					HDLNR	10	10				20
					FWS-R	10	10				20

Implementation Schedule for the Second Draft Revised Recovery Plan for Hawaiian Waterbirds, 2nd Rev. (cont.)

Priority Number	Action Number	Listing Factor	Action Description	Action Duration (Years)	Responsible Party[1]	Cost Estimates ($1,000's)					
						FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	Recovery Total
3	5.2	E	Coordinate with the Hawai`i Department of Education and private schools to incorporate waterbird information into school curricula.	2	HDLNR	20	20				40
					FWS-ES	20	20				40
					HDOE	20	20				40
3	5.3	E	Develop and maintain interpretive displays of endangered waterbirds and wetlands.	2	HDLNR	20	20				40
					FWS-ES	10	10				20
					FWS-R	20	20				40
					TOTALS [2]	**$2,442**	**$2,724**	**$2,507**	**$2,098**	**$1,598**	**$18,059**

[1]An asterisk (*) denotes the lead agency. If no asterisk is present, the agencies share the lead equally. Refer to page 101 for a description of acronyms.

[2] Some of the above costs are yet to be determined and there are likely to be additional costs as well.

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V. Appendices

APPENDIX A. Core Wetlands

Core Wetlands: Areas that provide habitat essential for supporting larger populations of Hawaiian waterbirds that comprise the bulk of the numbers prescribed for recovery. These sites must be protected and managed to recover Hawai`i's waterbirds.

Ni`ihau

Playa Lakes - The Playa Lakes on Ni`ihau are seasonally some of the most important wetlands in the State. Three large lakes dominate the 760-hectare (1,900-acre) wetland complex. Large numbers of Hawaiian coots, stilts, and migratory ducks have been observed on these lakes, but they have not been surveyed since 1999. The long-term protection of these wetlands should be sought through a cooperative effort with the private landowner.

Kaua`i

Hanalei National Wildlife Refuge - The first National Wildlife Refuge established for waterbirds in Hawai`i was acquired in Hanalei Valley, on Kaua`i, in 1972. This 367-hectare (917-acre) refuge supports large populations of all four endangered waterbirds and numerous migratory waterfowl. Taro is grown on portions of the refuge by local farmers, a practice that dates back more than 1,200 years in the valley. Management of wetland units for waterbird habitat is ongoing and has recently focused on providing additional foraging habitat.

*Hulē`ia National Wildlife Refuge* - In 1973, Hulē`ia National Wildlife Refuge was established on Kaua`i, south of the town of Līhu`e. The refuge encompasses 98 hectares (241 acres) of river bottom habitat along the Hulē`ia River. It was established to provide open, productive wetlands for endangered Hawaiian waterbirds.

*Lumaha`i Valley* - Lumaha`i Valley in northern Kaua`i covers approximately 121 hectares (300 acres) and is utilized by all four endangered waterbird species. The lower reaches of Lumaha`i Valley provide relatively undisturbed high quality feeding, loafing, and possibly nesting habitat. The land is owned by Bishop Estate. Protection of this area is needed. A partnership should be pursued to protect and preserve Lumaha`i Valley through a cooperative agreement, funding, or habitat with the landowner.

O`ahu

James Campbell National Wildlife Refuge - Established in 1976, this refuge has become one of the State's most important waterbird refuges. The refuge size (66 hectares [164 acres]), management, and location all contribute to its importance. The refuge contains a mix of naturally occurring, spring-fed marshes and man-made ponds and impoundments. The land is currently only leased to the Fish and Wildlife Service and permanent protection is needed. The permanent wetlands of the site are supported by numerous seasonal wetlands not currently within refuge boundaries. With additional protection measures, we have an opportunity to protect an important wetland system that supports waterbirds throughout their annual cycle.

Kawainui Marsh - Historically, this 300-hectare (741-acre) marsh on windward O`ahu contained a 180-hectare (450-acre) fishpond used by native Hawaiians. It is fed primarily by Manauwili and Kahanaiki streams. The marsh feeds into a canal and then into Kailua Bay. Most of the marsh is now vegetated, but some open water exists near the center. Expansion of open water areas would facilitate use by all four endangered waterbird species, which now use the area in small numbers. Kawainui Marsh is currently owned by the Department of Land and Natural Resources (76 hectares [188 acres] around the marsh periphery) and the City and County of Honolulu (the remaining 224 hectares [553 acres]). The entire area is managed by the State of Hawai`i. In 1993, the State began extensive planning efforts for wetland restoration, habitat development, and long term management.

*Nu`upia Ponds* - An interagency agreement exists under the Sikes Act between the U.S. Marine Corps, the Fish and Wildlife Service, the Hawai`i Department of Land and Natural Resources, and the National Marine Fisheries Service for management of this wetland area. Eight shallow ponds, totaling approximately 196 hectares (483 acres), comprise the Nu`upia Pond complex at the Kāne`ohe Marine Corps Base Hawai`i on the eastern side of O`ahu. The open water and extensive mudflats with stands of *Batis maritima* (pickleweed) provide valuable habitat for Hawaiian stilts. The ponds range in salinity from approximately that of the ocean (35 parts per thousand [ppt]) to hypersaline (100 ppt). Freshwater upwelling occurs in some ponds creating brackish water conditions (15 to 20 ppt) that support scattered patches of robust emergent plants. Over the past 20 years, the number of stilts at these ponds have doubled from about 60 to over 130 birds, which is currently approximately 10 percent of Oahu's stilt population (Rauzon *et al.* 2002). Various management plans have been developed and implemented for this area, the most comprehensive being an Integrated Natural Resources Management Plan for the Marine Corps Base Hawai`i (Drigot *et al.* 2001).

Pearl Harbor National Wildlife Refuge - This refuge, composed of two man-made wetland units (Honouliuli and Waiawa) totaling 25 hectares (62 acres), is managed under a cooperative agreement with the U.S. Navy. The refuge was established in

1976 as mitigation for construction of the Honolulu International Airport Reef Runway. The refuge is managed for a variety of waterbirds and supports substantial numbers of the four endangered waterbirds and numerous migratory waterfowl and shorebirds.

Moloka`i/Maui

*Kakahai`a National Wildlife Refuge* - In 1977, Kakahai`a National Wildlife Refuge was established on Molokai's southern shore. The 18-hectare (45-acre) refuge protects a pond and man-made impoundment. Twelve species of birds, including the Hawaiian coot and stilt, use this area.

Kanahā Pond Sanctuary - In 1952, Kanahā Pond on Maui was designated as the first State wetland sanctuary. The sanctuary encompasses a 57-hectare (143-acre) wetland that is owned by the Hawai`i Department of Transportation and managed by the Hawai`i Department of Land and Natural Resources. It provides valuable nesting, loafing, and feeding habitat for coots and stilts.

Keālia Pond National Wildlife Refuge - This important 280-hectare (692-acre) wetland and pond is located near Kīhei. Representing some of the last remaining natural wetland habitat in the State of Hawai`i, the area provides valuable nesting, loafing, and feeding habitat for coots and stilts. The area was acquired in 1992 and established as a National Wildlife Refuge. The U.S. Fish and Wildlife Service and Ducks Unlimited are currently developing a restoration and management plan that will improve habitat for waterbirds, provide secure water delivery to restored ponds, and provide for public use activities (*e.g.*, wildlife viewing and education).

Hawai`i

*`Aimakapā/Kaloko Pond* - This wetland comprises approximately 10 hectares (25 acres) of open water and another 8 hectares (20 acres) of marsh. The surrounding area is developing commercially. `Aimakapā Pond is an important Kona Coast wetland that supports many Hawaiian coots and stilts. The National Park Service acquired these ponds as part of Kaloko-Honokōhau National Historic Park. The National Park Service is currently monitoring bird use on the marsh; however, management plans emphasize restoration of the area as a demonstration fishpond for cultural resource preservation.

Loko Waka Pond - The Loko Waka Ponds are located near Hilo, and the privately owned portions are managed for fish culture. They provide nesting and feeding habitat for coots. The use of pesticides should be closely coordinated with the Hawai`i Division of Aquatic Resources to prevent habitat damage. Agreements should be sought with the landowner to enhance habitat for waterbirds. The public areas of these ponds near Hilo are managed for recreational fishing. Technical

assistance to private land managers could allow enhancement of waterbird habitat, especially for Hawaiian coots. Vegetation and water control management may increase the habitat value of Loko Waka Pond.

Waiākea Pond - Waiākea Pond, is an estuarine pond that drains into the Wailoa River, which then flows eastward about 0.5 miles into Hilo Bay. Waiakea Pond is one of the largest freshwater habitats for endangered waterbirds and provides habitat for a large portion of the island's Hawaiian coot population. It also harbors a population of feral mallards, which should be removed.

APPENDIX B. Supporting Wetlands

Supporting Wetlands: Additional areas that provide habitat important for smaller waterbird populations or that provide habitat needed seasonally by segments of the waterbird populations during part of their life cycle. Protection and management of these or similar wetlands is required to recover Hawaii`s waterbirds, but there is room for some flexibility in which sites must be managed, and it is possible that other sites may fulfill the same needs as those listed here.

Kaua`i

Hanalei Taro Fields and River - Protection in needed for the additional taro acreage in Hanalei Valley that is not part of the Hanalei National Wildlife Refuge. These farms are utilized by all four endangered waterbirds. Waterbirds move between these farms and refuge taro fields, and between Hanalei Valley sites and other wetlands on Kaua`i and Ni`ihau. Hawaiian ducks, coots, and moorhens are also known to utilize areas of the Hanalei River. Thus, these areas provide a continum of habitat between core wetland areas. Expanded outreach to farmers and education is the most appropriate management tool for the Hanalei taro fields and predator control may also be possible.

Hanapēpē Salt Ponds - The Hanapēpē Salt ponds are located on the southern coast of Kaua`i. This area is made up of two ponding basins separated by a road. Hawaiian coots, ducks, and especially stilts are known to utilize these ponds. Hawaiian stilts find this site attractive during winter months when rainfall is abundant, and year-round use of these ponds could be encouraged with effective management. Hanapēpē is mid-way between two stilt nesting and feeding areas (Mānā and Līhu`e Settling Basins) and provides a continum of habitat between these areas.

Kawai`ele Waterbird Sanctuary - The State, through a sand mining lease, has created several ponds totaling 14 hectares (35 acres). These ponds have been sculpted to provide nesting islands, sloped banks, and water depths suitable for all four endangered waterbirds.

Mānā Wetlands - Approximately 81 hectares (200 acres) of ponds, ditches, reservoirs, and flooded pastures remain from what was once a 810-hectare (2,000-acre) wetland expanse. Presently there is considerable use of this area by all four waterbird taxa. Habitat restoration is underway through efforts by Ducks Unlimited and the Pacific Coast Joint Venture, but further habitat restoration and management

of the area is necessary to realize its full potential for waterbird recovery. Although a formal cooperative agreement between the State, Kekaha Sugar Company, and Hawaiian Homelands declares the Mānā Plain a wildlife sanctuary, a more formal designation of specific waterbird areas should be made. The decline of the sugar industry in Hawai`i puts future land use in this area in question.

`Ōpaeka`a Marsh - Adjacent to the Wailua River, `Ōpaeka`a Marsh is a 20-hectare (50-acre) wetland that supports Hawaiian ducks, moorhens, and coots. The State already owns portions of the land. Protection of additional private land, and restoration and enhancement of managed units, could create an important wetland refuge.

Smith's Tropical Paradise (Paradise Pacific) - The lowest flatland along the Wailua River, once a tidal marsh, was modified in the 1960s by construction as a tropical gardern. This area contains seven shallow ponds, four of which are utilized by endangered waterbirds, especially moorhens. A cooperative agreement with the landowner should be developed to insure that this habitat is protected for waterbirds, and ideally to develop a restoration and management plan that will improve habitat for waterbirds. This site is unique in that it could also be an important area for education about waterbird conservation for the public (*e.g.*, wildlife viewing). Feral mallards and hybrids have been observed at this site, and should be removed.

Wailua River Bottoms - The Wailua River is located in the District of Kawaihau and runs parallel to `Ōpaeka`a Stream, which joins the Wailua River at a point approximately one-half mile west of the river mouth. Flat pasture lands border the downstream portion of the Wailua River, although most of the sloping hillsides are heavily forested. Hawaiian ducks, moorhens, and coots are known to utilize the river bottoms for foraging.

Waimea River System - the Waimea River is located in the southwestern region of Kaua`i. It is the island's largest river system, surrounded by densely vegetated land, and on the lower reaches, by taro patches agricultural lands. The Hawaiian duck is thought to utilize upland portions of the river and lower reaches may be good foraging habitat for Hawaiian coots and moorhens, although surveys have not been conducted to quantify waterbird usage because access to agricultural lands are limited.

Waitā Reservoir - Waitā is the largest fresh water reservoir on Kaua`i. It is surrounded mostly by cane fields, although emergent grasses line the edge when water level is high. Large numbers of Hawaiian coots periodically utilize this reservoir for loafing and feeding. Hawaiian ducks, moorhens, and stilts have also been recorded at this site. A cooperative agreement with the landowner should focus on measures to insure that feeding and loafing habitat for coots are not disturbed unnecessarily.

Wainiha Valley Taro Fields and River - Wainiha Valley is located in northern Kaua`i and provides a wide variety of wetland habitat for waterbirds, which includes a large estuarine area, flowing freshwater stream, ephemeral flooded pastures and taro fields. The Hawaiian stilt and moorhen are found in the taro fields and the Hawaiian coot is found in the lower stream and estuarine area. The Hawaiian duck may also utilize the valley. A cooperative agreement with the landowner should be developed that insures maintenance of stream flow throughout its normal course in the valley, and possibly predator trapping.

O`ahu

Kahuku aquaculture farms - Kahuku area wetlands provide valuable foraging and marginal nesting habitats for all four endangered waterbird species. Prior to 1994, this area supported one of the largest aquaculture developments (Amorient Prawn Farms) in the State. Much of the area is currently undergoing redevelopment by Ming Dynasty Aquaculture. The natural wetlands in the area have become overgrown with invasive species such as *Batis maritima*. Long-term protection is needed for the aquacultural and wetland ponds in this area.

Ka`elepulu Pond - This privately-owned wetland is surrounded by housing development but was once more than 200 acres in size (Shallenburger 1977). It is now approximately 1.2 hectares (3 acres) and supports nesting Hawaiian coots, as well as smaller numbers of nesting Hawaiian common moorhens and Hawaiian stilts. Vegetation management and predator control are carried out on the wetland.

Kuilima (Turtle Bay) Sewage Treatment Plant - This site is located in northern O`ahu and is periodically used by large numbers of Hawaiian coots and stilts. Long-term protection should be encouraged through cooperative agreements between the landowner and natural resource agencies.

*Hale`iwa Lotus and Taro Fields* - The Hale`iwa lotus and taro fields are located primarily in the Hale`iwa lowlands between Anahulu and Kaukonahua streams. The taro and lotus files are fed by springs, wells, and perennial streams, depending on their location. This area provides important habitat for waterbirds, particularly the Hawaiian moorhen.

Hāmākua Marsh Waterbird Sanctuary - Hāmākua Marsh is a 9-hectare (23-acre) wetland associated with Kawainui Marsh on the windward cost of O`ahu. Located along Hāmākua Drive in Kailua, it is utilized by all four species of waterbirds and has been secured by Ducks Unlimited, who donated the land to the Hawai`i Department of Land and Natural Resources. The site has been greatly improved as habitat for waterbirds, but further improvement might be possible through additional enhancement.

He`eia Marsh - This 160-hectare (400-acre) area was formerly a complex of tidal marshes and open water areas. It has been substantially modified and presently consists of nonnative mangroves, remnants of ponds, and wet pasture grazed by cattle. This wetland area should be restored and managed to provide enhanced habitat for all four waterbirds. The State secured this property through a land exchange in 1992. The Hawai`i Department of Land and Natural Resources is currently planning for enhancement and management of the site's upland and wetland resources.

Lā`ie Wetlands - This 81-hectare (200-acre) wetland complex comprises three natural ponds and several aquaculture ponds. All are linked hydrologically and all four endangered waterbird species use the site. This area is owned by the Church of Jesus Christ of Latter-day Saints and long-term protection is planned for the site. If restored and managed, the Lā`ie Wetlands would be an important addition to the available wetland habitat in the Kahuku area.

*Niuli`i Ponds Wildlife Refuge* - Located at Naval Computer and Telecommunication Area Master Station Pacific (NCTAMSPAC) Radio Transmitter Facility (RTF) Lualualei on O`ahu's leeward coast, this 35.7-hectare (88.4-acre) refuge was established by the Navy in 1972. The refuge is managed through a cooperative agreement between the Navy and the U.S. Fish and Wildlife Service. The refuge includes three small man-made ponds built for disposal and treatment of wastewater runoff effluent. Improvements to the ponds (*e.g.*, installation of a solar-powered groundwater pump to provide additional freshwater in the primary pond; periodic control of California grass and other invasive nonnative plant species; and control of feral and nonnative animals) facilitated the creation of wetland habitat that supported the four endangered waterbirds in addition to other waterfowl and shorebirds. However, recent realignment of Naval facilities has eliminated the majority of source water for the ponds and substantially reduced their size from 3.9 hectares (9.6 acres) to approximately 0.4 hectares (1 acre). An Integrated Natural Resources Management Plan for the area notes that Navy Region Hawaii will maintain the wetland as long as endangered waterbirds continue to populate the ponds (Naval Region Hawaii 2001).

Punaho`olapa Marsh - This former pond and large marsh of over 40 hectares (100 acres) has been highly altered due to the development of a golf course resort. The golf course surrounds the site, and a second planned resort will impact its coastal buffer. All four endangered waterbird species use this area. It has been suggested that incorporating Punaho`olapa Marsh into the refuge system as part of the James Campbell National Wildlife Refuge would ensure protection and management of this site.

`Uko`a Marsh - This is a 122-hectare (300-acre) freshwater marsh near Hale`iwa on the northern shore of O`ahu. Much of this privately owned marsh has been

overgrown by nonnative plants, but it still provides valuable waterbird habitat. A cooperative agreement with the landowner should be developed to ensure that this habitat is protected and managed for waterbirds.

Waialua Lotus Fields - Relatively few taro and lotus fields remain in what was once a large wetland agriculture development on the northern shore of O`ahu. The lotus fields in Waialua support the State's highest concentration of Hawiian common moorhens, which use the area to nest and feed. Hawaiian stilts, numerous shorebirds, and night-herons also feed in the wetland. Long-term protection of Waialua Lotus Fields could be reached through cooperative agreements between landowners and natural resource agencies.

*Waihe`e Marsh* - This 10-hectare (25-acre) marsh is located along the windward coast of O`ahu near the town of Waiāhole and supports limited numbers of waterbirds. The site is adjacent to the main road and close to City and County of Honolulu parks that could be integrated with wetland habitat conservation for public environmental education opportunities. Protection and enhancement of Waihe`e Marsh could improve its value to endangered waterbirds.

Moloka`i/Lāna`i/ Maui (Maui Nui)

Kaunakakai Sewage Treatment Plant - This site lies just north of the town of Kaunakakai, Moloka`i. Hawaiian stilts and especially Hawaiian coots in large numbers have been observed to utilize this site. Artificial nesting platforms placed in the ponds have encouraged coot nesting at this site. Long-term protection should be encouraged through cooperative agreements between the County of Maui and natural resource agencies.

*Kualapu`u Reservoir* - Located in north-central Moloka`i, this reservoir periodically supports relatively large numbers of coots. Monitoring of bird populations and protection of Kualapu`u Reservoir should be sought.

`Ōhi`apilo Wetland - This 10-hectare (25-acre) wetland is managed by the County of Maui and is an important area for endangered waterbirds (primarily stilts and coots) and migratory waterfowl. The wetland is part of the `Ōhi`apilo Playa (approximately 25 hectares [60 acres]), a seasonal wetland on the southern coast of Moloka`i near Kaunakakai. The wetland has become overgrown with pickleweed and other introduced plant species. As mitigation for wetland fill, the county worked with Ducks Unlimited to develop a wetland enhancement and management plan. The habitat enhancement was completed in November 1999, and provided open flats for nesting Hawaiian stilts, an additional 4 hectares (10 acres) of seasonally-flooded mudflat, an additional 1 hectare (3 acres) of semi-permanent ponds and channels to extend the hydroperiod (i.e. the period of time when a wetland normally receives its water) of Hawaiian coot and stilt chick foraging

habitat, and predator fencing. The 10-hectare (25-acre) wetland is surrounded by a 90-meter (300-foot) fenced buffer zone. Ducks Unlimited biologists are monitoring and conducting predator and vegetation control in conjunction with the county.

Paialoa Fish Pond - This is a privately owned freshwater marsh, about 2 hectares (5 acres) in size, used by coots and stilts. A cooperative agreement should be sought with the landowner to prevent habitat alteration.

*Lāna`i Sewage Treatment Plant* - This sewage treatment plant is located southwest of Lāna`i City adjacent to Kaumalapau Highway. It provides habitat for the Hawaiian stilt. Up to 100 Hawaiian stilts have been observed using this site. Long-term protection should be encouraged through cooperative agreements between the County of Maui and natural resource agencies.

*Ke`anae Point* - Waiokamilo and Palauhulu streams drain the upper Ke`anae Valley into an open ephemeral marsh. Below the marshland are extensive taro fields that are utilized by waterbirds. Long-term protection and management through cooperative agreements between private landowners and natural resource agencies should be encouraged.

Waihe`e Coastal Dunes and Wetlands (Waihe`e Preserve) - The Waihe`e Preserve is part of 112 hectares (277 acres) of coastal dune and wetland complex on the northern shore of Maui that has been under imminent threat of development as a golf course. The Maui Coastal Land Trust has arranged to purchase the Waihe`e Preserve through funding from the County of Maui, U.S. Fish and Wildlife Service Coastal Wetlands, and Endangered Species grants from private donations. The Maui Coastal Land Trust will restore and premanently protect 101 hectares (250 acres) of this wetland complex, which encompasses 9.7 hectares (24 acres) of wetlands, 41.7 hectares (103 acres) of buffering sand dunes, and approximately 3.2 hectares (8 acres) of riparian habitat (Maui Coastal Land Trust 2003). Waihe`e Preserve provides habitat for the Hawaiian stilt and coot.

Hawai`i

Ke`anae Pond (Kea`au) - Ke`anae Pond, located in eastern Hawai`i, is a spring-fed pond with connection to the ocean that has been altered through construction of a shoreline rock and wall and gate system. Hawaiian coots have been observed utilizing the marsh edge and some areas of the pond are suitable for loafing and feeding. Long-term protection and management should be encouraged through cooperative agreements between the landowner and natural resource agencies should be encouraged. Vegetation management and predator control are needed to enhance habitat for waterbirds.

Kona Sewage Treatment Plant - The County of Hawai`i has designed man-made wetlands for Hawaiian stilts at the Kona (Kealakehe) Wastewater Treatment Plant. Ponds will be constructed with predator fencing and nesting islands for stilts, and designed to allow public access, with a parking area and interpretive trails and signs. Support by resource agencies to the county should continue and future projects should be encouraged that incorporate wildlife habitat enhancement and the needs of the county.

Montane (Mauna Kea and Kohala) and Parker Ranch Stock Ponds - Several ponds located on the slopes of Mauna Kea and in the Kohala Mountains are owned by State, Federal, and private landowners, including Parker Ranch. These ponds support most of the reproducing population of the Hawaiian duck on the Big Island. Protection and enhancement of these ponds should be accomplished through cooperative efforts between agencies and private ranchers leasing the lands. Ducks Unlimited has been actively working with the Natural Resources Conservation Service to pursue these opportunities.

`Ōpae`ula Pond - This 3-hectare (7.5-acre) privately-owned coastal pond is located in the North Kona District. Habitat for waterbirds on this site may be improved with vegetation management.

Waipio Valley - Waipio Valley is located in Hawai`i's Hāmākua District, along the northeastern coastline of the Kohala Mountains. Several tributaries flow into Waipio Stream, but some are diverted by smaller ditches that feed taro fields. The central valley is dominated by taro fields, while the lower valley is marshland. The taro fields and the large pond at the north edge of the lower valley provide waterbird habitat. The Hawaiian duck and coot utilize this site. Long-term protection and management should be encouraged through cooperative agreements between the landowner and natural resource agencies. Extensive management of wetlands in the lower valley is needed, particularly extensive clearing of invasive wetland vegetation, creation of water impoundment areas, and effective water level manipulation.

APPENDIX C. Comprehensive List of Wetlands.

Ni`ihau wetlands	Protected	Core wetland	Supporting wetland
`Âpana Reservoir			
Hā`ao Dam			
Halāli`i Ditches			
Halāli`i Lake			
Halulu Lake			
Kahino Pond			
Kamalino Pond			
Kaununui Ponds			
Keanauhi Dam			
Ki`eki`e Ponds			
Lē`ahi Pond			
Makahau`ena Pond			
Nonopapa Ponds			
Palikoae Ponds			
Pohueloa Valley Pond			
Pu`u `Alalā Pond			
Pu`u Wai Pond			
Playa Lakes		X	X

Kaua`i wetlands	Protected	Core wetland	Supporting wetland
`A`aka Reservoir			
Aepo Reservoir			
Aepoalua Reservoir			
Aepoeha Reservoir			
Aepoekolu Reservoir			
Ahukini Reservoir			
Aii Reservoir			
Alexander Reservoir			
De Mello Reservoir			
Fern Grotto Reservoir			
Grove Farm Settling Basin (new)			
Grove Farm Settling Basin (old)			
Halenānahu Reservoir			
Hanalei National Wildlife Refuge	X	X	
Hanalei Taro Fields (includes Post Office Taro Fields, Hanalei Trader Taro Fields)			X
Hanalei River			X
Hanamā`ulu Air Strip Reservoir			
Hanapēpē Salt Ponds			X
Hanapēpē Taro Fields			
Hanini Reservoir			
Huinawai Reservoir			
Hukiwai Reservoir			
Hule`ia National Wildlife Refuge	X	X	
Hule`ia Stream Valley			
Ioleau Reservoir			
Ipuolono Reservoir			
Kaloko Reservoir			
Kaheluniui Reservoir			
Kailiiliahinale (Okinawa) Reservoir			
Kalihiwai Reservoir			
Kalihiwai River Estuary			
Kanaele Swamp			
Kanehu Reservoirs			
Kaneha Reservoir			
Kapa Reservoir			
Kapa`a Stream Estuary			
Kapaia Reservoir			
Kaumakani Gulch Ponds			
Kaupale Reservoir			
Kawai`ele Waterbird Sanctuary	X	X	
Kawai`ele Sand Mind			
Kaua`i Lagoons Westin			
Kawailoa Flats			
Kekaha Pasture (dried up)			

Kaua`i wetlands (continued)	Protected	Core wetland	Supporting wetland
Kekaha Settling Basins (dried up)			
Kekaha Landfill (Leachate) Pond			
Kekaha Slaughterhouse Reservoir			
Kekaha Sugar Company Settling Basin			
Kîlauea Stream Estuary			
Kîpû Reservoirs 1-4			
Kîpû Road Reservoir			
Kolo Reservoir			
Kôloa (Kukui`ula) Sewage Pond			
Koloakapohu Reservoir			
Kuhumu Reservoir			
Kumano Reservoir			
Lāwa`i Kai Estuary			
Lîhu`e Settling Basin			
Lono Reservoir			
Luawai Reservor			
Lumahai Wetlands	X	X	
Māhā`ulepû Ponds			
Mānā Base Pond	X		X
Mānā Ditches and Drains			
Mānā House Reservoir			
Mānā Ridge Reservoir			
Mānā Wetlands			X
Manuhonuhonu Reservoir			
Mauka Reservoir			
Menehune Fish Pond			
Morita Reservoir			
Niu Valley Reservoir			
Niumalu Reservoir			
Nonopahu Reservoir			
Olokele Settling Basin			
`Oma'o Reservoir			
`Opaeka`a Marsh			X
Pāpua`a Reservoir			
Smith's Tropical Paradise (Paradise Pacific)			X
Pia Mill Reservoir			
Pila`a wetlands			
Poa Marsh			
Po`ipû Ponds / Area			
Po`opueo Reservoir			
Princeville Golf Course Ponds			
Pukaki Reservoir			
Pu`u Ainako			
Pu`u Ka Ele Reservoir			

Kaua`i wetlands (continued)	Protected	Core wetland	Supporting wetland
Pu`u O Hewa Reservoir			
Pu`u O Papai Reservoir			
Pu`u Opae Reservoir			
Pu`uhi Crater Reservoir			
Pu`ulani Reservoir			
Reservoir 429			
Rodriques Reservoir 296 (defunct)			
Saki Mana Reservoir			
Sloggett (Wailua) Reservoir			
Twin Reservoirs			
`Umi Reservoir			
U.S. Navy Sewage Treatment Pond			
Waiakalua Reservoir			
Waiawa Reservoir			
Waikai Reservoir			
Waikoloi Reservoir			
Wailau Siphon Reservoir			
Waimea River System			X
Wailua River Bottoms			X
Wailua Jail Swamp			
Wailua Golf Course Pond			
Waimea Heights Reservoir			
Waimea Taro Fields			
Wainiha Taro Fields and River			X
Hā`ena Marsh			
Waioli Taro Fields/ Stream			
Waiopili Spring Reservoir			
Waipā Taro Fields			
Waitā Reservoir			X
Wakai Reservoir			
Wilcox Ponds			

O`ahu wetlands	Protected	Core wetland	Supporting wetland
Air Strip Ponds, Kahuku			
Amorient Aquafarm (Romey's and Ming Dynasty)			
Apoka`a Ponds 1and 2			
Barber's Point Golf Course Ponds			
Bellows Air Force Base Canal			
Chevron - Rowland Pond			
Chevron Impounding Basin			
Coconut Grove Marsh			
Crowbar Ranch Pond			
Diamond Head Marsh			
Dillingham Ranch Ponds			
Fort Kamehameha Reef Flats			
Hale`iwa Lotus/Taro Fields			X
Halekou Wetland			
Hāmākua Marsh State Wildlife Sanctuary	X		X
Hawai`i Prince Golf Course Ponds			
He`eia Marsh	X		X
Helemano Reservoirs			
Honolulu Airport Reef Runway Wetlands			
Honouliuli Golf Course Ponds			
Ho`omaluhia Park Ponds (Botanical Park)			
James Campbell NWR (Kii and Punamano Units)	X	X	
Ka`alaea Aquafarm Ponds			
Ka`awa wetlands			
Ka`elepulu Mitigation Wetland			
Kahana Marsh (Huilua Pond)			
Kahuku Aquaculture Farms			X
Kalou Marsh (University of Hawai`i Waiale`e Station Pond)			
Kaneshiro's Lotus Fields			
Kapolei Golf Course Ponds (Ewa Ponds)			
Kawainui Levee			
Kawainui Marsh	X	X	

O`ahu wetlands (continued)	Protected	Core wetland	Supporting wetland
Ke`ehi Lagoon (Mudflats)			
Ko Olina Golf Course Ponds			
Kualoa Aquafarm (University of Hawai`i Mariculture Research Center)			
Kualoa State Park Pond (Apua Pond)	X		
Kuapa Pond, Hawaii Kai			
Kuilima (Turtle Bay) Sewage Treatment Pond			X
Kuilima Mitigation Pond (Turtle Bay Mitigation Pond)			
Lā`ie Wetlands			X
Laulaunui Island Fish Pond (Naval Reservation)	X		
Loko Ea Pond			
Lualualei Rubber-lined Pond	X		
Makaha Golf Course Ponds			
Makaha Sewage Pond			
Marine Corps Base Kaneohe Klipper Golf Course Ponds	X		
Marine Corps Base Sewage Treatment Plant			
Mokuleia Quarry Pond			
Moli`i Fish Pond			
Nakatani watercress			
Niuli`i Ponds, Lualualei	X		
Nu`uanu Reservoirs 1-4			
Nu`upia Ponds Marine Corps Base Hawaii	X	X	
Olomana Golf Course Ponds			
Oneawa Canal			
`Opae`ula Reservoirs 1-5			
Paiko Lagoon Wildlife Sanctuary	X		X
PC Watercress			
Pearl Harbor NWR (Waiawa and Honouliulu Units)	X	X	
Pouhala Marsh	X	X	
Punaho`olapa Marsh			X
Punalu`u Prawn Farm			
Ranch Camp Ponds			

O`ahu wetlands (continued)	Protected	Core wetland	Supporting wetland
Sag Harbor Wetlands Marine Corps Base Hawaii	X		
Salt Lake (Honolulu) Country Club			
Salvage Yard Wetlands Marine Corps Base Hawaii	X		
Steamer's Lotus			
Sumida Watercress			
Tantog's Lotus			
Turtle Bay Golf Course Ponds			
`Uko`a Marsh			
Unisyn Pond			
University of Hawaii Experiment Station Ponds			
Wahiawa Reservoir			
Waialua Lotus Fields			X
Waialua Settling ponds			
Waihe`e Marsh			X
Waikane Aquaculture Ponds			
Waikele Harbor Mudflat			
Waimaea Falls Aboretum			
Waimānalo Reservoirs			
Waipi`o Pensinsula, Pear Harbor Shoreline			
Waipi`o Settling Basins			
Waipi`o Soccer Field Wetlands			
Walker's Bay Wetlands, Waipio Peninsula			

Molokai wetlands	Protected	Core wetland	Supporting wetland
Hālawa River Estuary			
Hawai`i Research Flats			
Kakahai`a National Wildlife Refuge	X	X	
Kalua Koi Golf Course Ponds			
Kalua`apuhi Fish Pond			
Kamahuehue Fish Pond			
Kamalo Flats			
Kaunakakai Sewage Treatment Pond			X
Kaunakakai Stream			
Kualapu`u Reservoir			X
Kupeke Fish Pond			
Maunaloa Sewage Treatment Pond			
Molokai Playas			
Mo`omi			
O` ô`ia Fish Pond			
`Ohi`apilo Wetland	X		X
Oliwai Sewage Treatment Pond			
One Ali`i Fish Pond			
Paialoa Fish Pond			X
Pālā`au Flats			

Lāna`i wetlands	Protected	Core wetland	Supporting wetland
Lāna`i City Oxidation Ponds			X
Hulopo`e Mud Flats			
Mānele Oxidation Ponds			
Mānele Road Reservoir			
Manele Mud Flats			
Kô`ele Golf Course Ponds			

Maui wetlands	Protected	Core wetland	Supporting wetland
Ahihikinau NAR	X		
Airport Drainage Ditch			
Azeka Pond 1			
Azeka Pond 2			
Cement House			
Crater Reservoir			
Crater Village			
Cut Mountain Settling Pond			
Hāli`imaile Treatment Pond			
Hale Nanea Drainage Pond			
Halua			
Kā`anapali Golf Course Ponds			
Kahului Drainage Ditch			
Kahului Fairgrounds Drainage			
Kahului Oxidation Pond			
Kahului Sewage Treatment Pond			
Kahului Settling Pond			
Kanaha Pond Wildlife Sanctuary	X	X	
Kaneaka Pond			
Kapalua Bay Golf Course			
Kapalua Reservoir			
Kapalua Village Golf Course			
Kauhi			
Kauhioaiakiui			
Kealia Pond National Wildlife Refuge	X	X	
Keanae Point			X
Kmart Ditch			
Lahaina Aquatic Center			
Lahainaluna			
Lahaina Settling Ponds			
Laniapoku			
Little Pond			
Longs Ponds			
Mâkena Golf Course			
Maluaka Pond			
Mauna Lani Golf Course			
Mill Pond			
Nu`u Pond			X
Olowalu Reservoir 1			
Olowalu Reservoir 2			
Ôma`opio Reservoir			
Paia Settling Pond			
Paniaka Pond			
Pioneer Crater Reservoir			
Pu`u Ali`i Pond			
Pu`u Kolii Reservoir 1			

Maui wetlands (continued)	Protected	Core wetland	Supporting wetland
Pu`u Kolii Reservoir 2			
Pu`u Kolii Reservoir 3			
Pu`u Nçnç Settling Basin (70,71)			
Reservoir 20			
Reservoir 21			
Reservoir 22			
Reservoir 23			
Reservoir 26			
Reservoir 29			
Reservoir 32			
Reservoir 33			
Reservoir 35			
Reservoir 40			
Reservoir 42			
Reservoir 50			
Reservoir 51			
Reservoir 52			
Reservoir 60			
Reservoir 61			
Reservoir 70			
Reservoir 72			
Reservoir 80			
Reservoir 81			
Reservoir 82			
Reservoir 84			
Reservoir 92			
Ukumehame Reservoirs 1-2			
Ukumehame Settling Pond			
Ukumehame Target Range			
VIP Drainage Ditch			
Wai`ale Reservoir			
Waihe`e Wetlands (Waihe`e Preserve)	X		
Waine`e Settling Ponds			

Hawai`i wetlands	Protected	Core wetland	Supporting wetland
Ahn's Pond			
`Aimakapā Pond, Kaloko-Honokôhau National Historic Park	X	X	
`Anaeho`omalu Pond			
Baker Paddock Ponds			
Cyanotech			
Honoapu			
Honokôhau Reef			
Ka`alu`alu			
Kaloko Pond, Kaloko-Honokôhau National Historic Park			
Kapulehu Ponds			
Kealakehe (Kona) Sewage Treatment Pond			X
Kealakekua Bay Pond			
Ke`anae or Kea`au Pond			X
Keanakolu Road Stock Ponds			
Kehena Pond 1			
Kehena Pond 2			
Kehena Pond 3			
Kehena Pond 4			
Kehena Pond 5			
Kehena Reservoir			
Kohala Stock Ponds			X
Kokoiki Reservoir			
Lahuipuaa Ponds			
Lālākea Reservoir			
Lālākea Stream			
Loko Waka Pond		X	
Mauna Kea Stock Ponds			X
Nakagawa			
Old Kahua Pond			
`Opae`ula Pond			X
Pāi`iakuli Reservoir			
Pololû River Valley			
Puakea Reservoir			
Punalu`u Pond			
Pu`u Iki Pond			
Pu`u Kapu Reservoir			
Pu`u Lio`lio Pond			
Pu`u Mauna Pond			
Pu`u Oo Ranch Stock Ponds			
Pu`u Pûlehu Reservoir			
Raley's Pond			

Hawai`i wetlands	Protected	Core wetland	Supporting wetland
Slatter Pond			
Tribble Pond			
Waiākea Pond		X	
Waikoloa Golf Course Pond			
Wailoa			
Waimanu Valley			
Waipi`o Valley			X
Waipuhi Pond 1			
Waipuhi Pond 2			

APPENDIX D. Endangered and Threatened Species Recovery Priority Number Guidelines*

Degree of Threat	Recovery Potential	Taxonomy	Priority
High	High	Monotypic genus	1
	High	Species	2
	High	Subspecies	3
	Low	Monotypic genus	4
	Low	Species	5
	Low	Subspecies	6
Moderate	High	Monotypic genus	7
	High	Species	8
	High	Subspecies	9
	Low	Monotypic genus	10
	Low	Species	11
	Low	Subspecies	12
Low	High	Monotypic genus	13
	High	Species	14
	High	Subspecies	15
	Low	Monotypic genus	16
	Low	Species	17
	Low	Subspecies	18

* adapted from Listing and Recovery Priority Guidelines (1983), Federal Register 48:43098-43105

APPENDIX E. Hawai`i Waterbird Count Instructions

Hawaiian Stilt:

- Record the numbers of adults and juveniles separately if possible. Juveniles can be distinguished by the white that extends farther onto the forehead and sides of the neck, the duller pink leg color, and their higher-pitched calls. Juveniles cannot be distinguished by back color; male stilts have black backs, females and juveniles have brownish-black backs.
- Do not separate male and female stilts; count both as adults.
- Check stilts for bands and record any band combinations. For example, red over aluminum on left leg, green over yellow on right leg, or RA/GY. Right and left are always from the bird's perspective.

Hawaiian Coot:

- Record the numbers of adults and juveniles separately. Juveniles are light gray and lack the white frontal shield of adults.
- Do not separate coots by frontal shield coloration. Hawaiian coots can have red or white frontal shields.

Hawaiian Moorhen:

- Record the numbers of adults and juveniles separately.
- Moorhens can be secretive and may not be visible right away. The chances of observing moorhens and obtaining a more accurate count will be improved if more time (at least 15 minutes) is spent watching quietly at each site.

Koloa or Hawaiian Duck:

Koloa are very similar to female mallards, but many birds can be distinguished by careful observation of the characters described in the table below. Koloa-Mallard hybrids are intermediate but variable, and individuals may exhibit characteristics of both species. Outside Kauai and parts of the Big Island, many ducks that superficially appear to be Koloa may actually be hybrids. Male Mallards in breeding plumage have a completely green head, white collar, chestnut breast, and gray back. Male mallards in non-breeding plumage and young males are duller in color and more similar to female mallards and to koloa, but show hints of the adult male breeding plumage- head suffused with green especially on the crown, breast feathers chestnut with dark tips, grayish back and sides, and a distinctive olive-green bill. Hybrid males often show some of the characteristics of male mallards, especially a grayish back, whitish tail, and blue speculum.

Character	Koloa	Female Mallard
Size	Small; 70-80% length of Mallards. Males 600 g, females 460 g	Large; males 1240 g, females 1080 g.
Bill size	Smaller, narrower	Larger, wider
Bill color	Mostly dark, often greenish, tip of bill may be orange in female	Mostly orange, with some dark splotches in center
Tail and undertail covert color	Mottled brownish	whitish
Speculum Color	Emerald green (may appear bluish in some light)	Blue

Migratory Shorebirds. Record the number of each species of migratory shorebird. If you are unable to identify a shorebird to species, take notes on its appearance and behavior that can be used later to help identify it, including relative size (e.g. smaller than a Kolea, but larger than a Sanderling), bill length (e.g. bill 1.5 times length of head), leg length (e.g. legs longer than bill), coloration of different body parts (legs, head, back, eye-stripe, breast, whether breast is streaked), behavior (e.g. walking on exposed mud, wading in shallow water, probing with bill, describe any vocalizations). The most frequently observed species are briefly described below, for other species consult field guides.

- Pacific Golden Plover or Kolea. You should at least know this one!
- Black-bellied Plover. Similar to Kolea but slightly larger and heavier, with larger bill, and more gray plumage. In flight has black axillaries (wing-pits).
- Semipalmated Plover. A small plover with orange legs and a single dark breast band.
- Ruddy Turnstone or `Akekeke. Smaller than Kolea. Back mottled brown, black marks on breast. Bill short and straight. Legs orange. Distinctive black and white back pattern in flight.
- Sanderling or Hunakai. Small. Bright white below, pale gray above, black legs, short straight bill.
- Wandering Tattler or `Ulili. Plain gray above, white below (may have dark barring in summer), narrow white stripe above eye. Legs medium long and yellow. Bill medium long and straight.
- Long-billed Dowitcher. A little larger than a Kolea, stocky, mostly gray, bill straight and very long. Often forages in slightly deeper water with repeated “sewing machine” probes of the bill.
- Lesser Yellowlegs. More slender than Kolea, speckled gray-brown plumage. Legs long and yellow. Bill medium-long, thin, and straight. Often very active when foraging.

- Pectoral Sandpiper. A little smaller than a turnstone, yellowish legs, bill medium length, sharp border between dense brown streaking on upper breast and white lower breast.
- Sharp-tailed Sandpiper. Like Pectoral Sandpiper, but breast streaking less distinct, lower border more gradual, white stripe above eye (supercilium) more obvious, becomes wider behind eye.
- Bristle-thighed Curlew or Kioea. Large, brown, with long curved bill. Loud "kee-oo-eet" call often given in flight.

Migratory Waterfowl. Record the number of each species of migratory waterfowl. Migratory waterfowl are not usually present during the summer count. If you are unable to identify a duck, goose, or some other species of waterfowl, take notes on its appearance and behavior that can be used later to help identify it, including bill shape, coloration of different body parts (head, breast, sides, speculum), behavior (dabbling on surface, diving under water). The most frequently observed species are briefly described below, for other species consult field guides.

- Canada Goose. Black neck with white cheek patch. Recently split into 2 species, best distinguished by size and bill length. Presence of white neck ring may help identify some forms. Take photographs if possible.
    - Canada Goose. Larger, longer-billed, generally paler, typical "honking" call.
    - Cackling Goose. Smaller, shorter-billed, darker on the breast and back, higher-pitched "cacking" call.
- White-fronted Goose. Grayish-brown with black marks on breast, white on face at base of pink bill, orange legs.
- Northern Pintail. Long and slim with pointed tail. Breeding males have brown head, white breast and neck stripe, nonbreeding males and females are speckled brown all over. Neck and tail longer than other ducks.
- Northern Shoveler. Long, flat, orangish bill is distinctive. Breeding males have green head, white breast, chestnut sides, nonbreeding males and females are brownish.
- American Wigeon. Males have green head with whitish forehead. Females brown. White patch on upper wing distinctive in flight.
- Teals. 3 species, all are small.
    - Green-winged Teal. Green speculum, bill small. Breeding males have green and chestnut head, vertical white stripe on side. In female dark line through eye more distinct than Blue-winged and Cinnamon.
    - Cinnamon and Blue-winged Teal. Large blue patch on upper wing. Breeding male Cinnamon Teal mostly cinnamon, breeding male Blue-winged Teal has dark head with white crescent in front of eye. Females and nonbreeding males hard to separate, consult

field guides.

- Lesser Scaup. Dives under water. Males have dark head, breast, and tail, gray back and sides. Females brownish with white patch at base of bill.
- Ring-necked Duck. Dives under water. Male has dark head, back, breast and tail, gray sides. Bill dark with white band near tip. Female dark with white eye ring and white at base of bill.

Feral Waterfowl. Several species of ducks and geese have been introduced to Hawaii and have become feral. Please note the presence and numbers of feral waterfowl. The most widespread species are briefly described below. Consult field guides for other species.

- Mallard. Males have green head, chestnut breast, and white neck ring; females brownish and streaked. Some wild Mallards may migrate to Hawaii; feral birds are usually less wary than wild birds, and feral Mallards are often larger.
- Muscovy. Large, black and/or white ducks with knobby red bill.
- Domestic ducks. Color variable; some are white with a yellow bill ("Peking" duck), some look like oversize mallards.
- Domestic geese. Large, long neck, color variable; some are gray with an orange bill, some are all white with an orange bill.

Other Information to Record:

1. Time each area was surveyed, wetland condition, and weather, using codes provided on field forms.
2. Any unusual habitat observations or anything inconsistent with previous waterbird surveys.
3. Note location and approximate size of any Cattle Egret roosts.

Other Issues:

- Wetland names. One of the biggest challenges in compiling and analyzing the waterbird count data has been inconsistent use of names. We need to produce a master list of wetland names, including all synonyms that have been used for each site, and choose one name to use for each wetland from now on.

- If at all possible, try to visit all wetlands on the scheduled itinerary. If you know in advance that a particular wetland no longer exists and there is no point in visiting it, make a note of it when submitting forms so that information can be recorded into a wetland database.

- Fill out a data sheet for each wetland you visit, even if no birds are present or the wetland appears dry. If no sheet is filled out and submitted, it may be assumed that the site was not visited that year.

- For wetlands with subsites (e.g., Kealia Pond, Kanaha Pond, Kaneohe Marine Base), record data separately for each individual subsite. Data from different subsites can be combined later if necessary, but if data is lumped when collected, we cannot separate it later.

- Copies of the data sheets should be kept by the compiler on each island, even after they have been submitted to the Oahu office. In some cases the data appears to have been lost in the DOFAW office on Oahu (or perhaps never received?), and the original data sheets could not be located. It is very unfortunate to lose this irreplaceable data after people have made the effort to collect it.

Revised January 2005. If you have comments or suggestions for improving the field form, the instructions, or the count in general, please contact Eric VanderWerf of the U.S. Fish and Wildlife Service (eric_vanderwerf@fws.gov; 792-9461), David Smith of the Hawaii Division of Forestry and Wildlife (viking@hgea.org, 973-9786), or Megan Laut of the Hawaii Natural Heritage Program (mlaut@hawaii.edu).

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