Revised Recovery Plan for Hawaiian Forest Birds

Cover photographs (clockwise from upper right): 1. Maui parrotbill, 2. Palila, 3. Captive puaiohi with fledglings, 4. O`ahu `elepaio at nest, 5. `Akiapōlā`au, 6. Po`ouli. 1, 4, 5 ©Eric A. VanderWerf, U.S. Fish and Wildlife Service; 2, 3 ©Jack Jeffrey, U.S. Fish and Wildlife Service; 6 by Paul Baker, Maui Forest Bird Recovery Project. All photographs used with permission.

Revised Recovery Plan

for

Hawaiian Forest Birds

Original plans completed:

February 1983 (Hawai`i Forest Birds)
July 1983 (Kaua`i Forest Birds)
May 1984 (Maui-Moloka`i Forest Birds)
June 1986 (Palila)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: [signature]
Regional Director, U.S. Fish and Wildlife Service

Date: September 22nd, 2006

Dedication

To the naturalists and scientists

who have contributed to our understanding

of the biology and ecology of Hawaiian forest birds.

GUIDE TO RECOVERY PLAN ORGANIZATION

This recovery plan provides individual species accounts and actions needed Statewide for the recovery of 21 taxa of forest birds in Hawai`i. The plan covers a group of species for which the threats and limiting factors are similar, and for which similar actions are needed for recovery. Many of the recovery actions apply across the identified recovery areas for each species. In other cases the plan identifies specific land parcels where a particular recovery action is needed. Section I, the Introduction, provides an overview of the causes for decline of the Hawaiian forest birds and the current threats, ongoing conservation efforts, and general recovery strategies for the species covered by this plan. The Species Accounts in Section II summarize the available information on the taxonomy, life history, habitat requirements, current and historical ranges, population status, reasons for decline and current threats, and species-specific conservation efforts and recovery strategies. Section III, Recovery, presents recovery objectives and criteria for each species, maps of the recovery areas identified on each of the main Hawaiian Islands where they occur, criteria used to delineate the recovery area boundaries, and a description of the steps to be taken in the event that an individual of one of the extremely rare species is located. Section IV, the Recovery Actions Narrative, lists and briefly describes the actions that must be undertaken to recover one or more species, some of which are presented in tabular form. Section V, the Implementation Schedule, lists all recovery actions in abbreviated form, their priority number and priority tier, the action duration, responsible parties, and cost estimate for completion of each action. Appendix A is a list of all recovery actions needed for each land parcel and is intended to assist landowners and managers in identifying recovery actions on their lands. Appendix B describes the captive propagation program management and release strategies. Spelling of Hawaiian bird, plant, and place names follows The Hawaiian Dictionary by Pukui and Elbert (1986) and Place Names of Hawai`i by Pukui *et al.* (1976).

U.S. FISH AND WILDLIFE SERVICE'S MISSION IN RECOVERY PLANNING

Section 4(f) of the Endangered Species Act of 1973, as amended, directs the Secretary of the Interior and the Secretary of Commerce to develop and implement recovery plans for species of animals and plants listed as endangered or threatened, unless such plans will not promote the conservation of the species. The U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) Fisheries have been delegated the responsibility of administering the Endangered Species Act. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of species with the minimum necessary investment of resources. A recovery plan delineates, justifies, and schedules the research and management actions considered necessary to support recovery of a species. Recovery plans do not, of themselves, commit personnel or funds, but are used in setting regional and national funding priorities and providing direction to local, regional, and State planning efforts. Means within the Endangered Species Act to achieve recovery goals include the responsibility of all Federal agencies to seek to conserve endangered and threatened species, and the Secretary's ability to designate critical habitat, to enter into cooperative agreements with the states, to provide financial assistance to the respective State agencies, to acquire land, and to develop habitat conservation plans and safe harbor agreements with applicants.

DISCLAIMER

Recovery plans delineate reasonable actions that are determined to be necessary for the recovery and/or protection of listed species. Plans are published by the U.S. Fish and Wildlife Service, and are often prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for action implementation and/or time for achievement of recovery are only estimates and are subject to change. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service *only* after they have been signed by the Regional Director or Director as *approved*. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and completion of recovery actions.

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http://www.fws.gov/endangered/recovery/index.html

http://www.fws.gov/pacific/ecoservices/endangered/recovery/plans.html

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EXECUTIVE SUMMARY

Introduction: This recovery plan covers 21 taxa of forest birds that occur in the main Hawaiian Islands: 19 are listed as endangered, 1 is a candidate for listing, and 1 is a species of concern. Ten of the listed taxa have not been observed reliably in more than 10 years and may possibly be extinct, but additional survey effort is needed to confirm their status, including the Maui nukupu`u (*Hemignathus lucidus affinis*); Kaua`i nukupu`u (*Hemignathus lucidus hanapepe*); Kaua`i `akialoa (*Hemignathus procerus*); `ō`ō `ā`ā or Kaua`i `ō`ō (*Moho braccatus*); oloma`o or Moloka`i thrush (*Myadestes lanaiensis rutha*); kāma`o or large Kaua`i thrush (*Myadestes myadestinus*); kākāwahie or Moloka`i creeper (*Paroreomyza flammea*); O`ahu `alauahio or O`ahu creeper (*Paroreomyza maculata*); Maui `ākepa (*Loxops coccineus ochraceus*); and `ō`ū (*Psittirostra psittacea*). One species, the po`ouli (*Melamprosops phaeosoma*), is critically endangered, and may have become extinct since the draft of this plan was written, at which time three known individuals remained (U.S. Fish and Wildlife Service 2003a). One po`ouli was taken into captivity but died of old age in November 2004, before a mate could be obtained. The last two known individuals have not been seen since. Two other listed species, the puaiohi or small Kaua`i thrush (*Myadestes palmeri*) and the Maui parrotbill (*Pseudonestor xanthophrys*), number approximately 300 and 500 individuals, respectively. Other listed species, including the `akiapōlā`au (*Hemignathus munroi*), palila (*Loxioides bailleui*), `ākohekohe or crested honeycreeper (*Palmeria dolei*), O`ahu `elepaio (*Chasiempis sandwichensis ibidis*), Hawai`i `ākepa (*Loxops coccineus coccineus*), and Hawai`i creeper (*Oreomystis mana*), have populations estimated between approximately 1,000 (`akiapōlā`au) and 8,000 to 12,000 individuals (Hawai`i `ākepa and Hawai`i creeper). The species of concern included in this plan, the Bishop's `ō`ō (*Moho bishopi*), has not been observed reliably since 1904 and is probably extinct. The candidate species, the `akikiki or Kaua`i creeper (*Oreomystis bairdi*), has an estimated population of 1,500 individuals and is declining rapidly.

Most of the species covered in this plan are now found only in upper elevation rain forests above 1,200 meters (4,000 feet) on the islands of Hawai`i, Maui, and Kaua`i. Two exceptions are the palila, which is limited to dry upland forests on Mauna Kea volcano on Hawai`i, and the O`ahu `elepaio, which occurs in native and nonnative forests on O`ahu at elevations as low as 100 meters (330 feet). Subfossil records and observations by early naturalists in the Hawaiian Islands indicate that most of the species once had much larger distributions and occurred at lower elevations.

Previous Recovery Plans: Previous recovery efforts for Hawaiian forest birds have been guided by earlier recovery plans, including plans for Hawai`i forest birds (U.S. Fish and Wildlife Service 1983a), Kaua`i forest birds (U.S. Fish and Wildlife Service 1983b), Maui-Moloka`i forest birds (U.S. Fish and Wildlife Service 1984a), and a separate plan for the palila (U.S. Fish and Wildlife Service 1986). This is the first recovery plan that covers the O`ahu `elepaio, which was listed in 2000, and the O`ahu `alauahio or O`ahu creeper, listed in 1970 (U.S. Fish and Wildlife Service 1970, 2000). The `io or Hawaiian hawk (*Buteo solitarius*) and the `alalā or Hawaiian crow (*Corvus hawaiiensis*) have their own recovery plans (U.S. Fish and Wildlife Service 1984b, 2003b). Many of the recovery recommendations in this plan, including forest protection, forest restoration, predator control, fencing and removal of feral ungulates, and the control of avian disease, will also benefit the `alalā and `io, which utilize many of the same habitat areas on the island of Hawai`i as some of the forest birds on Hawai`i described in this plan.

Five Categories of Threats to Species Recovery: As directed by section 4(a) of the Endangered Species Act, we consider five factors or categories of threats to list, delist, or reclassify a taxon. These five factors are: A) The present or threatened destruction, modification, or curtailment of habitat or range; B) Overutilization for commercial, recreational, scientific, or educational purposes; C) Disease or predation; D) Inadequacies of existing regulatory mechanisms; and E) Other natural or manmade factors affecting the continued existence of a species. The recovery actions recommended in this recovery plan address these threats in order to achieve recovery objectives.

The primary threats to Hawaiian forest birds are: habitat loss and degradation due to agriculture, urbanization, cattle grazing, browsing by feral ungulate species, timber harvesting, and invasion of nonnative plant species into native-dominated plant communities; predation by alien mammals; and diseases carried by alien mosquitoes. The periodic die-back of native plant species due to natural or alien-species-induced processes is a threat in some areas. The majority of recovery actions therefore address threats to habitat (factor A) and disease and predation (factor C). The direct overutilization of Hawaiian forest birds for commercial, recreational, scientific, or educational purposes (factor B) and the inadequacies of existing regulatory mechanisms (factor D) are not considered significant current threats. Several Hawaiian forest birds now occur in such low numbers and in such restricted ranges that they are threatened by natural processes, such as inbreeding depression and demographic stochasticity, and by natural and manmade factors such as hurricanes, wildfires, and periodic vegetation die-back (factor E). Impacts of alien birds are not well understood (factor E), but include aggressive behavior towards native bird species, possible competition for food, nest sites, and roosting sites, and possibly supporting elevated predator population levels.

Recovery Objectives: The primary recovery objectives for each species (taxon) are to:

1. Restore populations to levels that allow the taxon to persist despite demographic and environmental stochasticity and that are large enough to allow natural demographic and evolutionary processes to occur;
2. Protect enough habitat to support these population levels; and
3. Identify and remove the threats responsible for its decline.

Recovery Criteria: Recovery criteria were developed for each taxon to guide recovery efforts and ensure that all their recovery needs are addressed. The criteria are similar for all species because they face similar threats and many of them occur in the same geographic areas, but the first criterion in particular was adapted for each species and reflects the unique characteristics of the ecology, conservation needs, and current and historical distribution of each species.

A taxon may be downlisted from endangered to threatened when all four of the following criteria have been met, as well as any species-specific criteria listed in Table 6 (Section III, Recovery Criteria):

1. The species occurs in two or more viable populations or a viable metapopulation (as described in Table 6; viable as defined in criterion 2) that represent the ecological, morphological, behavioral, and genetic diversity of the species.

2. Viability of the populations is demonstrated through either a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (lambda, λ) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.
3. Sufficient habitat in recovery areas (described in Section III-C) is protected and managed to achieve criteria 1 and 2 above.
4. The threats that were responsible for the decline of the species have been identified and controlled.

A taxon may be delisted when all four of the criteria above have been met for a 30-year period, as well as any species-specific criteria listed in Table 6.

Recovery Areas: To better address the recovery needs of endangered Hawaiian forest birds, recovery areas have been identified to emphasize where recovery efforts should be focused. Recovery areas in this plan are defined as those areas that will allow for the long-term survival and recovery of endangered Hawaiian forest birds. The identification of recovery areas is the result of an evaluation of habitat that is potentially important for the recovery of Hawaiian forest birds from a biological standpoint only. Recovery areas are intended to help guide recovery efforts to emphasize those areas with the greatest potential to achieve recovery, and convey no legal obligation on the part of any entity to manage lands that they own or have management responsibility over for the recovery of Hawaiian forest birds. The foremost consideration in identifying recovery areas for the majority of endangered Hawaiian forest birds is existing habitat and restorable habitat at higher elevations, because the cooler temperatures at these elevations are less suitable for the parasite that causes avian malaria and the introduced mosquito that is the primary vector of malaria and pox virus. Recovery areas in most cases encompass existing endangered forest bird populations, as well as habitat areas from which these species have disappeared in the recent past, but which still provide or could provide the conditions and resources necessary to support populations of endangered forest bird species. The elevational boundaries of recovery areas were based on the need to include areas that lie above the mosquito zone and within elevations that can be expected to support suitable forest habitat. An effort was made to incorporate naturally occurring habitat heterogeneity that can shape local adaptation and that is consistent with the conditions under which particular species evolved and that likely are needed for recovery and to maintain demographic and population stability.

Recovery Actions: Recovery actions include measures to protect core habitat and restore degraded habitat, as well as actions to address threats, such as introduced ungulates, predators, and disease. For some species sufficient habitat for recovery is still available, but in most cases management is needed to restore degraded areas in order to provide sufficient suitable habitat for species recovery. Management emphasis differs somewhat among species because they are affected differently and to varying degrees by a complex set of limiting factors. Key to management for most species will be: control of feral ungulates that degrade forest habitat by promoting the spread of introduced plant species and creating breeding sites for disease-carrying mosquitoes; control of introduced rodents, mongooses, and feral cats that prey on nests and adults; control of invasive plant species; and reductions in disease prevalence. Habitat management and restoration will encourage the natural expansion of existing bird populations into unoccupied habitat; however, the establishment of new populations using various translocation and/or captive propagation techniques likely will be needed in some cases to accelerate population expansion and to establish new populations in disjunct suitable habitat.

Monitoring and Research Program: Population monitoring and research are essential for recovery in order to assess population status and trends, determine the nature and importance of threats, evaluate the effectiveness of management actions, and to evaluate the potential reclassification of a taxon. Systematic surveys of all recovery areas will be required at least once every 5 years, with more frequent monitoring in core areas, to determine changes in distribution and population size. Systematic searches will be required to determine with greater confidence the status of the rarest species that have not been sighted in recent years. Research on habitat carrying capacity, limiting factors, response to management actions, improved management methods, and in some cases general species biology are also needed to achieve recovery.

Estimated Date of Recovery: Because of the minimum time periods prescribed under the recovery criteria, the earliest date by which most species covered under this plan could be expected to have recovered is 30 years from the date of publication, or 2036. The recovery objectives and recovery criteria are defined in terms of maintaining stable or increasing populations that represent the ecological, morphological, behavioral, and genetic diversity of the species, and the time required to reach these conditions will depend on the effectiveness of management strategies designed to control threats and the response of species' populations. It is possible that a few species with larger current populations, wider distributions, and less degraded habitat may recover more rapidly. Recovery of other species, such as the po`ouli and species that have not been seen in recent years, will require substantial habitat restoration and large population increases.

Total Estimated Cost of Recovery: The total estimated cost of recovery is $2,477,395,000 over the minimum of 30 years it will take to recover the species covered in this plan. Although the total cost for recovery may seem high, it should be remembered that this plan covers 21 taxa of birds and costs are for a 30-year period. This figure could be substantially reduced by the development of more cost-effective methods to address threats, particularly control of predators and feral ungulates. In addition, as mentioned above, many of the recovery actions recommended in this plan will benefit other listed species as well, such as the `io and `alalā. Certain costs, such as for some research actions and public information sharing, have yet to be determined. A detailed cost breakdown with expected annual costs for the first 4 years of recovery implementation is provided in the Implementation Schedule (Table 19).

Recovery actions are ranked according to priority, from 1 (highest) to 3 (lowest). Highest priority recovery actions should be implemented first, and in most cases are the most cost-effective and provide maximum recovery benefit. The total cost for recovery is broken down by priority number as follows:

Priority 1 actions: $1,183,300,000

Those actions that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2 actions: $1,191,645,000

Those actions 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 actions: $102,450,000

All other actions necessary to meet recovery objectives.

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I. INTRODUCTION

A. Overview

Recovery of the endangered forest birds of the Hawaiian Islands is a massive operation in terms of the number of species and the diversity and extent of threats. Over two-thirds of the remaining forest birds in Hawai`i are federally listed under the Endangered Species Act, so the recovery is directed at essentially an entire avifauna. Each of the main islands, Kaua`i, O`ahu, Maui Nui (Maui, Moloka`i, Lāna`i, and Kaho`olawe), and Hawai`i, is involved. No other area of the United States has experienced so many avian extinctions or as large an influx of introduced species that include competitors, predators, vectors of infectious disease, and pathogens (see reviews in Scott *et al.* 1986, van Riper and Scott 2001). Some plant species introduced to the Hawaiian Islands have the potential to permanently alter the ecosystems in which endangered birds exist.

This recovery plan includes species from four families of birds (Tables 1 and 2). The majority (15 species) are Hawaiian honeycreepers (family Fringillidae, subfamily Drepanidinae), and include the `ō`ū (*Psittirostra psittacea*), palila (*Loxioides bailleui*), Maui parrotbill (*Pseudonestor xanthophrys*), Kaua`i `akialoa (*Hemignathus procerus*), Kaua`i nukupu`u (*Hemignathus lucidus hanapepe*), Maui nukupu`u (*Hemignathus lucidus affinis*), `akiapōlā`au (*Hemignathus munroi*), Hawai`i creeper (*Oreomystis mana*), O`ahu `alauahio or O`ahu creeper (*Paroreomyza maculata*), kākāwahie or Moloka`i creeper (*Paroreomyza flammea*), Hawai`i `ākepa (*Loxops coccineus coccineus*), Maui `ākepa (*Loxops coccineus ochraceus*), `ākohekohe or crested honeycreeper (*Palmeria dolei*), and po`ouli (*Melamprosops phaeosoma*). All are federally listed as endangered. The `akikiki or Kaua`i creeper (*Oreomystis bairdi*) is a candidate for listing.

Evolutionary biologists consider the Hawaiian honeycreepers to be a premiere avian example of adaptive radiation within an island chain (Freed *et al.* 1987). The Hawaiian Islands formed in chronological sequence as the Pacific plate moved over a volcanic hot spot in the earth's crust, providing a series of new land masses, new habitats, and opportunities for "stepping-stone" colonization by birds (Fleischer and MacIntosh 2001). The number of listed

Table 1. Federally listed endangered species of Hawaiian forest birds addressed in this recovery plan, their estimated population size or date last observed, listing date, Federal recovery priority number, and International Union for the Conservation of Nature species status (IUCN 1994). Federal guidelines for determining recovery priority numbers are in Appendix C.

Table 1				
Species (common name, scientific name, acronym)	Estimated number or last observation	Federal Listing Date and Reference; State Listing Date	Federal Status; Recovery Priority Number	IUCN Status
O\`ahu \`elepaio, *Chasiempis sandwichensis ibidis*, OAEL	1,980	18 April 2000 (USFWS 2000); 18 April 2000	Endangered; 3	Vulnerable
Kāma\`o (large Kaua\`i thrush), *Myadestes myadestinus*, KAMO	Last detected in 1989	13 October 1970 (USFWS 1970, 1980, 1992); 22 March 1982	Endangered; 5	Critically Endangered
Oloma\`o (Moloka\`i thrush), *Myadestes lanaiensis rutha*, OLOM	Last detected in 1988	13 October 1970 (USFWS 1970, 1980, 1992); 22 March 1982	Endangered; 5	Critically Endangered
Puaiohi (small Kaua\`i thrush), *Myadestes palmeri*, PUAI	300	11 March 1967 (USFWS 1967, 1980, 1992); 22 March 1982	Endangered; 2	Critically Endangered
\`Ō\`ō \`ā\`ā (Kaua\`i \`ō\`ō), *Moho braccatus*, OO	Last detected in 1987	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 4	Extinct
\`Ō\`ū, *Psittirostra psittacea*, OU	Last detected in 1989	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 4	Critically Endangered
Palila, *Loxioides bailleui*, PALI	3,390 (16-year average)	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 1	Endangered
Maui parrotbill, *Pseudonestor xanthophrys*, MAPA	500	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 1	Vulnerable
Kaua\`i \`akialoa, *Hemignathus procerus*, KAAK	Last detected in late 1960s	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 5	Extinct
Kaua\`i nukupu\`u, *Hemignathus lucidus hanapepe*, KANU	Last confirmed detection in 1987	11 March 1967 (USFWS 1967, 1970, 1980); 22 March 1982	Endangered; 5	Critically Endangered
Maui nukupu\`u, *Hemignathus lucidus affinis*, MANU	Last detected in 1996	11 March 1967 (USFWS 1967, 1970, 1980); 22 March 1982	Endangered; 5	Critically Endangered
\`Akiapōlā\`au, *Hemignathus munroi*, AKIP	1,163	11 March 1967 (USFWS 1967, 1980, 1992); 22 March 1982	Endangered; 2	Endangered

Table 1				
Species (common name, scientific name, acronym)	Estimated number or last observation	Federal Listing Date and Reference; State Listing Date	Federal Status; Recovery Priority Number	IUCN Status
Hawai`i creeper, *Oreomystis mana*, HCRE	12,500	25 September 1975 (USFWS 1975, 1980, 1992); 22 March 1982	Endangered; 8	Endangered
O`ahu `alauahio (O`ahu creeper), *Paroreomyza maculata*, OAAL	Last confirmed detection in 1985	13 October 1970 (USFWS 1970, 1980, 1992); 22 March 1982	Endangered; 5	Critically Endangered
Kākāwahie (Moloka`i creeper), *Paroreomyza flammea*, MOCR	Last detected in 1963	13 October 1970 (USFWS 1970, 1992); 22 March 1982	Endangered; 5	Extinct
Hawai`i `ākepa, *Loxops coccineus coccineus*, AKEP	14,000	13 October 1970 (USFWS 1970, 1992); 22 March 1982	Endangered; 8	Endangered
Maui `ākepa, *Loxops coccineus ochraceus*, MAAK	Last confirmed detection in 1970	13 October 1970 (USFWS 1970, 1992); 22 March 1982	Endangered; 6	Endangered
`Ākohekohe (crested honeycreeper), *Palmeria dolei*, AKOH	3,800	11 March 1967 (USFWS 1967); 22 March 1982	Endangered; 7	Vulnerable
Po`ouli, *Melamprosops phaeosoma*, POOU	Last 2 known birds not seen since 2004	25 September 1975 (USFWS 1975, 1992); 22 March 1982	Endangered; 4	Critically Endangered

Table 2. Candidate species and species of concern addressed in this recovery plan, their estimated population size or date last observed, Federal listing priority number, and International Union for the Conservation of Nature species status (IUCN 1994). Guidelines for determining listing priority numbers are in Appendix D.

Table 2				
Species (common name, scientific name, acronym)	Estimated number or last observation	Federal Conservation Status	USFWS Listing Priority Number	IUCN Status
Kaua`i creeper, *Oreomystis bairdi*, KACR	1,472	Candidate species (USFWS 2005)	2	Endangered
Bishop's `ō`ō, *Moho bishopi*, BIOO	Last detected in 1904	Species of concern	N/A	Endangered

Hawaiian forest birds is large because adaptive radiation produced many specialized and closely related taxa endemic to different islands. Endangered honeycreepers include granivorous, frugivorous, insectivorous, and nectarivorous taxa, so no part of the adaptive radiation has escaped endangerment.

The other forest birds covered in this plan include a monarch flycatcher (family Monarchidae), the O`ahu `elepaio (*Chasiempis sandwichensis ibidis*); two honeyeaters (family Meliphagidae), the Kaua`i `ō`ō (*Moho braccatus*) and Bishop's `ō`ō (*Moho bishopi*); and three solitaires or thrushes (family Turdidae), the kāma`o or large Kaua`i thrush (*Myadestes myadestinus*), the oloma`o or Moloka`i thrush (*Myadestes lanaiensis rutha*), and the puaiohi or small Kaua`i thrush (*Myadestes palmeri*). All are federally listed as endangered, with the exception of Bishop's `ō`ō, which was a species of concern, but is now most likely extinct.

The isolation of the Hawaiian Islands has contributed both to the endemism of the forest birds and to their potential for endangerment. The main islands are 4,000 kilometers (2,500 miles) from the nearest continent. Colonization by natural processes therefore has been rare, and the few successful cases have resulted in isolation from the continental source population. This alone would have resulted in genetic divergence through neutral evolutionary processes such as drift. However, natural selection from features of the Hawaiian environment has shaped adaptive divergence from the sources. All of the forest birds in this recovery plan are endemic to Hawai`i at the level of species, genus, or even subfamily in the case of the honeycreepers. Divergence of populations on different islands reflects a similar process of colonization, isolation, time, and selection. As a result, many of the birds in this recovery plan are endemic to a single island.

The high level of endemism resulting from isolation means that the various sources of natural selection that have shaped the morphology, behavior, and life history of these birds vary locally: the species have evolved both in relation to each other and to the resources available in Hawaiian forests (Freed 1999). Many Hawaiian forest birds have unique and often spectacular morphological and behavioral specializations for obtaining food that have been shaped by interspecific competition and resource partitioning. Moreover, the specialized nature of many species makes them vulnerable to habitat alteration, resulting in lower population density in degraded forests (VanderWerf 2004) and limiting their ability to respond adaptively to novel resources available in introduced forests.

Evolution in isolation also resulted in increased susceptibility to introduced organisms. Prior to the arrival of humans, no mammalian predators of adult birds, eggs, or nestlings ever existed in Hawai`i, and alien mammals such as rats (*Rattus* spp.), cats (*Felis catus*), and the small Indian mongoose (*Herpestes auropunctatus*) have severely impacted populations of native forest birds (Atkinson 1977, Scott *et al.* 1986, VanderWerf and Smith 2002). An adaptive response by Hawaiian birds to the novel selection pressure of alien predators is unlikely given the limited time of exposure and high predation rate. No social insects are native to Hawai`i, but western yellow jacket wasps (*Vespula* spp.), introduced accidentally by humans, may compete for food with insectivorous birds and perhaps kill and eat the nestlings of native birds.

Introduced diseases and disease vectors pose an even more serious threat to Hawaiian forest birds because Hawaiian birds evolved in isolation from many common avian pathogens and most species have no natural defenses or immunity to these organisms. The introduction of mosquitoes, avian malaria (*Plasmodium relictum*) and avian pox virus (*Poxvirus avium*) to the islands has had a devastating impact on native forest bird populations. The rapid disappearance of native birds from low elevations, even in intact native forest, can be attributed to these mosquito-transmitted diseases (Warner 1968, van Riper *et al.* 1986, Scott *et al.* 1986, Atkinson *et al.* 1995, van Riper *et al.* 2002). Most remaining populations of endangered birds are found above the "mosquito zone" at higher elevations, where the cooler temperatures limit development of both the mosquito vector and the avian malarial parasite during its development in the mosquito (van Riper *et al.* 1986, LaPointe 2000). Climate change could enable the transmission of pox and malaria at higher elevations, further threatening remaining populations of endangered birds (Benning *et al.* 2002).

This recovery plan addresses some of our most difficult recovery challenges. Several of the species covered have not been sighted for years, and their status is uncertain. The po`ouli may have become extinct since the draft of this plan was written; one bird taken into captivity died of old age in November 2004, before a mate could be obtained. The last two known individuals have not been seen since.  Another species, the O`ahu `elepaio, exists entirely within the range of introduced mosquitoes and pathogens (VanderWerf *et al.* in press). Most of the remaining species are restricted to remote areas of forest at elevations above 1,500 meters (5,000 feet; Scott *et al.* 1986).

Despite often pessimistic characterizations of the status of Hawai`i's endangered forest birds, much has been accomplished since the writing of the first recovery plans for these species (U.S. Fish and Wildlife Service 1983a, 1983b, 1984a, 1986). Statewide surveys of the distribution, abundance, and habitat occurrences of native forest birds have been completed (Scott *et al.* 1986, VanderWerf *et al.* 2001). These efforts have been followed up with an annual survey that rotates among islands, an annual monitoring program across the entire range of the palila (van Riper *et al.* 1978, Jacobi *et al.* 1996), and regular counts at selected study sites for other species. From 1994 to 1996, a Rare Bird Search Team conducted surveys for the rarest species (Reynolds and Snetsinger 2001).

Habitat loss from ranching and logging has been addressed in some areas through a series of changes in land use activities ranging from fee simple acquisition to pending safe harbor agreements. More than 80,000 hectares (197,600 acres) of forest bird habitat has been dedicated as National Wildlife Refuges (Hakalau Forest National Wildlife Refuge, O`ahu Forest National Wildlife Refuge), Nature Conservancy Preserves (Waikamoi, Honouliuli), and State Natural Area Reserves managed by the Hawai`i Department of Land and Natural Resources (Hanawī, Manukā, Pu`u Maka`ala, and others). Introduced ungulates and predators, long recognized as threats to Hawai`i's avifauna, have been the target of a number of management activities.  Nonnative goats, sheep, and pigs have been successfully eliminated from Hawai`i Volcanoes and Haleakalā National Parks, Hanawī Natural Area Reserve, and from much of the acreage in other areas important to the recovery of endangered forest birds (Stone 1985, Katahira *et al.* 1993).

Earnest efforts to eliminate rats, cats, and other nonnative predators and competitors have begun more recently. Predator control efforts thus far generally have not been conducted over areas large enough to result in significant improvement in the status of a species or subspecies. However, studies of the O`ahu `elepaio demonstrate that rat control can result in significant increases in reproductive success and survival of adult females (VanderWerf 2001c, VanderWerf and Smith 2002). Increases in the number of `akiapōlā`au have been documented on Kamehameha Schools land above Hawai`i Volcanoes National Park after control efforts for rats and cats were implemented (T. Casey, Kamehameha Schools, pers. comm.), although alternative hypotheses for the increase were not evaluated. Introduced species of insects and birds have been considered competitors for food and other resources. Nonnative wasps and the Japanese white-eye (*Zosterops japonicus*) are two of the most frequently cited species (Banko and Banko 1976, Pimm and Pimm 1982, Moulton and Pimm 1983, Mountainspring and Scott 1985, Banko *et al.* 2001), but evidence of actual competition is scarce. There currently are no efforts to control competing species within the recovery areas of endangered forest birds.

Control of feral ungulates has served to reduce the number of breeding sites for the mosquito vector of avian diseases in some areas, and there have been experimental efforts to reduce pools of water in downed logs and tree ferns (C. Atkinson and D. LaPointe, U.S. Geological Survey, unpubl. data). Molecular genetic tools are being employed to document more accurately the prevalence, tolerance, and resistance to disease in some forest birds (Feldman *et al.* 1995, Jarvi *et al.* 2001, Shehata *et al.* 2001). A continuing research effort to develop new tools that will mitigate the effects of introduced diseases and parasites is a necessary component of a successful fight to recover Hawai`i's avian evolutionary heritage for the benefit of future generations.

Several restoration projects point a way to recovery. Kamehameha Schools pioneered restoration of native plant species with their koa (*Acacia koa*) reforestation project at Keauhou Ranch on the island of Hawai`i. Plantings of koa trees at Keauhou Ranch in 1977 and since have resulted in encouraging increases in `akiapōlā`au and native Cerambycid beetles after only 25 years (Pejchar 2004; T. Casey, pers. comm.). This bodes well for the value of reforestation efforts at Hakalau Forest National Wildlife Refuge, where over 350,000 koa and other trees have been planted since 1987. It is also known that koa reforestation facilitates regeneration of `ōhi`a (*Metrosideros polymorpha*), a dominant canopy tree used for foraging by the Hawai`i creeper, Hawai`i `ākepa, and several non-endangered forest bird species. Elimination of feral ungulates has resulted in recovery of native plants in many areas of forest bird habitat (Stone 1985, Scowcroft and Conrad 1992, Cabin *et al.* 2000), and has been particularly effective in the dry māmane (*Sophora chrysophylla*) forests on Mauna Kea, home to the endangered palila (Scowcroft and Hobdy 1986). The vision of restoring high elevation koa/`ōhi`a forest as a hedge against changes in climatic conditions (Scott *et al.* 1986) and as a refugium from avian pox and avian malaria is still alive, but greater incentives to private landowners are needed to make it happen in some areas. Safe harbor agreements and habitat conservation plans under section 10 of the Endangered Species Act are tools by which this might be accomplished. Artificial nesting boxes have been used successfully on a small scale by the Hawai`i `ākepa, and may be a promising technique to increase the quality of younger forests for Hawai`i `ākepa, as well as to replace natural cavities lost by tree-fall in old-growth forest (Freed 2001).

The captive propagation of Hawaiian forest birds has made significant progress over the past 20 years. Beginning with the initial efforts of the Hawaiian Forest Bird Consortium of the American Zoo and Aquarium Association, followed by the success of The Peregrine Fund and the Zoological Society of San Diego, 11 native Hawaiian bird species have been artificially hatched and reared in captivity. Of these, 10 species have now bred in captivity: Hawai`i `amakihi (*Hemignathus virens*) (Kuehler *et al.* 1996), `i`iwi (*Vestiaria coccinea*), `ōma`o (*Myadestes obscurus*), `apapane (*Himatione sanguinea*) (P. Luscomb, Honolulu Zoo, pers. comm.), puaiohi, Hawai`i creeper, Hawai`i `akepa, palila, Maui parrotbill, and `alala (Kuehler *et al.* 2001). In the puaiohi, a founder flock of 15 birds from wild eggs has produced over 200 chicks in captivity, of which 113 have been released in the Alaka`i Wilderness Preserve since 1999. Several of the birds released to the wild have reproduced successfully (Tweed *et al.* 1999, Kuehler *et al*. 2000). The restoration and management of forest bird habitat will continue in concert with captive propagation and release to augment existing populations of endangered forest birds, and to re-establish populations in portions of their former ranges. Twenty-one palila have been released at Pu`u Mali on the northern side of Mauna Kea from 2003 to 2005, and several areas on Maui are being considered for releases or translocation of the Maui parrotbill.

The future of the endangered forest birds of Hawai`i lies in our ability and willingness to use the tools currently available to combat the introduced species and processes acting to limit their ecological and evolutionary potential. This work has begun and shows promise, but must be expanded to scales that are more biologically meaningful. In many areas this can be accomplished only through public and private partnerships, which will require creative incentives for private landowners and increased public support for endangered species recovery.

B. Recovery Planning for Hawaiian Forest Birds

The Draft Revised Recovery Plan for Hawaiian Forest Birds was written by the Hawaiian Forest Bird Recovery Team during two periods of intensive work from 1994 to 1996 and 1999 to 2002. Revisions to the draft plan, including updates of several species accounts, were made in 2005 and 2006. The Team's intent was to simplify the recovery planning process by combining the existing single-island recovery plans for forest birds into a single comprehensive multi-island recovery plan encompassing all of the main Hawaiian Islands. In addition, the Revised Recovery Plan for Hawaiian Forest Birds includes two listed species, the O`ahu `elepaio and O`ahu creeper, for which this recovery plan is not a revision, but the first recovery plan. Between 2000 and 2002, the 16 members of the Hawaiian Forest Bird Recovery Team met on average 4 times a year. Smaller working groups within the Hawaiian Forest Bird Recovery Team met more frequently to work on sections of the recovery plan pertaining to each island and certain topics. Team members with expertise on a species or a particular topic, such as captive propagation or avian disease, were called upon to draft certain sections of the plan. The entire Hawaiian Forest Bird Recovery Team then reviewed the species accounts and contributions of individual team members. The Hawaiian Forest Bird Recovery Team is composed of biologists from the Hawai`i Department of Forestry and Wildlife; biologists from Federal agencies including the National Park Service, the U.S. Geological Survey-Biological Resources Discipline, and the U.S. Fish and Wildlife Service; avian captive propagation specialists; university professors; and a representative from Kamehameha Schools, the largest private landowner in Hawai`i. In addition, the Hawaiian Forest Bird Recovery Team requested technical assistance from individuals not on the team for drafting the recovery areas (see Section III-C) and species distribution maps and answering certain questions regarding individual species biology and recovery needs.

A Gazetteer of Place Names (Table 3) is provided to assist the reader in locating the place names and specific parcels of land referred to in this recovery plan. Figure 1 provides a map of the main Hawaiian Islands, and Figures 2 through 5 present maps of the islands of Hawai`i, Moloka`i and Maui, O`ahu, and

Kaua`i, with numbers cross-referenced to the place names in Table 3. TNCH on the maps refers to The Nature Conservancy of Hawai`i.

C. Implementation Participants

Forest bird habitat in Hawai`i includes Federal, State, and private lands. Although we, the U.S. Fish and Wildlife Service, have the statutory responsibility for implementing this recovery plan, and only Federal agencies are mandated to take part in the effort, recovery will not occur without the participation of a number of public and private groups and partnerships. In Hawai`i, conservation partnerships have been formed to address watershed protection and invasive species concerns and to protect native biodiversity. Hunters, recreational users, and traditional use gatherers often share a keen interest in protecting and maintaining native plant and animal communities. We encourage development of safe harbor programs and habitat conservation plans as incentives for landowners to maintain and create endangered species habitat on their property, and we seek to work creatively with stakeholders and all interested parties to form working partnerships for recovery implementation. Because many contingencies cannot be anticipated, it will be necessary to periodically revisit recovery strategies and management techniques. With the completion of this plan, we encourage the Hawai`i Forest Bird Recovery Team and all partnership groups, working groups, and interested individuals to continue their involvement in recovery planning and implementation.

Table 3. Gazetteer of place names used in this plan and identified in Figures 2 through 5. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 3		
Place Name	Island	Number on Map
Hakalau Forest National Wildlife Refuge	H	1
Hawai`i Volcanoes National Park	H	2
Hilo Forest Reserve	H	3
Hōnaunau	H	4
Honomalino	H	5
Hualālai Volcano	H	6
Kahauale`a Natural Area Reserve	H	7
Kanakaleonui	H	8
Kapāpala Forest Reserve	H	9
Ka`ū Forest Reserve	H	10
Keauhou Bird Conservation Center	H	11
Keauhou Ranch	H	12
Kīlauea Forest	H	13
Kīpāhoehoe Natural Area Reserve	H	14
Kona unit of Hakalau National Wildlife Refuge	H	15
Kūlani Correctional Facility	H	16
Pu`u Maka`ala Natural Area Reserve	H	17
Manukā Natural Area Reserve	H	18
Mauna Loa Strip of Hawai`i Volcanoes N.P.	H	19
`Ōla`a Tract of Hawai`i Volcanoes N.P.	H	20
Pōhakuloa Training Area	H	21
Pua `Ākala Tract of Hakalau Forest N.W.R.	H	22
Pu`u Lā`au	H	23
Pu`u Wa`awa`a Forest Bird Sanctuary	H	24
Upper Waiākea Forest Reserve (kīpukas)	H	25
Haleakalā National Park	MA	1
Hāna Forest Reserve	MA	2
Hanawī Natural Area Reserve	MA	3
Kīpahulu Valley	MA	4
Ko`olau Forest Reserve	MA	5
Ko`olau Gap	MA	6
Kūhiwa Valley	MA	7
Kula	MA	8
Manawainui	MA	9
Pu`u `Alaea	MA	10
Waikamoi Preserve	MA	11

Table 3		
Place Name	Island	Number on Map
West Maui Mountains	MA	12
Hālawa	MO	1
Kalaupapa National Historic Park	MO	2
Kamakou Preserve	MO	3
`Ōhi`alele Plateau	MO	4
Oloku`i	MO	5
Pelekunu	MO	6
Pu`u Ali`i Natural Area Reserve	MO	7
Pu`u Haha on Ka`āpahu ridge	MO	8
Pu`u O Waha`ula	MO	9
Hālawa Valley	O	1
Hau`ula Forest Reserve	O	2
Honolulu Forest Reserve	O	3
Honouliuli Preserve	O	4
Kahana Valley State Park	O	5
Ka`ala Natural Area Reserve	O	6
Kahanahāiki Gulch	O	7
Kaluakauila Gulch	O	8
Kapakahi Gulch	O	9
Kuli`ou`ou Forest Reserve	O	10
Lualualei Naval Magazine	O	10
Mākaha Valley	O	12
Makaleha Gulch	O	13
Mākua Military Reservation	O	14
Mānana Trail	O	15
Mānoa Valley	O	16
Moanalua Valley	O	17
O`ahu Forest National Wildlife Refuge	O	18
Pāhole Natural Area Reserve	O	19
Pālolo Valley	O	20
Pia Valley	O	21
Poamoho Trail	O	22
Schofield Barracks West Range	O	23
Wai`alae Nui Gulch	O	24
Wai`anae Kai Valley	O	25
Waianu Valley	O	26
Waikāne Valley	O	27
Wailupe Valley	O	28
Waimano Valley	O	29
Alaka`i Wilderness Preserve	K	1
Halehaha Stream	K	2
Halekua Stream	K	3

Table 3		
Place Name	Island	Number on Map
Halemanu Steam	K	4
Halepā`ākai Stream	K	5
Kawaikōī Stream	K	6
Koai`e Stream	K	7
Kōke`e State Park	K	8
Lā`au Ridge	K	9
Pihea-Alaka`i Swamp Trail	K	10
Sincock's Bog	K	11
Upper Waiakoali Stream	K	12
Wai`alae Trail	K	13
Waiau Stream	K	14

Figure 1. The Main Hawaiian Islands and Major Cities

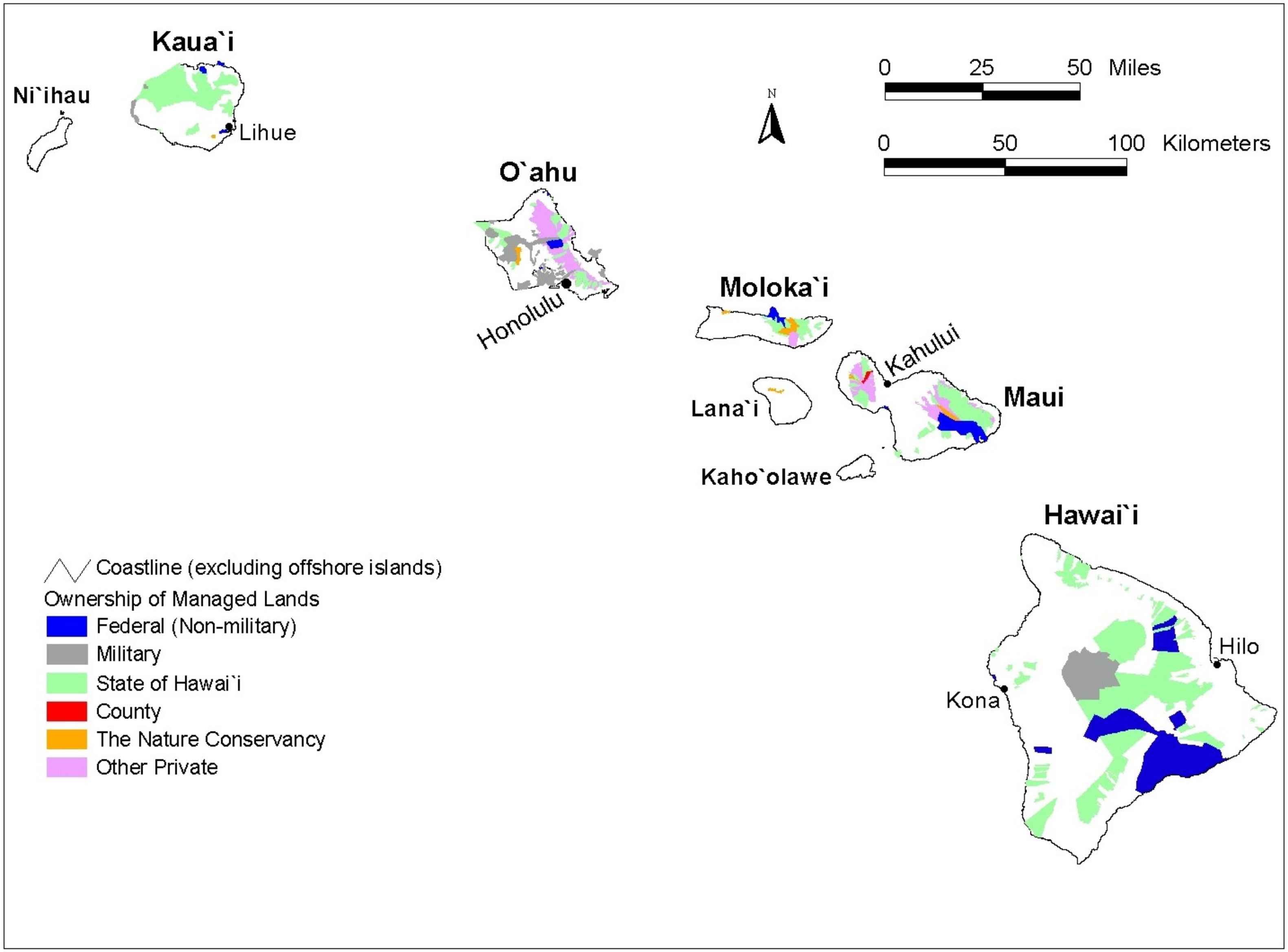


Figure 2. Locations of land parcels on the island of Hawai`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

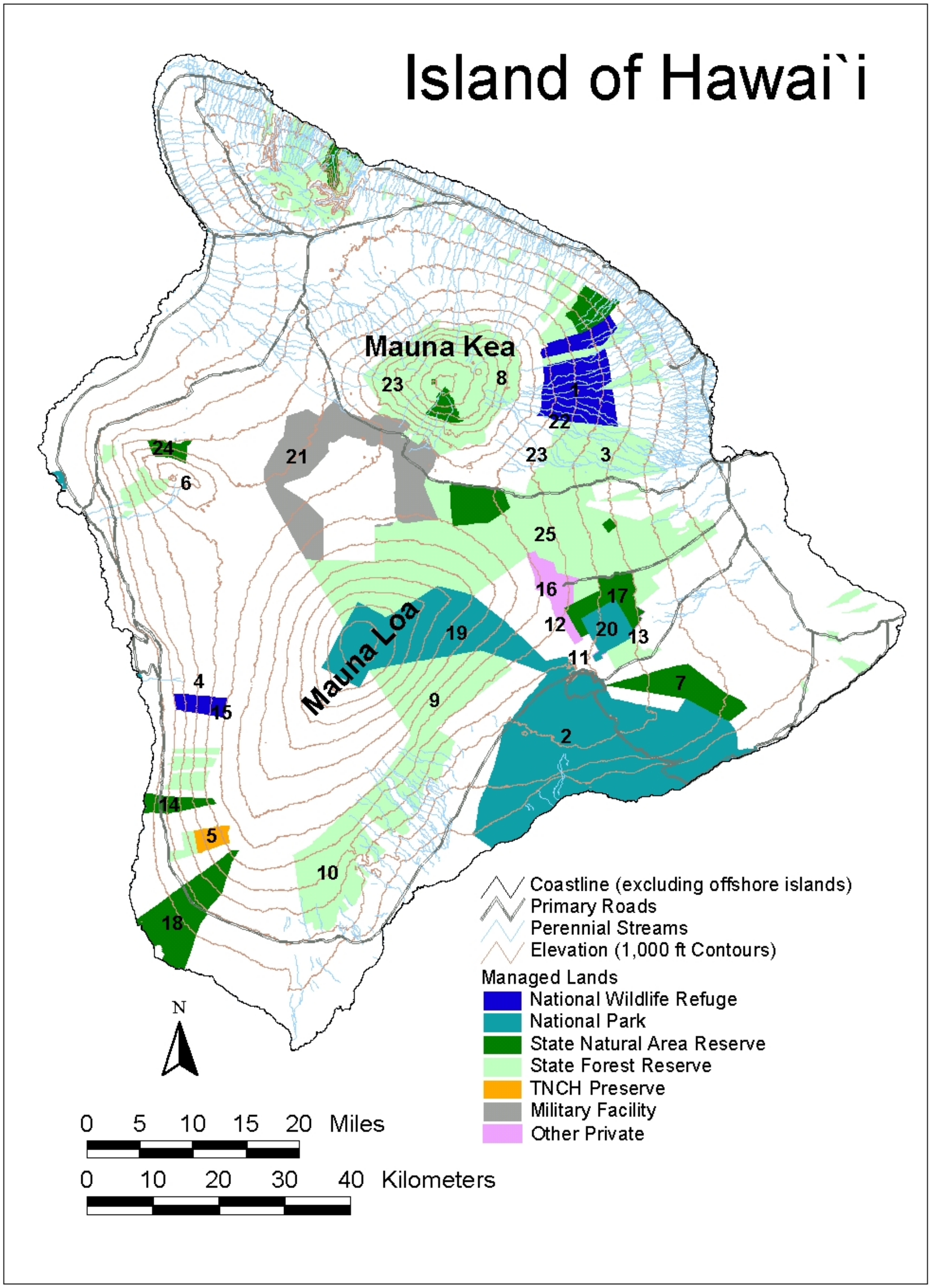


Figure 3. Locations of land parcels on the islands of Maui and Moloka`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

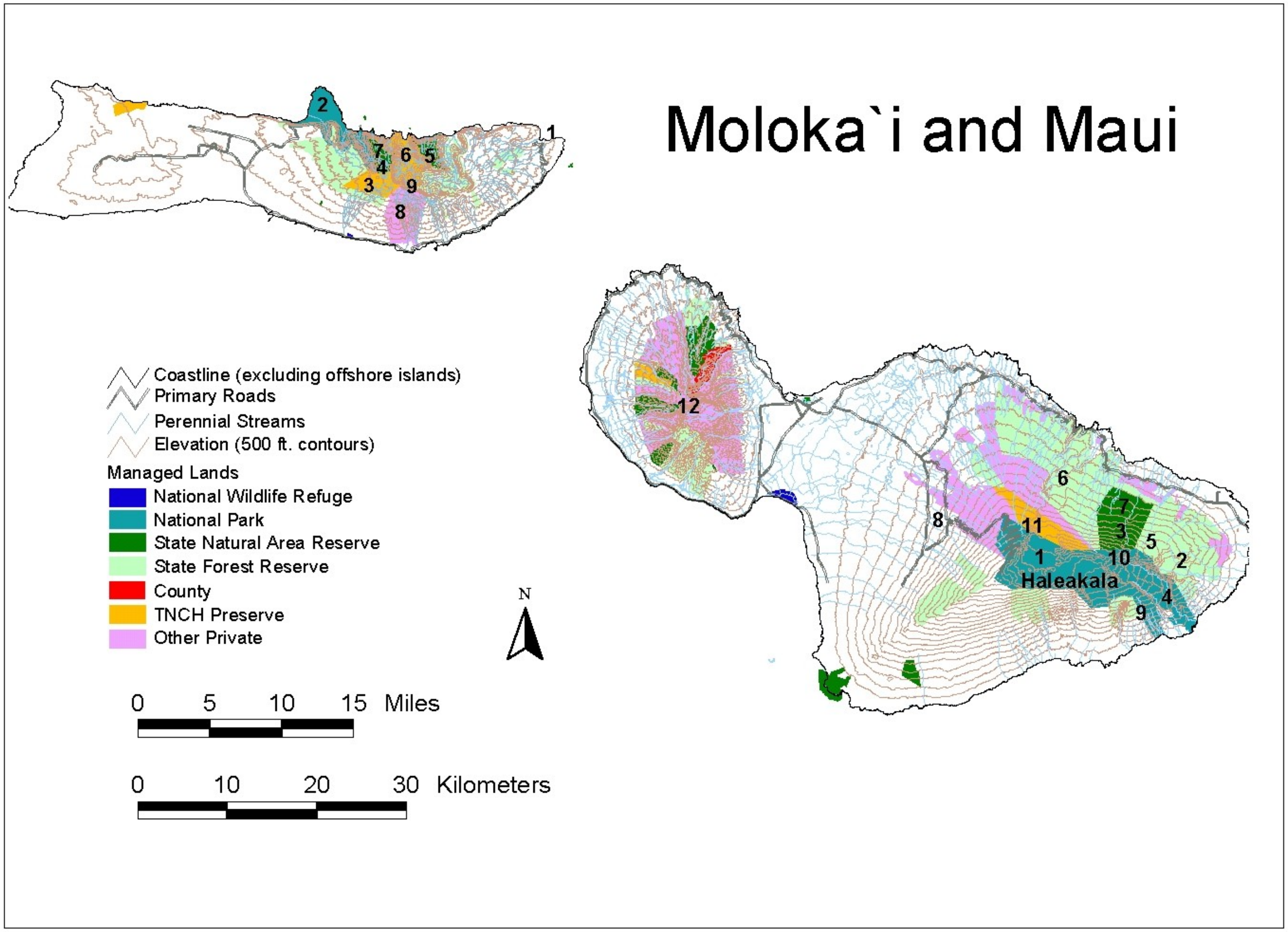


Figure 4. Locations of land parcels on the island of O`ahu that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

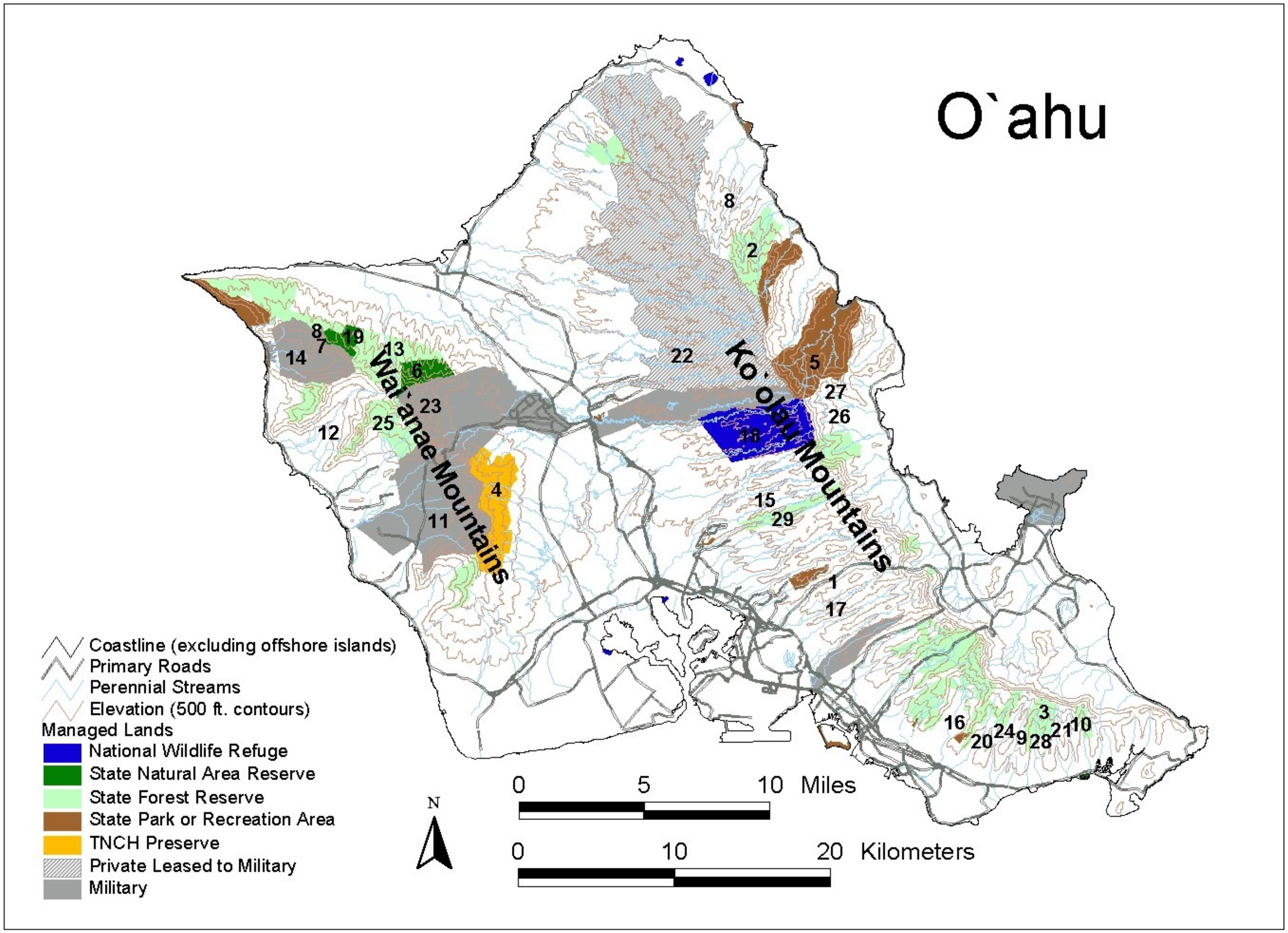
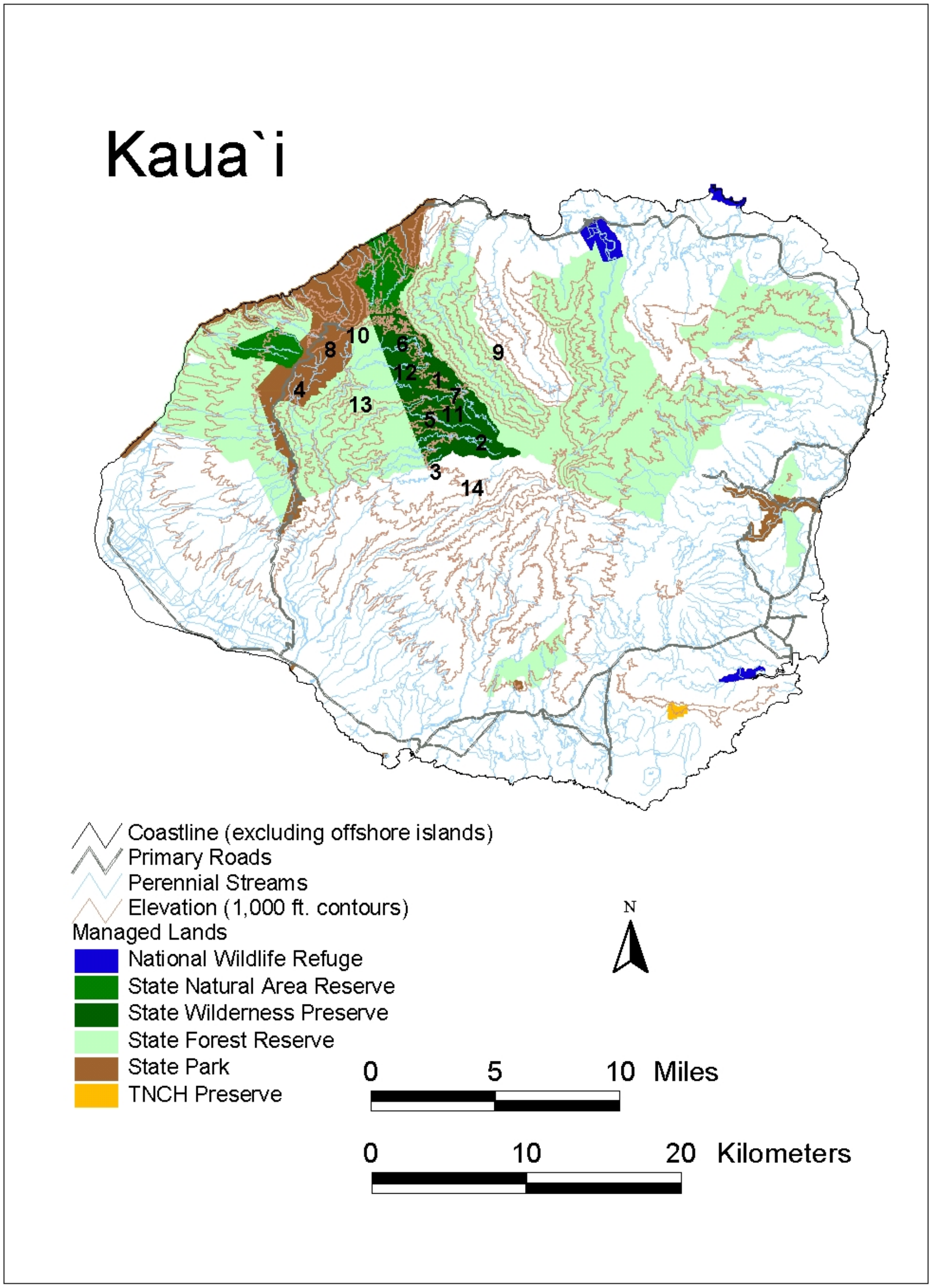


Figure 5. Locations of land parcels on the island of Kaua`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).



II. SPECIES ACCOUNTS

Section II contains accounts of all species covered in this recovery plan, presented in taxonomic order following the American Ornithologists' Union checklist (1998). These accounts are not meant to be a complete reference, but rather to summarize sufficient relevant information about each species in order to understand the prescribed recovery strategy and the prioritization of recovery actions. All of the Hawaiian forest birds face the same set of threats, but the relative importance of those threats varies among species depending on their life history, current distribution and status, and habitat requirements. The priority placed on each component of the recovery strategy therefore varies among species. The species accounts build on and refine the overall recovery strategy discussed in the Introduction (Section I), and justify the recovery criteria presented in Section III as well as the recovery actions and priorities presented in the Recovery Actions Narrative (Section IV). Each account also includes a summary of previous and ongoing conservation efforts, including Federal and State regulations, land acquisition, research, and management directed at or relevant to the recovery of the species. All of the accounts follow the same format and contain the following section headings: description and taxonomy; life history; habitat description; historical and current range and status; reasons for decline and current threats; conservation efforts; and recovery strategy. Longer accounts for better-studied species contain additional subheadings to help locate information. When available, maps showing the historical and current distribution of the species and recovery areas appear in the accounts (Figures 6 through 21).

Recovery plans are prepared following a determination that a species merits listing as endangered or threatened under the Endangered Species Act (Act). The Act is not meant to serve as a primary mechanism for species conservation, but the protections afforded by the Act are intended to arrest the immediate decline of the listed species and provide opportunities for partnerships and funding that will enable its recovery. The Federal listing of a species as endangered or threatened is included in this plan as a conservation effort, but it should be recognized that the ultimate goal of our recovery program is to effectively address the threats to listed species and restore their populations to the point that their long-term viability in their natural ecosystems is assured and the protections of the Act are no longer needed.

1. O`ahu `Elepaio, *Chasiempis sandwichensis ibidis*

DESCRIPTION AND TAXONOMY

Adult male O`ahu `elepaio. Photo © Eric VanderWerf.

Description. The O`ahu `elepaio is a small (12.5 grams [0.4 ounce] average weight, 15 centimeters [5.9 inches] total body length) monarch flycatcher endemic to the island of O`ahu (VanderWerf 1998a). It is dark brown above and white below, with light brown streaks on the breast. The tail is long (6.5 centimeters [2.6 inches]) and often held cocked up at an angle. Adults have conspicuous white wingbars, a white rump, and white tips on the tail feathers that are often displayed. The throat is white with black markings in both sexes, but males tend to have more black than females, especially on the chin. The lores (area between the eye and bill) are white and the auricular (ear patch) is often blackish. Juveniles and subadults are rufous above and on the breast, with a white belly and rusty wingbars. `Elepaio have a 2-year delay in plumage maturation, acquiring the distinctive white markings of adults when they are 3 years old (VanderWerf 2001b). The bill is medium-length, straight, and black, with the base of the lower mandible bluish-gray in adults and yellow in juveniles. The legs and feet are dark gray. The iris is dark brown. Males average approximately 10 percent larger than females in wing length, tarsus length, and weight, but bill length does not differ between the sexes (VanderWerf 1998a). Geographic plumage variation has been described in the Hawai`i subspecies (Pratt 1980), and coloration of the O`ahu subspecies also varies among different parts of the island; birds in drier, leeward areas are paler and grayer on the back, while birds from wet, windward forests are darker and more reddish-brown (E. VanderWerf, unpubl. data).

The primary song, given almost exclusively by males, is a shrill, whistled "el-e-pai-o," with an accent on the third syllable, from which the Hawaiian name is derived. The female often answers the male song with a loud two-note call. Both sexes also give a variety of scolding calls and chatter, and a soft "chup" contact call given by pairs while foraging. The song varies among different parts of the island, and response varies to playbacks of different local dialects (E. VanderWerf, unpubl. data).

Identification. Identification of adult `elepaio is relatively easy. White-rumped shama (*Copsychus malabaricus*) and red-vented and red-whiskered bulbuls (*Pycnonotus cafer* and *P. jocosus*) have white rumps and white-tipped tails like adult `elepaio, but are much larger and lack white wingbars. Juvenile `elepaio can be confused with juvenile `apapane (*Himatione sanguinea*), which are similar in size and overall color and may also cock the tail up, but `apapane have a curved black bill and lack the contrasting wingbars and tail tips of the `elepaio.

Taxonomy. The `elepaio comprises a monotypic genus of the monarch flycatcher family (Monarchidae) that is endemic to the Hawaiian Archipelago (American Ornithologists' Union 1998). The closest relatives of `elepaio are other monarch flycatchers from eastern and central Polynesia (Filardi and Moyle 2005). Three subspecies of `elepaio are recognized, each endemic to a single island: the Hawai`i `elepaio (*C. s. sandwichensis*); the O`ahu `elepaio (*C. s. ibidis*); and the Kaua`i `elepaio (*C. s. sclateri*). The taxonomy used here follows Pratt *et al.* (1987) and Pyle (2002), in which all forms are regarded as subspecies, but the form on each island originally was described as a separate species. The O`ahu form was known as *C. s. gayi* (Wilson 1891b) until Olson (1989) pointed out that the epithet *ibidis* (Stejneger 1887) has priority. Only the O`ahu subspecies is listed as endangered; the Kaua`i and Hawai`i subspecies are still relatively common. Throughout the remainder of this account, `elepaio refers to the listed O`ahu subspecies unless otherwise noted.

LIFE HISTORY

Demography and Reproduction. `Elepaio are non-migratory and defend all-purpose territories year-round (Conant 1977, VanderWerf 1998a). The average territory size was 2.0 hectares (4.9 acres) in forest composed of alien plant species in Mānoa Valley (Conant 1977) and ranged from 1.2 to 1.8 hectares (3.1 to 4.5 acres) in three valleys in southeastern O`ahu, depending on forest structure (VanderWerf and Smith 2002). Annual survival is high, 81 percent in the absence of predation by alien mammals, but survival of females is heavily impacted by predation from alien rats (VanderWerf and Smith 2002; see Current

Threats below). `Elepaio are socially monogamous and have high mate and site fidelity; in the absence of predation by alien mammals, 97 percent of males and 95 percent of females remain on the same territory between years, and almost all pairs remain together between years (VanderWerf and Smith 2002). Young birds are subordinate and act as floaters while they attempt to acquire a territory and a mate.


O`ahu `elepaio nest. Photo © Eric VanderWerf.

The nesting season usually extends from February to May, but active nests have been found from January to July (VanderWerf 1998a). The nest is a finely-woven, free standing cup made of rootlets, bark strips, leaf skeletons, lichens, and spider silk, and is placed in a fork or on top of a branch (Conant 1977, VanderWerf 1998a). Nests have been found in a variety of plants, including 7 native species and 15 introduced species (E. VanderWerf, unpubl. data). Both sexes participate in all aspects of reproduction, but the female plays a slightly larger role in nest building and the male provides more food for the nestlings (VanderWerf 1998a). Although both sexes incubate and brood, only the female develops a brood patch and only the female incubates at night. Clutch size is usually two, sometimes one or three, and eggs hatch after 18 days (Conant 1977, VanderWerf 1998a). The nestling period averages 16 days, and fledglings are fed by their parents for more than a month after leaving the nest, remaining on the natal territory for up to 9 months at the start of the next breeding season (VanderWerf 1998a). Fecundity is low; even if nest predators are controlled the mean number of fledglings per pair is 0.70 per year (VanderWerf and Smith 2002; see Current Threats below). O`ahu `elepaio will re-nest once or twice after failure, but they rarely attempt to re-nest if the first nest is successful. Other than introduced predators, the most common cause of nest failure is storms with heavy rain and strong winds (VanderWerf 1998a).

Annual Variation and Population Fluctuation. Survival and reproduction of O`ahu `elepaio vary considerably among years (VanderWerf and Smith 2002; E. VanderWerf, unpubl. data), probably in association with climatic factors that affect populations of nest predators and disease-carrying mosquitoes. These annual variations are unpredictable in nature and are not cyclic, but the average interval of occurrence of both rodent irruptions and disease episodes is approximately 5 years. Demographic monitoring from 1995 to 2006 revealed that there were two years (1996 and 2004) with high disease prevalence and two years (1999 and 2004) with high rodent abundance (VanderWerf *et al.* in press; E. VanderWerf, unpubl data). Conditions that increase the severity of these two threats do not necessarily coincide, and `elepaio populations therefore can be expected to fluctuate over time in a complex pattern.

Diet and Foraging. The foraging behavior and diet of `elepaio are extremely varied. In a study on Hawai`i Island, VanderWerf (1993, 1994) found that `elepaio foraged at all heights on all available plant species, and that they caught insects from a variety of substrates, including the ground and fallen logs (2 percent), trunks (5 percent), branches (24 percent), twigs (38 percent), foliage (20 percent), and in the air (11 percent). `Elepaio are versatile and agile in pursuit of prey, using a diversity of foraging behaviors that is among the highest recorded for any bird, including perch-gleaning (48 percent), several forms of flight-gleaning (30 percent), hanging (11 percent), aerial flycatching (7 percent), and active pursuit (4 percent) (VanderWerf 1994). The diet consists of a wide range of arthropods, particularly insects and spiders, and includes nonnative taxa such as fruit flies (Tephritidae; VanderWerf 1998a). Large prey such as moths and caterpillars are beaten against a branch before being eaten.

HABITAT DESCRIPTION

O`ahu `elepaio are adaptable and occur in a variety of forest types composed of both native and introduced species (Conant 1977; VanderWerf 1993, 1994, 1998a). Plant species composition in `elepaio habitat varies considerably depending on location and elevation, but some of the most common native plants in areas where `elepaio occur are alahe`e (*Psydrax odorata*), pāpala kēpau (*Pisonia umbellifera*), lama (*Diospyros sandwicensis*), hame (*Antidesma platyphyllum*), māmaki (*Pipturus albidus*), kaulu (*Sapindus oahuensis*), and `āla`a (*Pouteria sandwicensis*), and some of the most common introduced plants are strawberry guava (*Psidium cattleianum*), common guava (*Psidium guajava*), kukui (*Aleurites moluccana*), mango (*Mangifera indica*), and Christmas berry (*Schinus terebinthifolius*) (VanderWerf *et al.* 1997, VanderWerf 1998a). Nest site selection by O`ahu `elepaio is non-specialized; nests have been found in 7 native and 15 introduced plant species (E. VanderWerf, unpubl. data). Shallenberger and Vaughn (1978) found the highest relative abundance of `elepaio in forest dominated by introduced guava (*Psidium* spp.) and kukui (*Aleurites moluccana*) trees, but they were also found in the following forest types (in order of decreasing abundance): mixed native-exotic; tall exotic; koa (*Acacia koa*) dominant; mixed koa-`ōhi`a (*Metrosideros polymorpha*); low exotic; `ōhi`a dominant; and `ōhi`a scrub. They currently are not found in very wet, stunted forest on windswept summits or in very dry scrubland.

Unlike many Hawaiian forest birds, `elepaio have adapted well to disturbed forest composed of introduced plants (Conant 1977, VanderWerf 1998a). VanderWerf *et al.* (1997) found that: 1) forest structure was more important to `elepaio than plant species composition, 2) most `elepaio occurred in areas with a continuous forest canopy and a dense understory, and 3) population density was roughly twice as high in tall riparian vegetation in valleys than in scrubby vegetation on ridges. Fifty-five percent of the `elepaio's current range is dominated by introduced plants, and 45 percent is dominated by native plants (VanderWerf *et al.* 2001). This does not imply that `elepaio prefer introduced plant species, but simply reflects a preference by `elepaio for riparian vegetation in valleys and the high degree of habitat disturbance and abundance of alien plants in these riparian areas (VanderWerf *et al.* 1997). Of the 45 percent dominated by native plants, 23 percent is categorized as wet forest, 17 percent as mesic forest, and 5 percent as dry forest, shrubland, and cliffs (Hawai`i Heritage Program 1991).

HISTORICAL AND CURRENT RANGE AND STATUS

Historical Range and Status. Before humans arrived, forest covered about 127,000 hectares (313,690 acres) on O`ahu (Hawai`i Heritage Program 1991), and it is likely that `elepaio formerly inhabited much of that area (Figure 6). Reports by early naturalists indicate that `elepaio were once widespread and abundant on O`ahu. Bryan (1905) called the O`ahu `elepaio "the most abundant Hawaiian species on the mountainside all the way from the sea to well up into the higher elevations." Perkins (1903) remarked on its "universal distribution..., from the lowest bounds to the uppermost edge of continuous forest." Seale (1900) stated the `elepaio was "the commonest native land bird to be found on the

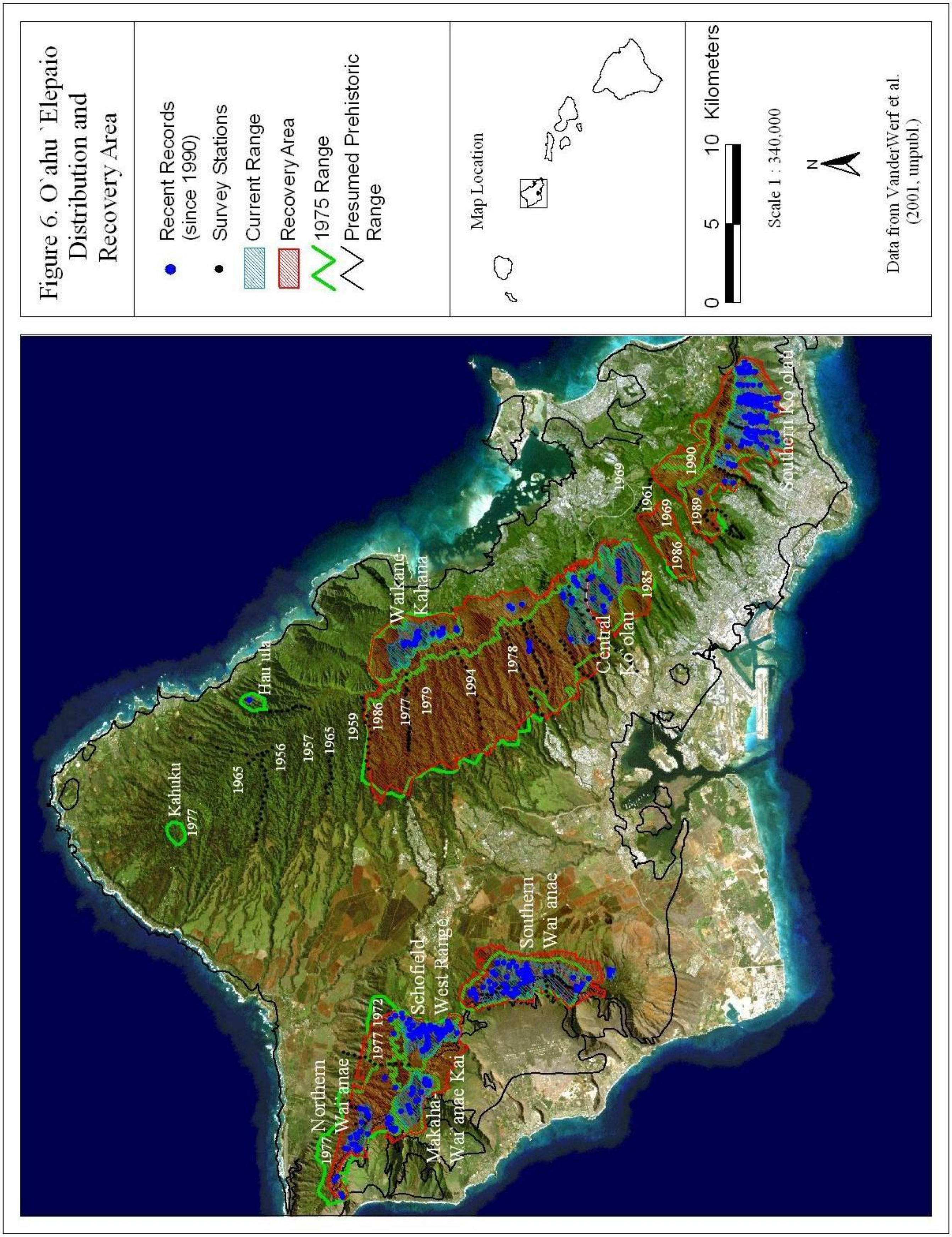


Figure 6. O`ahu `Elepaio Distribution and Recovery Area
Recent Records (since 1990)
Survey Stations
Current Range
Recovery Area
1975 Range
Presumed Prehistoric Range
Map Location
0 5 10 Kilometers
Scale 1 : 340,000
N
Data from VanderWerf et al. (2001, unpubl.)
Kahuku
1977
Hau`ula
1965
1956
1957
1965
1959
1986
1977
1979
1994
1978
Waikane-Kahana
Central Ko`olau
1985
1986
1969
1961
1989
1969
1990
Southern Ko`olau
Southern Wai`anae
Schofield West Range
1977 1972
Northern Wai`anae
1977
Makaha-Wai`anae Kai

island," while MacCaughey (1919) described it as "the most abundant representative of the native woodland avifauna" and "abundant in all parts of its range." The historical range of the O`ahu `elepaio thus apparently included most forested parts of the island, and it was formerly abundant.

Despite its adaptability, the O`ahu `elepaio has declined seriously since humans arrived, and it has disappeared from many areas where it was formerly common (Shallenberger 1977, Shallenberger and Vaughn 1978, Williams 1987, VanderWerf *et al.* 1997). Based on the dates when `elepaio were last observed in various locations (Figure 6), the decline of `elepaio began in three areas, the northern Ko`olau Mountains, the northern slope of Mt. Ka`ala in the northern Wai`anae Range, and near Konahuanui in the south-central Ko`olau Mountains. Perhaps not coincidentally, these are also the three areas with the highest rainfall on O`ahu, suggesting mosquito-borne diseases may have played an important role in the decline.

Current Range and Status. The total geographic area of all current populations is approximately 5,451 hectares (13,464 acres) (Table 4; VanderWerf *et al.* 2001). The O`ahu `elepaio thus currently occupies only about 4 percent of its presumed prehistoric range, and has declined by roughly 96 percent since humans arrived in Hawai`i 1,600 years ago (Kirch 1982). In 1975, `elepaio inhabited approximately 20,900 hectares (51,623 acres) on O`ahu, almost four times the area of the current range (VanderWerf *et al.* 2001). The range of the `elepaio has thus declined by roughly 75 percent in the last 25 years (Figure 6).

The total current population of O`ahu `elepaio is approximately 1,980 birds that are distributed in 6 relatively large populations and several small population remnants (Table 4 and Figure 6; VanderWerf *et al.* 2001). The only previous population estimate (200 to 500 birds; Ellis *et al.* 1992) was not accurate because little information was available when the estimate was made. The number of birds is divided almost evenly between the Wai`anae Mountains in the west and the Ko`olau Mountains in the east, with three relatively large populations in each mountain range. Although the central Ko`olau population covers the largest area (Table 4), `elepaio are sparsely distributed in much of this region and the number of birds is smaller than in more dense populations. Several tiny population remnants consisting entirely of males remain in both the Wai`anae

Table 4. Estimated size and area of O`ahu `elepaio populations. Data from VanderWerf *et al.* (2001).

Population	Total population size	Breeding population size	Area (hectares)
**Wai`anae Mountains** A. Southern Wai`anae (Honouliuli Preserve, Lualualei Naval Magazine)	458	418	1,170
B. Schofield Barracks West Range	340	310	538
C. Mākaha, Wai`anae Kai Valleys	123	112	459
D. Pahole, Kahanahāiki	18	4	256
E. Schofield Barracks South Range	6	0	20
F. Mākua Valley	7	2	49
G. Ka`ala Natural Area Reserve	3	0	21
H. Makaleha Gulch	2	0	7
I. Kuaokalā	3	2	14
J. Kaluakauila Gulch	1	0	6
**Ko`olau Mountains** K. Southern Ko`olau (Pia, Wailupe, Kapakahi, Kuli`ou`ou, Wai`alae Nui)	475	434	1,063
L. Waikāne, Kahana Valleys	265	242	523
M. Central Ko`olau (Moanalua, north and south Hālawa, `Aiea, Kalauao)	226	206	1,396
N. Pālolo Valley	46	42	78
O. Waihe`e Valley	5	4	32
P. Mānoa Valley	2	0	19
Q. Hau`ula	1	0	4
R. Waianu Valley	1	0	8
TOTAL	1,982	1,774	5,663

and Ko`olau mountains, but since there is no chance of reproduction without females and population rescue by immigration is unlikely, these relicts likely will disappear in a few years as the last adult birds die.

The breeding population is about 1,770 birds, lower than the total population, due to a male-biased sex-ratio; only 84 percent of territorial males have mates in large populations (n = 147; E. VanderWerf, unpubl. data), and many small, declining populations contain mostly males (breeding population = 0 in Table 4). The genetically effective population size probably is further reduced by the geographic isolation of populations (Grant and Grant 1992). Adults have high site fidelity and natal dispersal distances usually are less than a kilometer (0.62 mile) (VanderWerf 1998a), but most `elepaio populations on O`ahu are separated by many kilometers of unsuitable urban or agricultural habitat. There may be infrequent dispersal among populations within each mountain range, but it is unlikely that `elepaio cross the extensive pineapple fields that separate the Wai`anae and Ko`olau Mountains. The current distribution superficially appears to constitute a metapopulation (Hanski and Gilpin 1997), but this would be true only if dispersal occurred among populations. There have been no observations of banded `elepaio moving among populations (E. VanderWerf, unpubl. data), though this would be difficult to detect. Investigation of the genetic population structure has begun (Burgess 2005), but requires additional analysis.

REASONS FOR DECLINE AND CURRENT THREATS

Habitat Loss and Degradation. Much of the historical decline of the O`ahu `elepaio can be attributed to habitat loss, especially at low elevations. Fifty-six percent of the original prehistoric range has been developed for urban or agricultural use, and no `elepaio remain in these developed areas (VanderWerf *et al.* 2001). Habitat loss thus has been a major cause of decline, but `elepaio are adaptable, and moderate habitat alteration in the form of gradual replacement of native forest with alien forest has not limited their distribution (VanderWerf *et al.* 1997). Moreover, several areas of O`ahu that recently supported large `elepaio populations and still contain suitable native forest habitat are unoccupied, demonstrating that habitat loss is not the only threat. `Elepaio were observed regularly into the 1970s or early 1980s at Poamoho, Schofield-Waikāne, Mānana, and other areas (Figure 6; Shallenberger 1977, Shallenberger and Vaughn 1978), but they have since disappeared from all of these areas even though the forest is still largely intact (VanderWerf *et al.* 2001).

Predation and Disease. Recent declines in O`ahu `elepaio populations are due to a combination of low adult survival and low reproductive success. The two main causes of reduced survival and reproduction on O`ahu are nest predation by alien black rats (*Rattus rattus*) and diseases, particularly avian pox (*Poxvirus avium*), which is carried by the introduced southern house mosquito (*Culex quinquefasciatus*).

O`ahu `elepaio foot with active pox lesion. Photo © Eric VanderWerf.

In a 10-year study of mosquito-borne diseases from 1995 to 2005, VanderWerf *et al*. (in press) found that each year 20 ± 4 percent of O`ahu `elepaio had active lesions likely caused by pox, and an additional 16 ± 4 percent had deformities and missing toes indicative of healed pox lesions. The prevalence* of avian malaria (*Plasmodium relictum*) was 87 percent over all years combined. Pox prevalence varied among years, and was associated with annual rainfall, presumably due to greater abundance of mosquito breeding sites in wet years. Rainfall amounts at least as high as those associated with pox epizootics in 1996 and 2004 have occurred in 13 years since 1947, or once every 4.5 years (VanderWerf *et al*. in press). The severity of infection varied considerably among birds, and infections involving three or more toes, the feet, or the head were less common in birds with healed lesions than in those with active lesions, suggesting that such infections resulted in mortality more often. Annual survival of `elepaio with active avian pox lesions (65 percent) was lower than annual survival of `elepaio with no pox symptoms (80 percent; E. VanderWerf, unpubl. data). Pairs in which at least one bird had active pox produced fewer fledglings than healthy pairs or those in which at least one bird had healed pox (E. VanderWerf, unpubl. data). Many birds with active pox lesions did not even attempt to nest, and infected birds were sometimes deserted by their mate. Avian malaria is known to be a serious threat to many Hawaiian forest birds (Warner 1968, van Riper *et al.* 1986, Atkinson *et al.* 1995), but its effect on `elepaio has not been quantified.

Black rats are the main predator on O`ahu `elepaio nests, though feral cats (*Felis catus*) may also occasionally prey on adults and nests. An experiment in which automatic cameras were wired to artificial nests containing quail eggs showed that a black rat was the predator in all 10 predation events documented (VanderWerf 2001c). All predation events occurred at night, and most occurred

* "Prevalence" refers to the percent of a population that is affected at a given time

on the first night nests were placed in the field, indicating predation pressure was very high. Control of rats with snap traps and diphacinone bait stations from 1996 to 2000 resulted in an increase in reproduction from 0.33 to 0.70 fledglings per pair (112 percent) and an increase in annual survival of adult female `elepaio from 0.50 to 0.83 (66 percent; VanderWerf and Smith 2002).  Both sexes of `elepaio incubate the eggs and brood the nestlings, but only the female incubates at night, making them more vulnerable to predation by nocturnal predators such as rats (VanderWerf 1998a).

The relative threat posed by disease and nest predation can be determined by calculating the rate of population growth, or lambda (λ), under different conditions (calculated as $\lambda = P_A + P_J B$, where P_A is annual adult survival, P_J is juvenile survival, and B is mean number of fledglings per pair per year; Pulliam 1988, VanderWerf and Smith 2002). Without any management lambda was 0.76 ± 0.12, indicating a rapid 24 percent decline per year. At this rate of decline, less than 10 percent of the population would remain in 9 years. With rat removal lambda was 1.00 ± 0.05, indicating a stable population. If disease could be eliminated somehow and all birds survived at the rate of healthy individuals, but rats were not removed, lambda would be approximately 0.83 (E. VanderWerf, unpubl. data), indicating that the population would still be declining at a rate of 17 percent a year. If disease could be eliminated and rats were removed, lambda might be as high as 1.04, which would allow the population to double in 19 years. These calculations suggest that the removal of rats alone may prevent further decline of O`ahu `elepaio, but may not be enough to allow rapid recovery of `elepaio populations.

Other Natural and Manmade Factors. The remaining `elepaio populations are small and isolated, comprising 6 core populations that contain between 100 and 500 birds each, and several small remnant populations, most of which contain fewer than 10 birds and few or no breeding pairs (Table 4). Even if the threats responsible for their decline were controlled, the existing populations would still be threatened with extinction because their small sizes and restricted distributions make them vulnerable to a variety of natural processes, including reduced reproductive vigor caused by inbreeding depression, loss of genetic variability and evolutionary potential over time due to random genetic drift, stochastic fluctuations in population size and sex ratio, and natural disasters such as hurricanes and fires (Lande 1988, International Union for the Conservation of Nature 2000).

O`ahu `elepaio also are threatened by human actions, such as the potential introduction of the brown treesnake (*Boiga irregularis*) from the Mariana Islands, which has devastated the avifauna on Guam (Savidge 1987). A study of the effects of noise from military training showed that O`ahu `elepaio at U.S. Army Schofield Barracks are not affected by noise from military training (VanderWerf *et al*. 2000). However, fires ignited by military training activities are a serious long-term threat to `elepaio and have reduced the amount of suitable habitat for the species, including areas designated as critical habitat for the O`ahu `elepaio at Schofield Barracks and Mākua Military Reservation (USFWS 2003c). Firebreak roads exist to help prevent the spread of fires into mesic forest occupied by `elepaio, but fires regularly start beyond the firebreaks, and each fire removes additional habitat, which is replaced by nonnative fire-adapted plants that are not used by `elepaio, such as swamp mahogany (*Eucalyptus robusta*) and bottlebrush (*Melaleuca quinquenervia*). If this pattern is allowed to continue, there eventually will be no mesic forest left at Schofield Barracks and Makua Valley, and those populations will be lost.

CONSERVATION EFFORTS

The O`ahu `elepaio was federally listed as endangered on April 18, 2000 (U.S. Fish and Wildlife Service 2000b), and thus receives regulatory protection under the Federal Endangered Species Act. Species listed under the Federal Endangered Species Act are automatically added to the State of Hawai`i list of endangered species, and are thus also protected by State regulations. Critical habitat for the O`ahu `elepaio was designated on December 10, 2001 (U.S. Fish and Wildlife Service 2001). The recently established O`ahu Forest National Wildlife Refuge protects a large area of suitable forest habitat in the north-central Ko`olau Mountains (U.S. Fish and Wildlife Service 2000a). This area currently supports few or no `elepaio, but it is suitable for management of threats and reintroduction.

Conservation efforts for the O`ahu `elepaio thus far have included surveys to determine current distribution and abundance (VanderWerf *et al.* 1997, 2001), demographic monitoring to assess population status and identify threats

(VanderWerf 1999), removal of introduced predators (VanderWerf and Smith 2002), and investigation of disease (VanderWerf *et al*. in press). Surveys have been conducted over most of O`ahu, and have shown the distribution to be highly fragmented and the total population to be fewer than 2,000 birds (see Current Range and Status, above). Long-term demographic studies have shown that the two most important current threats are nest predation by black rats and introduced mosquito-borne diseases (see Predation and Disease, above). Rat control is a promising conservation technique for increasing both reproductive success and survival of adult females. Ground-based rat control using snap traps and diphacinone bait stations has been conducted in the Honolulu Watershed Forest Reserve by the Hawai`i State Division of Forestry and Wildlife since 1997, at Schofield Barracks West Range and Mākua Military Reservation by the U.S. Army Environmental Division since 1998, at Honouliuli Preserve by The Nature Conservancy of Hawai`i since 2000, in Lualualei Naval Magazine by the U.S. Navy and U.S. Department of Agriculture, Wildlife Services from 2002 to 2004, in Mākaha Valley by the City and County of Honolulu Board of Water Supply and the U.S. Army since 2004, and in and Moanalua Valley by the U.S. Army since 2005. Blood samples have been collected from over 150 `elepaio for use in disease screening, determination of genetic population structure, and to assist in identification of potentially disease-resistant populations or individuals.

RECOVERY STRATEGY

There are several important components to the recovery strategy for the O`ahu `elepaio, including the identification of recovery areas and protection of remaining forest from development and fire; control of alien nest predators, especially rats; research on disease resistance and transmission; public information and outreach; and possibly captive propagation.

The O`ahu `elepaio currently has a highly fragmented distribution, with 6 relatively large populations of at least 100 birds, a few smaller populations of 10 to 50 birds, and several very small population remnants containing only a few single males (Table 4). Recovery efforts should focus on protecting and managing the six large "core" populations first. These core populations are distributed throughout most of the original historical range, have the greatest chance of long-term persistence because their larger sizes make them less susceptible to stochastic events, probably have lost less genetic diversity than smaller populations, and are most likely to be recovered *in situ* through habitat management. All core populations should be conserved to preserve as much genetic, morphological, and behavioral (vocal) variation as possible. Smaller populations should be addressed next if there are sufficient resources or interested parties, followed by very small populations. If management actions are effective, the core populations eventually may serve as sources of dispersing individuals that can help support smaller populations or even recolonize areas where `elepaio have disappeared.

Habitat Protection. Protection of remaining forest habitat on O`ahu is fundamental to the survival and recovery of the `elepaio. Although `elepaio are adaptable, they are forest birds and require some form of forest in which to forage and nest. Suitable habitat for recovery of O`ahu `elepaio includes wet, mesic, and dry forest consisting of native and/or introduced plant species, but higher population density can be expected in closed canopy riparian forest with a continuous canopy and dense understory (VanderWerf *et al.* 1997, 2001).

The remaining O`ahu `elepaio populations are small and fragmented; even if the threats responsible for their decline were controlled, the existing populations would still be threatened with extinction because their small sizes and restricted distributions make them vulnerable to stochastic fluctuations and catastrophes such as hurricanes and fires. `Elepaio are highly territorial; each pair defends an area of a certain size, depending on the forest type and structure, resulting in a maximum population density or carrying capacity (VanderWerf 2003). Consequently, the currently occupied areas are too small to support `elepaio populations large enough to be considered safe from extinction. Complete recovery will require restoration of `elepaio in areas where they do not occur at present, through translocation, captive propagation and release, or natural dispersal. Identified recovery areas therefore include areas that are currently not occupied by `elepaio, but that still contain suitable forest.

The O`ahu `elepaio evolved in an environment with large areas of continuous forest habitat covering much of the island, and their dispersal behavior is not adapted to a fragmented landscape. `Elepaio are sedentary; adults have high fidelity to their territory and juveniles rarely disperse more than 1 kilometer (0.62 mile) in search of a territory (VanderWerf 1998a). Because the areas currently occupied by `elepaio are separated by many kilometers and `elepaio are unlikely to disperse long distances, the existing populations are probably isolated from one another (VanderWerf *et al.* 2001). Maintaining or restoring links among populations by providing habitat for dispersal would increase the overall effective population size, thereby helping to alleviate the threats associated with small population size. In particular, the enlargement of small subpopulations by expansion onto adjacent lands not only would increase the chances of their long-term survival, but also would improve connectivity among populations by enhancing their value as "stepping stones" within the entire distribution. Recovery areas therefore include areas that may not be used by `elepaio for nesting, but that provide dispersal corridors among populations and suitable forest areas.

Based on the estimated density of `elepaio in currently occupied areas, the recovery areas identified in Table 5 can be expected to support approximately 10,000 `elepaio (see also Figure 6; VanderWerf *et al.* 2001).

Table 5. Recovery areas and potential O`ahu `elepaio populations.

Recovery area	Area in hectares (acres)	Current `elepaio density in area (birds/hectare)	Potential `elepaio population
Northern Wai`anae	4,454 (11,005)	0.45	2,004
Southern Wai`anae	2,422 (5,985)	0.39	945
Central Ko`olau	14,801 (36,573)	0.33	4,884
Kalihi-Kapālama	804 (1,987)	0.39	314
Southern Ko`olau	4,180 (10,329)	0.45	1,881
All Areas	26,661 (65,879)	0.37	10,028

Predator Control. Control of alien predators, especially rats, has been shown to be an effective method of increasing reproductive success and survival of female `elepaio (VanderWerf and Smith 2002). Rodent control programs should be continued and expanded by whatever methods are available. Ground-based methods of rodent control using snap traps and diphacinone bait stations have been effective on a small scale, but are labor intensive. Recovery of the O`ahu `elepaio likely will require large-scale rat control, which can be achieved more efficiently through aerial broadcast methods. Registration of aerial broadcast of diphacinone or other rodenticides with the U.S. Environmental Protection Agency and Hawai`i Department of Agriculture Pesticides Branch should be actively pursued and supported. Aerial broadcast of rodenticides may be feasible only in areas where secondary poisoning to non-target species such as feral pigs and indirect exposure to the human food chain can be avoided. Public education about predator control and coordination of toxicant use among agencies will therefore be important parts of the recovery strategy.

Disease Research. No areas of O`ahu are of sufficient elevation to be free from disease-carrying mosquitoes, and all populations of O`ahu `elepaio appear to be affected by disease (VanderWerf *et al*. in press). Reducing mosquito numbers by removing breeding sites or treating them with larvicides would be extremely difficult due to the abundance of breeding sites (C. Atkinson and D. LaPointe, pers. comm.). The best long-term method of reducing the threat from disease may be to investigate disease resistance or tolerance and its genetic basis. If disease-resistant or tolerant birds can be identified, translocation or captive propagation and release of these birds might help populations recover more quickly and perhaps obviate the need to control mosquitoes. Controlling rodents also may lessen the threat from disease by providing birds that have greater natural immunity a greater chance of reproducing, thereby increasing the proportion of resistant birds more quickly (VanderWerf and Smith 2002). The potential evolutionary acceleration of disease resistance through rodent control was demonstrated quantitatively by Kilpatrick (2006), and appears promising.

Population Surveys and Monitoring. To determine whether the overall recovery strategy is effective and whether the recovery criteria have been met, it will be necessary to conduct rangewide population surveys and monitor demography of populations. Standard survey routes should be established to determine distribution and measure population density. Surveys should be conducted at least once every 5 years to address whether the recovery criteria have been met, and annually if possible to more closely examine population trends and assess efficacy of management actions. Demographic monitoring will require mist-netting, banding, and resighting of birds to measure survival rate, nest searching to measure reproductive success, and data analysis.

Setting a goal of demographic persistence highlights the need for monitoring and helps ensure that threats have been adequately managed and population increases are not transient. Research to date indicates that survival and reproduction of `elepaio populations on O`ahu fluctuate from year to year, in association with epizootics of disease and variation in predator (rodent) populations (VanderWerf and Smith 2002, VanderWerf *et al*. in press). Epizootics of disease and irruptions in rodent populations appear to occur approximately once every 5 years (see Life History: Annual Variation), so the third recovery criterion for the O`ahu `elepaio, stable or increasing populations over a period of 15 years for downlisting and 30 years for delisting, likely would encompass either three (downlisting) or six (delisting) population cycles. If populations are stable in the long-term despite periodic episodes of increased disease and predation, then the species can be considered recovered.

Captive Propagation. Captive propagation and release of O`ahu `elepaio are not necessary for recovery at this time because the number of O`ahu `elepaio remaining in the wild is relatively large and recovery can be achieved more cost-effectively through habitat management. Moreover, the threats that caused the decline of `elepaio have not been corrected in most areas, and no suitable release sites are currently available. Captive propagation and/or rear and release of O`ahu `elepaio may become necessary in the future if habitat management alone proves insufficient to allow recovery, and would be especially valuable if genetically disease-resistant birds can be identified for use as breeding stock. Attempts at captive propagation of `elepaio should consider using birds known to have recovered from pox or identified as genetically resistant. In anticipation of the possible need to implement a captive propagation program for the recovery of this species in the future, surrogate efforts have begun at the Keauhou Bird Conservation Center with the Hawai`i subspecies of the `elepaio. Techniques have been developed for the collection and transfer of eggs, artificial incubation and hand-rearing of chicks, as well as long-term maintenance of birds in captivity (The Peregrine Fund 1995, 1996, 1997, 1998, 1999; Zoological Society of San Diego 2004). Captive management has yet to produce a successful captive breeding or a release of `elepaio from captive-bred animals.

2. Kāma`o, *Myadestes myadestinus*

DESCRIPTION AND TAXONOMY

The kāma`o, also known as the large Kaua`i thrush, is endemic to the island of Kaua`i and is a member of the thrush family (Turdidae). Early descriptions of the kāma`o were made by Stejneger in 1887 from specimens provided to the Smithsonian Institution by Valdemar Knudsen in the 1880s (Munro 1944). Originally described as *Phaeornis obscura myadestina*, Pratt (1982) offered convincing evidence that *Phaeornis* should be merged with the American solitaire genus *Myadestes*, and that some Hawaiian taxa formerly treated as subspecies are sufficiently distinct to merit full species status.

The kāma`o is a medium-sized (20 centimeters [7.9 inches] in length) solitaire, gray-brown above, tinged with olive especially on the back, and light gray below with a whitish belly and undertail coverts. The legs are dark gray-brown and relatively short, but the ventral surface of the toes is pale yellow. The eyes are dark and the bill is black. The kāma`o lacks the white eye-ring and pinkish legs of the smaller puaiohi (small Kaua`i thrush). Immature birds have a spotted appearance. The song is sweet and melodic, sometimes lavish and flute-like, and is often given just before dawn and after dusk. A scolding or hissing "police whistle" alarm note has also been described.

LIFE HISTORY

Little is known of the life history of the kāma`o, but presumably it is similar in many respects to the more common and closely related `ōma`o or Hawai`i thrush (*Myadestes obscurus*). The periods of greatest singing occur in the winter (January to March). Nesting likely occurs in the spring (April to July). The nest has not been described, but may be a cavity or low platform as with the `ōma`o. The eggs are grayish-white with irregular reddish-brown splotches, and the clutch size is one or two. The diet of the kāma`o is reported to consist of fruits and berries, particularly the bracts of the `ie`ie vine (*Freycinetia arborea*), as well as insects and snails (Munro 1944). The kāma`o was often described for its habit of rising on the wing into the air, singing a few vigorous notes and then suddenly dropping down into the underbrush. Early in the morning it sings an elaborate song from treetops. The kāma`o seems to spend less time on the ground than does the smaller puaiohi.

HABITAT DESCRIPTION

In the past half century, the kāma`o has not been seen below 1,100 meters (3,500 feet) elevation. In recent years, kāma`o have been seen most frequently where a healthy open forest canopy existed, primarily of `ōhi`a (*Metrosideros polymorpha*) and `ōlapa (*Cheirodendron* spp.). A diverse understory, lush with epiphytes, tree ferns, mosses, and a variety of native fruit-producing plants, such as `ie`ie, `ōhā wai (*Clermontia* spp.), and `ōhelo (*Vaccinium* spp.), are probably associated with good kāma`o habitat. The `ie`ie vines favored by kāma`o still exist in some areas of the island, but not in the higher elevations to which the birds may be currently restricted. `Ie`ie does not thrive above 1,500 meters (5,000 feet) elevation (Wagner *et al.* 1999). The fact that the kāma`o once existed near sea level, but is now restricted to high elevation native forest without its most preferred food plant, suggests that it may be surviving in marginal habitat.

HISTORICAL AND CURRENT RANGE AND STATUS

In 1881, the kāma`o was considered extremely common in the moist forests near sea level on northern Kaua`i as well as in the upland interior mountain forests. It was still considered common on the outer forest edges in 1899, but by 1928 it became difficult to find in the lower forests. In 1941, it was still considered common in the upland interior forested plateau of the Alaka`i Wilderness Preserve (Munro 1944). The kāma`o became noticeably rare by the mid 1960s. At this time it remained only in the uppermost regions of the Alaka`i in very sparse numbers. From 1968 to 1973, Sincock (1982) found the kāma`o near the southern edge of the Alaka`i Wilderness Preserve, although one isolated occurrence was reported in the upper elevations of Kōke`e State Park (Figure 7). In the summer of 1985, two kāma`o were seen during an intensive 2-week survey of the Alaka`i (Hawai`i Department of Land and Natural Resources, unpubl. data). This followed the moderately severe Hurricane Iwa that occurred in November 1982. The last confirmed observation of the kāma`o was made during the February 1989 Kaua`i forest bird survey (Hawai`i Department of Land and

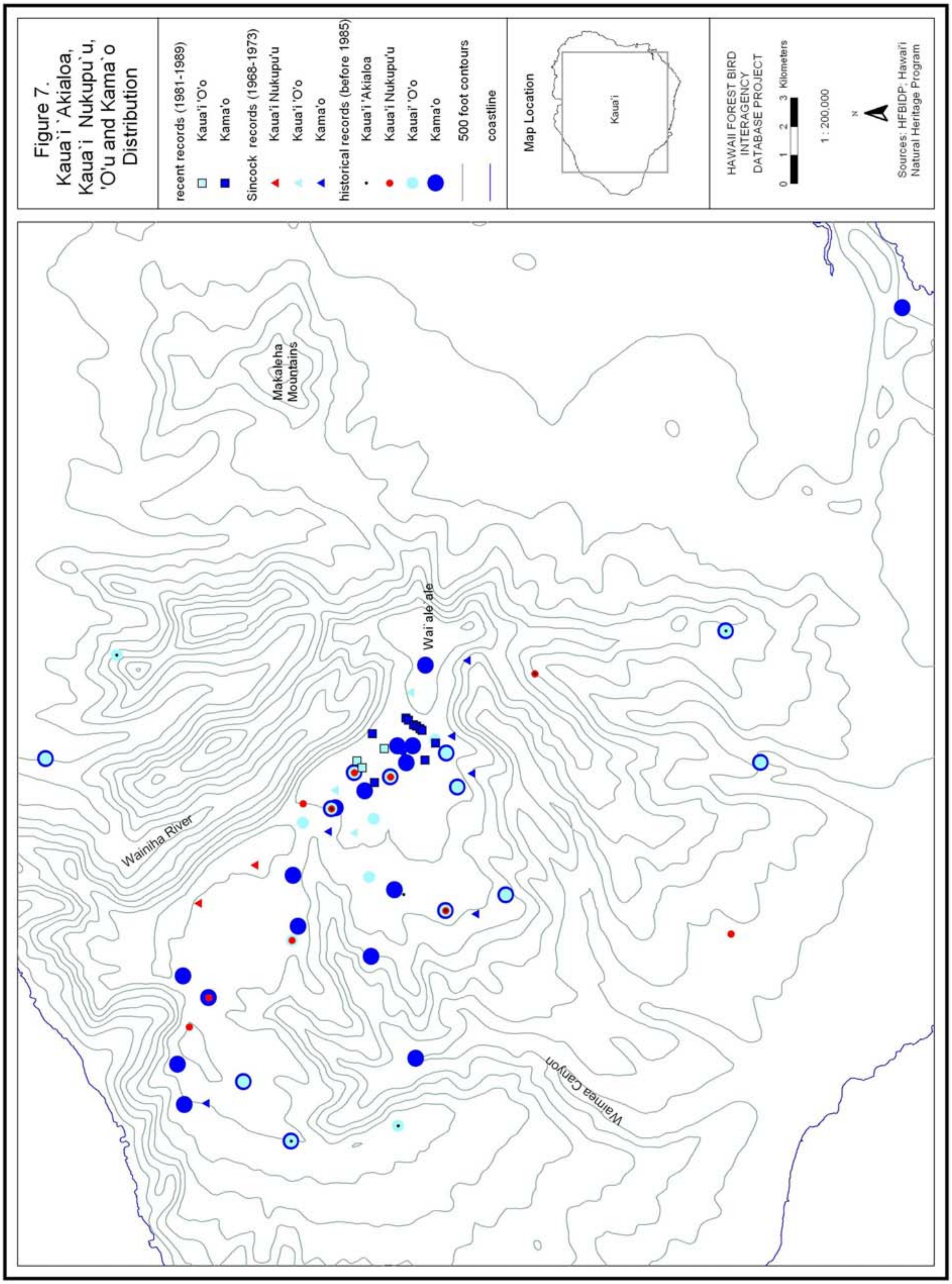


Figure 7.
Kaua`i `Akialoa,
Kaua`i Nukupu`u,
'O'u and Kama`o
Distribution
recent records (1981-1989)
Kaua'i 'O'o
Kama'o
Sincock records (1968-1973)
Kaua'i Nukupu'u
Kaua'i 'O'o
Kama'o
historical records (before 1985)
Kaua'i 'Akialoa
Kaua'i Nukupu'u
Kauai' 'O'o
Kama'o
500 foot contours
coastline
Map Location
Kaua'i
HAWAII FOREST BIRD
INTERAGENCY
DATABASE PROJECT
0 1 2 3 Kilometers
1 : 200,000
N
Sources: HFBIDP; Hawai'i
Natural Heritage Program
Makaleha
Mountains
Wai`ale`ale
Wainiha River
Waimea Canyon

Natural Resources, unpubl. data). In September 1992 hurricane Iniki severely damaged Kaua`i's forests. No sightings of kāma`o were made during a brief post-hurricane survey made in February 1993 (Telfer 1993; Hawai`i Department of Land and Natural Resources, unpubl. data), nor in more intensive surveys conducted in February and March 1994, March 2000, and March 2005 (Hawai`i Department of Land and Natural Resources, unpubl. data; Foster *et al.* 2004).

The fact that the kāma`o has not been seen since 1989 indicates this species is on the brink of extinction. It should be noted, however, that its congener, the puaiohi or small Kaua`i thrush, went many years without being seen, but is now known to number 300 to 400 individuals. Periodic unconfirmed sightings of the kāma`o have been reported since 1989, the most recent in 1995, suggesting the species could still survive. In view of the kāma`o's original widespread distribution to near sea level and the apparent negative impact of avian diseases and the destruction of its lowland habitat, it is unlikely that it will ever be restored to its historical range, but recovery of a population in the upper Alaka`i plateau is remotely possible, should any individuals persist. Additional targeted searches are needed to confirm the status of the species.

REASONS FOR DECLINE AND CURRENT THREATS

Avian disease is by far the most significant factor suspected to limit the kāma`o. Early ornithologists noted the difficulties these birds had with "lumps on their feet and sometimes at the corners of the mouth," which likely were avian pox lesions, transmitted by mosquitoes or other vectors. The fact that some good quality native forest with abundant fruit-bearing plants exists below their current range demonstrates that habitat destruction cannot account for the extirpation of the species in the lowlands and that factors other than habitat quality are limiting the population. The proliferation of introduced fruits, such as blackberry (*Rubus argutus*), banana passionflower (*Passiflora mollissima*), guava (*Psidium cattleianum*), and thimbleberry (*Rubus rosaefolius*) into the mid-elevations, may have been an attractive food source that enticed kāma`o into lower elevations where they were exposed to avian diseases such as pox and avian malaria.

If kāma`o are cavity or low platform nesters, as Hawaiian solitaires generally are, predators such as rats (*Rattus* spp.) may severely limit their nesting success and would explain why some of the smaller arboreally nesting species that nest higher off the ground have had a greater degree of nesting success. Feral cats (*Felis catus*) are occasionally found in high elevation rain forest habitat, and young solitaires foraging on the ground are probably one of the easier prey species for these predators.

Several introduced birds, including the Japanese white-eye (*Zosterops japonicus*), melodious laughing-thrush (*Garrulax canorus*), white-rumped shama (*Copsychus malabaricus*), and the recently established Japanese bush-warbler (*Cettia diphone*) share the same habitat with the kāma`o and may compete with the kāma`o for food and nest sites to some degree. The establishment of other potentially detrimental birds on Kaua`i, such as the red-vented bulbul (*Pycnonotus cafer*) found on some of the other Hawaiian Islands, remains a persistent threat.

Habitat degradation resulting from the invasion of pernicious alien weeds has drastically changed the forest structure and integrity. Two hurricanes in 1982 and 1992 severely disrupted portions of high quality native forest, and have made space for the germination and expansion of noxious weeds such as yellow ginger (*Hedychium flavescens*), daisy fleabane (*Erigeron karvinskianus*), glorybush (*Tibouchina urvilleana*), Japanese honeysuckle (*Lonicera japonica*), and others (see Table 10, page 4-50).

Feral pigs, and goats to a lesser degree, have had a long-term damaging effect upon native forests in the remaining kāma`o range by consuming and damaging understory vegetation, creating openings on the forest floor for weeds, and transporting weed seeds into the forest. Soil erosion and disruption of seedling regeneration of native plants is one of many forest management problems in kāma`o range.

Perhaps less obvious, but potentially detrimental to the health of the remaining kāma`o habitat, are introductions of new alien invertebrates to the forest ecosystem. Although kāma`o are primarily frugivorous, insects and spiders are likely to be an important component of the diet, especially for nestlings. Introductions of predatory and parasitic invertebrates that compete with native species for food pose a continuing threat throughout the islands. Introduced predatory insects also may reduce or eliminate specialized native insects that are necessary for pollination of certain food plants. Many of the food plants used by kāma`o could be negatively affected by herbivorous alien insects, such as the two-spotted leafhopper (*Sophonia rufofascia*), which may reduce their range, fruit set, and eventual survival. Introduced snails that prey on indigenous snails could also reduce food resources of the kāma`o. On the other hand, the detrimental effects of some of these new insects and molluscs could be somewhat offset if they are utilized as direct prey items by the kāma`o.

Finally, the remaining kāma`o population, if indeed it exists, is likely to be extremely small and genetically impoverished, increasing the risks of demographic instability and inbreeding depression.

CONSERVATION EFFORTS

So little is known about the kāma`o and its limiting factors that few species-specific conservation actions have been attempted. Efforts have centered on protecting the integrity of the remaining native forest habitat in the Alaka`i Wilderness Preserve where these and other endangered forest birds have survived during the past half century. The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. It was later strengthened and re-titled "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104, Rules Regulating Activities Within Forest Reserves," which protects native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the value of the pristine forest of that area and the need to control potential degrading factors.

The kāma`o was federally listed as endangered on October 13, 1970 (U.S. Fish and Wildlife Service 1970), and it became protected under the State of Hawai`i endangered species law on March 22, 1982.

Surveys and Monitoring. Regular surveys of Kaua`i forest bird populations and habitat conditions in the Alaka`i Wilderness Preserve have been conducted on established transects since the late 1960s. John L. Sincock, Research Biologist with the U.S. Fish and Wildlife Service, Kaua`i Field Station, conducted intensive status and distribution surveys of Kaua`i's forest birds from 1968 to 1973 (Sincock 1982). Large-scale, multi-agency surveys were conducted on established transects in 1981, 1985, 1989, 1994, 2000, and 2005 (Hawai`i Department of Land and Natural Resources, unpubl. data).

Control of Feral Ungulates. The Hawai`i Department of Land and Natural Resources has maintained liberal public hunting seasons to minimize forest damage caused by feral pigs and goats within the Alaka`i Wilderness Preserve for several decades. Unfortunately, public hunting succeeds only in the more accessible areas of the preserve, and ungulate populations in more remote areas remain quite high. Very limited aerial reconnaissance and shooting of feral goats and pigs has been attempted in the most remote regions, but has not been economically effective.

Public Information and Awareness. Materials featuring Kaua`i's endangered forest birds, as well as those found on other islands, have been published and provided to schools to assist in the effort to inform the public and gain support for conservation of endangered species. Privately funded filmmakers including the British Broadcasting Company and National Geographic Society have produced documentaries that inform the public of the plight of endangered forest birds. Several articles have appeared in popular nature magazines and local newspapers to increase public awareness of issues related to the conservation of Hawaiian forest birds, including those on Kaua`i.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

3. Oloma`o, *Myadestes lanaiensis rutha*

DESCRIPTION AND TAXONOMY

The oloma`o or Moloka`i thrush is a medium-sized (21 centimeters [8.3 inches] in length) solitaire with olive-brown upper parts, grayish white under parts, and a buffy patch at the base of the primaries. The bill and legs are dark. Juveniles exhibit the same scalloped plumage as other young native thrushes. Differences between the sexes and between adults and young have not been studied in detail, nor has molt, but may be similar to those of the closely related `ōma`o (*M. obscurus*) on Hawai`i Island. In that species, males are larger than females on average, and birds in first basic plumage usually retain juvenile scalloping in the wing coverts (Fancy *et al.* 1994). `Ōma`o molt from June through November (Ralph and Fancy 1994b).

The oloma`o is a member of the thrush family (Turdidae) and was historically found on the islands of Lāna`i and Moloka`i, although its former range may have included O`ahu and Maui as well. Recent changes in the taxonomy of the Hawaiian thrushes have done away with the endemic genus *Phaeornis* and instead placed them with the New World solitaires, *Myadestes*, to which they are similar in appearance and song (Pratt 1982, American Ornithologists' Union 1985). The two subspecies, *M. l. lanaiensis* of Lāna`i (now extinct) and *M. l. rutha* of Moloka`i (more grayish below), cannot be safely distinguished by coloration or measurements (Pratt 1982). With the wing measuring 95 millimeters (3.7 inches) and the tail 80 millimeters (3.1 inches), the oloma`o is slightly smaller and has a proportionately longer tail than the `ōma`o. Whether the `amaui (*M. woahensis*) of O`ahu and subfossil remains of solitaires from Maui may actually be oloma`o is one of the remaining questions regarding the systematics of the Hawaiian solitaires (Pratt 1982, James and Olson 1991).

LIFE HISTORY

The breeding biology of the oloma`o is largely unknown but may be similar to that of the closely-related `ōma`o. Three nests attributed to oloma`o were 8 to 9 meters (26 to 30 feet) up in `ōhi`a (*Metrosideros polymorpha*; two nests) and kōlea (*Myrsine* spp.; one nest) trees; one of the nests was found in May, and the dates of the other two were not recorded (Perkins 1903, Bryan

1908). In the `ōma`o, modal clutch size is two, both young usually fledge, and parents tend their fledglings for about 6 weeks (van Riper and Scott 1979, Wakelee *et al.* 1999). Successful `ōma`o parents can raise two broods per season. Immature birds are not known to provide care at subsequent nestings by their parents.

Oloma`o consume a variety of small fruits that they swallow whole and insects are taken at all levels in the forest (Rothschild 1893 to 1900, Perkins 1903, Bryan 1908). The diet of the `ōma`o is essentially the same, and these foods are also fed to nestlings (Perkins 1903, van Riper and Scott 1979, Wakelee *et al.* 1999).

Much like the related `ōma`o, oloma`o live solitarily or in pairs and seldom leave their small home range (Bryan 1908, Ralph and Fancy 1994b). They do not make long flights over the canopy, but rise above the trees during song flights (Bryan 1908). Like other Hawaiian solitaires, they often tremble their wings when perched (Rothschild 1893 to 1900, Perkins 1903, Bryan 1908).

Oloma`o are easily detected by song or calls. Oloma`o usually sing from treetops, but because of the song's ventriloquial quality, the singer is often difficult to locate (Bryan 1908). The song is beautiful, thrush-like, "of a jerky nature" (Rothschild 1893 to 1900), and similar to that of the `ōma`o (Bryan 1908). Described as voluble singers during the day, oloma`o also sing at night in good weather (Perkins 1903, Bryan 1908). Munro (1960) claimed that the Lāna`i bird was "no singer at all." Calls were reported as "a clear call-note" (Rothschild 1893 to 1900), and a questioning cat-like call (Rothschild 1893 to 1900, Bryan 1908), both notes similar to those of `ōma`o.

HABITAT DESCRIPTION

Oloma`o prefer closed forest; if in open forest, they stay close to cover (Bryan 1908). Originally they were ubiquitous throughout wet and dry forests on Moloka`i and Lāna`i, in the lowlands as well as at the highest elevations (Rothschild 1893 to 1900, Perkins 1903). The most recent records have all been from dense rainforest above 1,000 meters (3,300 feet) elevation adjacent to the steep pali (cliff) of Pelekunu (Scott *et al.* 1986).

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range of the oloma`o encompassed the mountains of East Moloka`i and Lāna`i (Figure 8). Bryan reported that oloma`o were most abundant at Hālawa, Moloka`i, where closed forest provided prime habitat (Rothschild 1893 to 1900, Bryan 1908). Past distribution may have included O`ahu (if the `amaui is considered the same species; James and Olson 1991) and Maui, where ample fossils of Hawaiian solitaires have been found (James and Olson 1991) and where, at `Īao Valley, a native informant claimed solitaires to be abundant in the 1860s (Perkins 1903).

The only detections of oloma`o since Bryan's trip in 1907 have been on Moloka`i, including: (1) two birds vividly described in 1963 at Pu`u Haha on Ka`āpahu ridge at 1,100 meters (3,600 feet; Pekelo 1963); (2) two sightings in 1975 one-half mile east (*sic*; west?) of Pu`u O Waha`ulu at 1,360 meters (4,460 feet; Scott *et al.* 1977); (3) five to six detections at various locations near the rim of Pelekunu and on Oloku`i during the Hawai`i Forest Bird Survey in 1979 and 1980 (Figure 8); and (4) a fleeting glimpse in 1988 on Kapapamoa ridge somewhat above 1,220 meters (4,000 feet) (A. Engilis, Ducks Unlimited, pers. comm.). At least three of the detections by the Hawai`i Forest Bird Surveys were questionable and were perhaps Japanese bush-warblers (*Cettia diphone*), a species that had just recently colonized Moloka`i. Scott *et al.* (1986) estimated a population of 19 ± 38 birds. Surveys in 1988, 1995, and 2004 turned up no oloma`o (Reynolds and Snetsinger 2001; Hawai`i Department of Land and Natural Resources, unpubl. data). Currently, there are no known oloma`o populations, and whether the species remains extant is unknown. Survey efforts for this species have been relatively low, due in part to the difficulty of accessing some of its best remaining habitat. An unconfirmed sighting in 2005 provided some hope that the species may still survive (G. Hughes, *in litt*. 2005). Additional searches are needed to ascertain the current status of the oloma`o with greater confidence, particularly of the Oloku`i Plateau.

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for decline and current threats presumably are the same as for other forest birds in Hawai`i. The Lāna`i population of oloma`o died out from 1923 to 1931 when Lāna`i City was built, and "the people brought bird disease

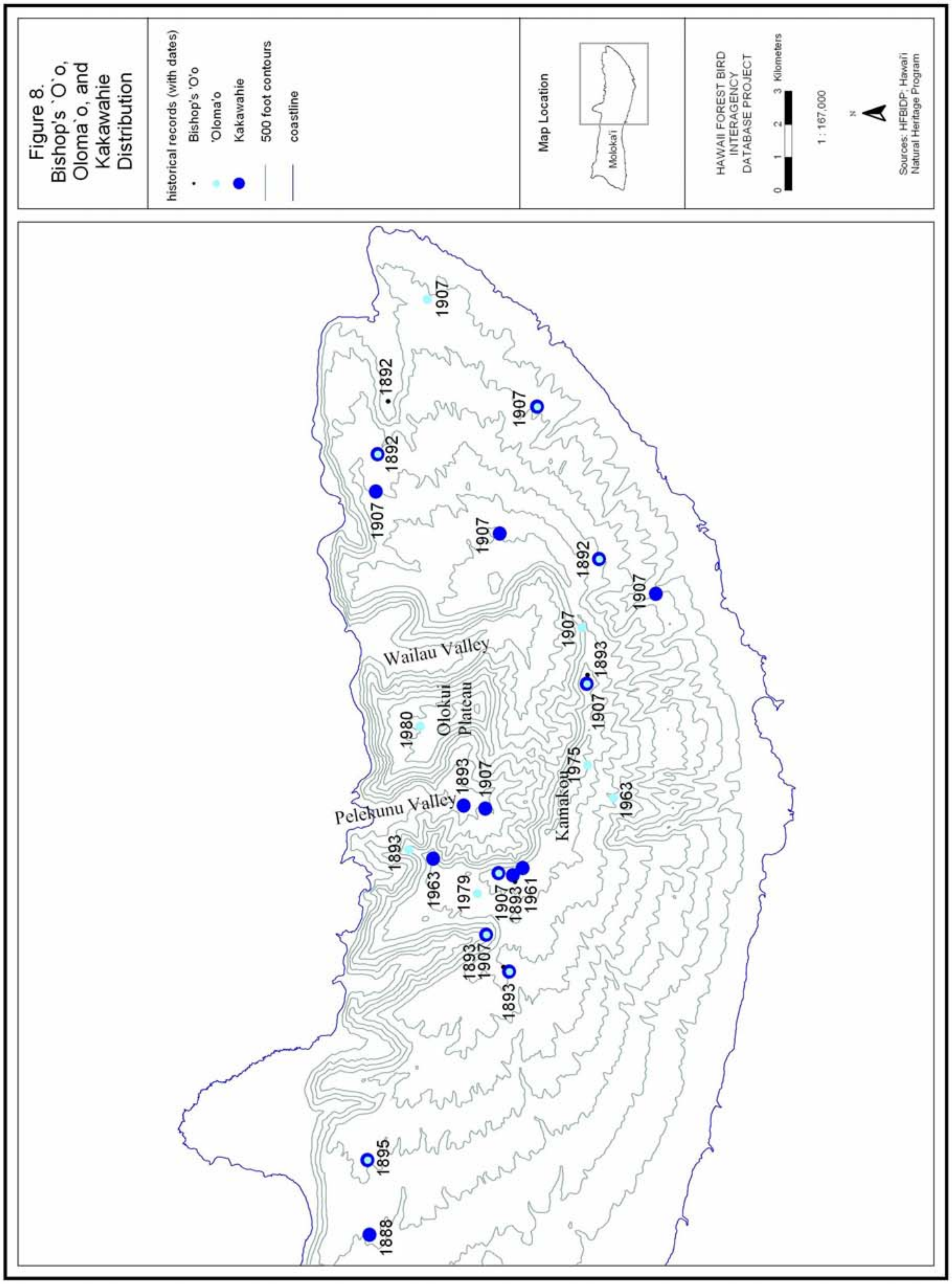


Figure 8. Bishop's `O`o, Oloma`o, and Kakawahie Distribution

with their poultry and these, evidently carried by mosquitoes, were fatal to the native bird population" (Munro 1960). Extensive habitat exists on O`ahu, Moloka`i, and Maui, but only on Maui could a solitaire population be established at elevations mostly above the reach of mosquitoes.

CONSERVATION EFFORTS

The oloma`o was federally listed as an endangered species on October 13, 1970 (U.S. Fish and Wildlife Service 1970), and was included in the Maui-Moloka`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1984a). Past conservation efforts have included the above-mentioned surveys, plus periodic surveys by the State of Hawai`i, and habitat protection. Habitat protection on Moloka`i includes ungulate and weed control on the Pu`u Ali`i Natural Area Reserve by the State of Hawai`i Department of Land and Natural Resources, and on the Kamakou Preserve by The Nature Conservancy of Hawai`i. Forest on the privately owned Lāna`i Hale, the highest point on Lāna`i, suffers from browsing by axis deer (*Axis axis*), for which hunting regulations change from year to year. For habitat protection on Maui, refer to the po`ouli species account.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

4. Puaiohi, *Myadestes palmeri*

DESCRIPTION AND TAXONOMY

The puaiohi or small Kaua`i thrush is a medium-sized (16.5 to 17.8 centimeters [6.5 to 7.0 inches] long; 37.0 to 43.0 gram [1.3 to 1.5 ounce]) solitaire, drab olive brown above, and medium gray below on the throat, belly and undertail coverts. The legs are pink and relatively long and the tail is relatively short. The eyes are dark with a prominent white eye-ring. The bill is dark gray and narrower than that of the kāma`o. Immatures have an off-white breast with prominent brown scalloping, and light-buffy spotting on the brown back. The simple reedy song usually consists of a preparatory whistle and a prolonged trill, followed by several sharp descending notes. It also commonly uses a scolding or hissing "sherrr" alarm note. Other calls are described in detail in Snetsinger *et al.* (1999).

Adult puaiohi. Photo pending permission

Early descriptions of the puaiohi were made by Rothschild based on skins obtained by Henry Palmer in 1891, in the mountains of Kaua`i at Halemanu (Berger 1972). Originally described as *Phaeornis palmeri*, Pratt (1982) offered convincing evidence that *Phaeornis* should be merged with the New World solitaire genus *Myadestes*, and that some Hawaiian thrushes formerly treated as subspecies are sufficiently distinct to merit full species status (Scott *et al.* 1986). The puaiohi is in the thrush family, Turdidae.

LIFE HISTORY

Puaiohi nest in cavities or on ledges, usually on vegetated overhanging rock faces, where the nest may be concealed by mosses and ferns (Kepler and Kepler 1983, Ashman *et al.* 1984, Snetsinger *et al.* 1999), or more rarely, in secondary cavities formed in trees (Snetsinger *et al.* 1999). Captive-bred and released birds nested more often in trees than did wild birds, although whether this is an effect of nest-site availability, inexperience, or sampling bias is unknown (Tweed *et al.* 2006). The great majority of available ecological information on wild breeding puaiohi comes from a 3-year study in the Upper Mōhihi drainage of the Alaka`i Wilderness Preserve (Snetsinger *et al*. 2005) During this study, 96 active nests were found, compared to only 4 reported previously for this species. The remainder of this section is drawn from that report unless otherwise indicated.

Puaiohi sing occasionally throughout the year, but with increased frequency immediately before and during the breeding season, with a peak from April to May. The frequency of song of an individual bird is dependent on its stage in the nesting cycle. A socially monogamous mating system is believed to predominate, but verifying this is impeded by the fact that few color-banded adults have been observed nesting. One instance of polygyny was recorded in 1999, when a captive-bred male paired and nested with two captive-bred females simultaneously (Tweed *et al.* 2006). Nesting begins as early as March, peaks from April to June, and continues with decreasing frequency through mid-September. Nest building requires 1 to 7 days, followed by a latent period of 8 to 10 days before the first egg is laid. The female alone builds the nest, and incubates and broods the young. Clutch size is almost always two, although Tweed *et al.* (2006) observed one- and three-egg clutches (one of each type) in captive-bred released females. Eggs are grayish-green to pale greenish-blue with irregular reddish-brown splotches (Berger 1972). Eggs hatch after 13 to 15 days. The male and female both provision the chicks, with the female acting as the primary provider while chicks are still in the nest. After fledging, the male assumes primary responsibility for feeding chicks while the female frequently initiates a subsequent nesting attempt. Occasionally (8 percent of nests), second-year and hatch-year birds assist in nest defense and feeding of nestlings and fledglings, although the relationship of helpers to the breeding adults is unknown. Recently fledged young are highly sedentary for 2 to 4 days after fledging, remaining within 2 meters (6 feet) of the ground, where they may be particularly vulnerable to predation by introduced mammalian predators.

Females readily and quickly re-nest after success or failure of a nesting attempt. This propensity to re-nest, combined with long breeding seasons (3 to 4.5 months) and high rates of nest success, led to remarkably high productivity in 1996 and 1997: an average of 2.8 and 4.9 fledglings per pair, respectively. In 1998, when El Niño Southern Oscillation drought struck the islands, the breeding season lasted only 1.7 months and nest success decreased, leading to production of only 0.4 fledglings per pair per year. The decrease in nesting success appeared to be due to elevated rat predation on nests and nesting females, although additional data are needed to confirm this trend. Whether the observed increase was due to a change in behavior of the rats or the birds, or to a population increase of rats after two favorable years, is unknown. Regardless, based on this limited evidence, it appears that puaiohi are vulnerable to severe drought and to rat predation.

Adult and juvenile survival and dispersal are poorly known because of the difficulty of marking and following sufficient numbers of birds over successive years. At least 73 percent of marked adults, and 25 percent of juveniles (first-year birds) survived until the April of the next breeding season. Dispersal distances of young may generally be short, a fact that has important implications for the rate of natural recolonization of recovering habitat. Of 31 nestlings banded in 1997, 5 established breeding territories 140 to 540 meters (460 to 1,772 feet) from their natal territory, 2 others were seen within 50 meters (164 feet) of the nest they hatched from, and 2 more were observed as floaters. If these short dispersal distances are representative, and keeping in mind the observations of helper behavior by second-year birds on their natal territories, one interpretation is that it is difficult for young puaiohi to establish breeding territories in high-quality sites, hence they may enhance their fitness either by helping their parents rear siblings, or by inheriting their parents' high-quality territories or nest sites.

The diet of the puaiohi includes fleshy native fruits, insects, snails, and other invertebrates (Wilson and Evans 1890 to 1899, Rothschild 1893 to 1900, Perkins 1903, Richardson and Bowles 1964, Snetsinger *et al.* 1999). During the non-breeding season, foraging attempts were 82 percent fruits and 18 percent insects or other invertebrates. While rearing nestlings, the proportion of foraging maneuvers directed at insects increased to 57 percent. A total of 75 percent of foraging attempts occurred in terminal fruit or leaf clusters in lower to midcanopy, 16 percent in upper canopy, 8 percent on main branches or trunks in midcanopy, and 1 percent on the ground. \`Ōlapa (*Cheirodendron trigynum*) fruit is known to be an important food of this bird (Richardson and Bowles 1964, Scott *et al.* 1986). Other important fruits include lapalapa (*C. platyphyllum*), \`ōhi\`a ha (*Syzygium sandwicensis*), kanawao (*Broussaisia arguta*), \`ōhelo (*Vaccinium* spp.), pa\`iniu (*Astelia* spp.), thimbleberry (*Rubus rosifolius*), pūkiawe (*Styphelia* *tameiameiae*), kāwa`u (*Ilex anomala*), and pilo (*Coprosma* spp.). In its earlier history, the puaiohi was reported by Perkins (1903) to be a bird of the underbrush and to be largely insectivorous, feeding on beetles, spiders and caterpillars, especially a beetle found on koa (*Acacia koa*) trees, which currently do not occur within the existing puaiohi range. Caterpillars and seeds were identified in the stomachs of type specimens (Perkins 1903).

pending permission

HABITAT DESCRIPTION

Puaiohi are permanent residents of stream valleys and associated ridges of the Alaka`i Wilderness Preserve and adjacent forest. Historically occupied habitat was mesic (1,000 to 2,000 millimeters [39 to 79 inches] rainfall a year) to extremely wet (2,500 to 13,000 millimeters [98 to 512 inches] rainfall a year,) montane forest, with deeply dissected terrain containing steep-walled ravines above 1,000 meters (3,300 feet) (Perkins 1903, Scott *et al.* 1986). Its mesic forest habitat is dominated by koa and `ōhi`a (*Metrosideros polymorpha*), while the wet forest is dominated by `ōhi`a, with subdominant `ōhi`a ha and several species of `ōlapa (*Cheirodendron*). Formerly occupied mesic forest is now dominated largely by introduced plant species, including fire tree (*Myrica faya*), glory-bush (*Tibouchina urvilleana*), kahili ginger (*Hedychium gardnerianum*), silk oak (*Grevillea robusta*), strawberry guava (*Psidium cattleianum*), and black wattle (*Acacia mearnsii*). Puaiohi are now confined to wet montane forest, with greater than 6,000 millimeters (236 inches) rainfall a year, at 1,050 to 1,300 meters (3,450 to 4,250 feet) (Scott *et al.* 1986, Snetsinger *et al.* 1999), and are associated with `ōlapa fruit (Scott *et al.* 1986) and `ōhi`a ha (Snetsinger *et al.* 1999).

Photo pending permission.

Although a strong flier, the puaiohi seems to have specific habitat requirements that keep it within areas that provide a year-round food supply and nesting habitat (Wilson and Evans 1890 to 1899, Perkins 1903, Snetsinger *et al.* 1999). Prime nesting sites are found on rock faces along small streams that drain the Alaka`i Wilderness Preserve to the south and west. Species density is currently low in some apparently suitable habitat, but the cause of this pattern is unknown. In recent years this included tracts directly east of Kōke`e State Park that were chosen for experimental release of captive bred birds in 1999, 2000, and 2001, and that now harbor an experimental population of fewer than 10 captive and wild birds.

HISTORICAL AND CURRENT RANGE AND STATUS

Even in the late 1800s, the puaiohi was considered exceedingly rare (Perkins 1903). It has been found in extremely limited numbers during the past half century. Sincock *et al.* (1984) estimated the population at 176 ± 192 for the period 1968 to 1973, and Scott *et al.* (1986) estimated that there were only about 97 ± 129 puaiohi within their 25 square kilometer (9.7 square mile) study area in the heart of the Alaka`i.

Based on more recent field surveys, the total current population of puaiohi is estimated to consist of 300 to 500 individuals (T. Savre, Kaua`i Forest Bird Recovery Project, pers. comm.), in stream valleys and on associated ridges above 1,050 meters (3,450 feet) elevation on the southern and central plateau of the Alaka`i Wilderness Preserve (Figure 9). Although this most recent estimate is slightly higher than previous estimates, it is unlikely that the population has actually increased since previous population estimates were made. The recent surveys have focused on puaiohi and have employed methods designed specifically for puaiohi, so the apparently higher population estimate is likely due to improved survey methods and greater effort. The breeding population is restricted to an area less than 25 square kilometers (9.7 square miles) in size, and more than half of the breeding population occurs within only 10 square kilometers (3.9 square miles). The highest densities of puaiohi occur in three adjacent drainages: the Upper Mōhihi, Upper Waiakoali and the northeastern upper Kawaikōī (the "core" or "Mōhihi/Waiakoali" population). In the Mōhihi, where the intensive study of breeding biology took place, adult puaiohi can be found at a density of approximately 6.3 pairs per kilometer (0.62 mile) of primary stream bottom, plus an undetermined number of floaters (Snetsinger *et al.* 2005). Helpers at the nest, in some cases known to be previously fledged young of the resident pair, were observed at 8 percent of 87 nests by Snetsinger *et al.* (2005). In the Mōhihi area, puaiohi density declines with elevation to about 1,050 meters

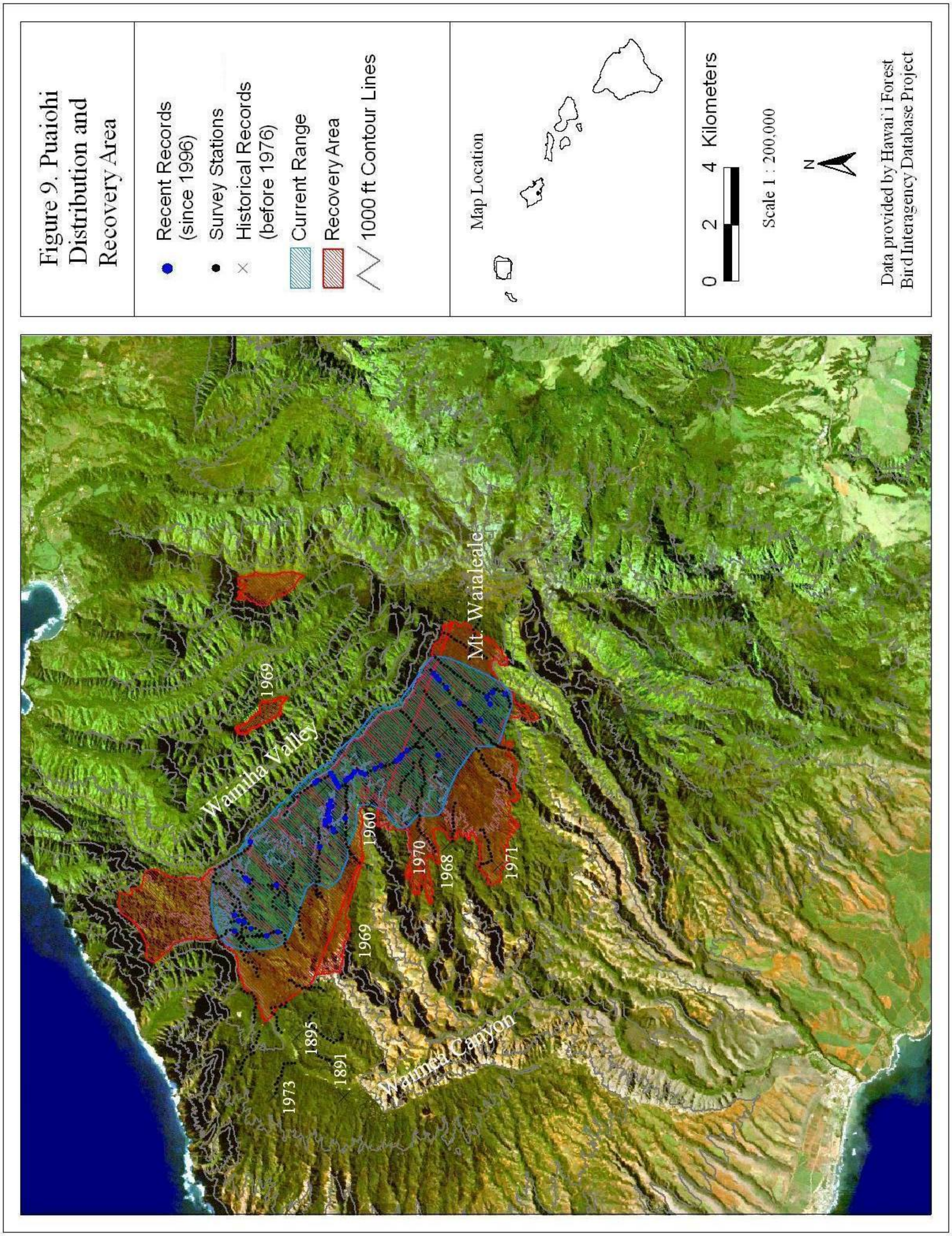


Figure 9. Puaiohi Distribution and Recovery Area

(3,450 feet), a pattern that may be applicable to other areas. The Mōhihi is contiguous with a relatively large area of habitat that probably supports medium to low densities along the Wai`alae Trail to the south and the forest reserve boundary to the north (T. Snetsinger, U.S. Geological Survey, unpubl. data).

The upper reaches of the Halehaha and Halepā`ākai drainages contain a medium-density population that probably continues in lower densities downstream, although the distributional limits of this population are unknown (the "Halehaha/ Halepā`ākai" population). Two small, low-density populations were detected during State forest bird surveys in 1994, on private lands along the Halekua and Waiau streams at the southern edge of the species' range. Neither population was detected during surveys in March 2000 (T. Telfer, Hawai`i Department of Land and Natural Resources, pers. comm.). As of 2006, several additional streams have been surveyed for puaiohi, bringing the total surveyed area to more than 70 percent of the species' current range, but these data have not yet been completely analyzed. These surveys include seven tributaries of the Koaie stream (low to medium puaiohi density), two upper branches of Waialae stream (low puaiohi density), and areas along the cliff edge above Wainiha valley (low to medium puaiohi density) (Hawai`i Division of Forestry and Wildlife and U.S. Geological Survey, unpublished data). Lā`au Ridge, where an incidental observation of puaiohi was made in 1969 (Sincock 1982), has rarely been visited in recent decades; crews did not detect any puaiohi there in March 2000, but a more thorough search is warranted.

The northwestern upper Kawaikōī drainage, near the intersection of the Alaka`i Swamp and Pihea Trails, harbored only two birds prior to the first release of captive-bred birds in connection with a captive propagation and reintroduction program in January 1999 (Kuehler *et al.* 2000).

REASONS FOR DECLINE AND CURRENT THREATS

Disease. Early ornithologists did not note difficulties with lumps on the feet and bills of puaiohi as they did with the kāma`o (evidence of avian pox, *Poxvirus avium*). However, avian diseases, including both pox and malaria (*Plasmodium relictum*), almost certainly limit puaiohi from the lower reaches of stream drainages with suitable nesting cliffs. Mist-netting of forest birds from 1994 to 1997 at three locations, Pihea/Alaka`i Swamp Trail, Koaie Stream**,** and

Sincock's Bog, documented 2 to 5 percent of individuals of all bird species with active malaria infections and up to 12 percent with malarial antibodies (C. Atkinson, U.S. Geological Survey, unpubl. data). Malarial infection rates were highest in the west, at Pihea, and lowest in Sincock's Bog. Mosquitoes are present to the highest elevations on Kaua`i (D. LaPointe, pers. comm.). Two fatalities of native birds near puaiohi habitat are attributed to malaria, indicating that active malaria transmission occurs in the area. The first, a Kaua`i `amakihi, occurred in the fall of 1999 in Kōke`e State Park, and the second, an `apapane, was found in late spring of 2006, just east of Koke`e State Park along the Pihea trail (C. Atkinson, pers. comm.).

As of 2006, only six wild puaiohi have been tested for disease. Of these, none had active infections, but one had antibodies to malaria, suggesting that at least some puaiohi may be able to survive malarial infection (Atkinson *et al.* 2001). However, it is impossible to tell from these data whether survival rates of infected puaiohi are high or low; low infection rates could reflect either low transmission rates or high mortality of infected birds. Because puaiohi are endangered, challenge experiments have not been used to determine survivorship of infected birds.

Predation from introduced mammals. Predators such as rats (*Rattus* spp.) may be a serious limiting factor on puaiohi nesting success and survival of breeding females (females are more vulnerable than males since they attend the nest at night when rats are active). Although their habit of nesting on steep cliff faces may provide some protection from nest predation, 48 percent of wild nest failures and 1 adult female's death were attributed to rats (Snetsinger *et al.* 2005), at least 4 of 9 failed nests built by captive-bred puaiohi were depredated by rats, and 2 nesting captive-bred females were killed by rats (Tweed *et al.* 2006). The tendency of young puaiohi to remain close to the ground for several days after fledging probably makes them particularly vulnerable to predation by feral cats.

Competition from introduced birds. Several introduced birds, including the Japanese white-eye (*Zosterops japonicus*), melodious laughing-thrush (*Garrulax canorus*), and white-rumped shama (*Copsychus malabaricus*) share the same habitat with the puaiohi to some degree and may compete with the puaiohi for food. These and other alien bird species, including the recently established Japanese bush-warbler (*Cettia diphone*), also may serve as reservoirs of disease.

The establishment of other potentially detrimental birds on Kaua`i, such as the red-vented bulbul (*Pycnonotus cafer*) found on some of the other Hawaiian Islands, remains a persistent threat.

Habitat degradation. Feral pigs, and goats to a lesser degree, have had a long-term damaging effect upon native forests in the remaining puaiohi range, opening space for weeds and transporting weed seeds into the forest. As the range of introduced black-tailed deer (*Odocoileus hemionus*) expands, it is expected that they too will degrade native forest. The negative impacts of feral ungulates on forested ecosystems in Hawai`i have been reviewed elsewhere (Cabin *et al.* 2000). Soil erosion and disruption of seedling regeneration of beneficial plants is one of many forest management problems within puaiohi range. Habitat degradation resulting from the invasion of many nonnative weeds has drastically changed the forest structure and integrity. Two hurricanes in 1982 and 1992 severely disturbed areas of native forest and made space for the germination and expansion of alien plants.

Perhaps less obvious, but potentially detrimental to the health of remaining puaiohi habitat, are additions of new exotic invertebrates to the forest ecosystem. Introduced species may affect the birds' food supply directly, as for example by the parasitoid wasps introduced as biocontrol agents, which are known to prey heavily on caterpillars in the Alaka`i (Henneman and Memmott 2001). Introduced snails that prey on indigenous snails could also reduce food resources of the puaiohi. Puaiohi may also be negatively affected indirectly by introduced insects that reduce fruit supplies. Newly introduced insects, such as the two-spotted leaf hopper (*Sophonia rufofascia*), are causing serious damage to many native and nonnative plants. Other introduced predatory insects may reduce or eliminate specialized native insects that are necessary for pollination of certain food plants. On the other hand, the detrimental effects of some introduced insects could be offset if they are eaten by puaiohi.

All of Kaua`i's endangered forest birds are so few in number that lack of genetic diversity poses potential problems. Some of these birds are highly specialized and are ill-adapted for rapid changes in their environment. The puaiohi, with a population size of 300 to 500 birds in a number of widely separated subpopulations, falls below the minimum effective population size of

500 individuals recommended for long-term maintenance of genetic diversity (Soulé 1987).

CONSERVATION EFFORTS

The puaiohi is the only one of the six endangered forest birds on Kaua`i that exists in sufficient numbers to allow research and species-specific management actions to take place. Beginning in 1995, the conservation community initiated a program to study and develop management techniques for this species. Actions taken towards conservation of the puaiohi include legal protection, ecological studies, reintroduction of captive-bred individuals, periodic surveys and inventories, control of feral ungulates, small mammal control, and information and education.

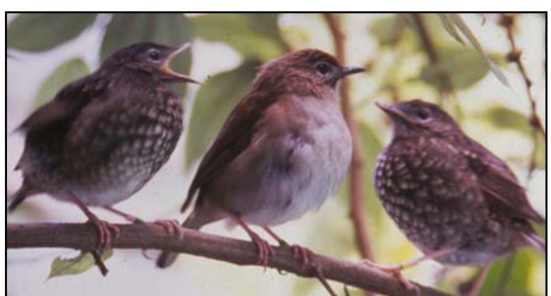
Legal Protection. The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. It was later strengthened and re-titled "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104, Rules Regulating Activities Within Forest Reserves," which protects native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the value of the pristine forest of that area and the need to control potential degrading factors.

The puaiohi was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service, 1967), and it was included in the Kaua`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1983b). By virtue of being on the Federal endangered species list, it also became protected under the State of Hawai`i endangered species law on March 22, 1982.

Ecological Studies. An intensive field study of the ecology and behavior of the puaiohi was initiated in 1995, with the cooperation of the Biological Resources Discipline, U.S. Geological Survey (then the National Biological Service), the Hawai`i Division of Forestry and Wildlife, The Peregrine Fund, the U.S. Fish and Wildlife Service, and Kamehameha Schools. A team of biologists was tasked with locating and learning more about the life history of the puaiohi. Over 200 active nests and old nests were located, and the breeding biology, nesting success, survival, dispersal, and behavior of the species were studied. The results of that research have been presented in quarterly and annual reports to cooperators, in a Birds of North America account (Snetsinger *et al.* 1999), and in several publications recently published, planned, or in preparation (e.g., Snetsinger *et al.* 2005). The biological and ecological data collected during that study forms the foundation on which to make decisions regarding future management of the species (Woodworth 2000).

Dr. Carter Atkinson of the Biological Resources Discipline, U.S. Geological Survey, initiated forest bird disease studies on several of the main Hawaiian islands, including Kaua`i, focusing primarily on blood-borne diseases within the range of endangered Hawaiian forest birds. This research is aimed at understanding the significance of disease and confirming the long-held theory that diseases brought to Hawai`i by introduced exotic birds, and the establishment of alien vectors of disease such as mosquitoes, have had a major role in the decline and extinction of native birds in Hawai`i. As a consequence of this research, one peer-reviewed article relating directly to the puaiohi has been published as of 2006 (Atkinson *et al.* 2001). Although it is a formidable task, hope exists for finding ways of mitigating the disease problem of rare native forest birds.

Captive Propagation and Reintroduction. Beginning in 1995, the U.S. Fish and Wildlife Service, The Peregrine Fund, U.S. Geological Survey, and the Hawai`i Division of Forestry and Wildlife began developing and testing rear-and-release and translocation techniques with the closely-related `ōma`o (*Myadestes obscurus*) as a surrogate for the endangered puaiohi. The research showed that rearing Hawaiian solitaires in captivity and releasing them to the wild using soft-release techniques was highly successful (Kuehler *et al.* 2000). Furthermore, captive-reared yearling birds had greater site fidelity than translocated adult birds (Fancy *et al.* 2001).



Captive adult puaiohi with two fledglings. Photo © Jack Jeffrey.

A captive breeding program for puaiohi was established at The Keauhou Bird Conservation Center on Hawai`i and at the Maui Bird Conservation Center.

The program began in 1996, when five eggs were hatched in captivity from eggs collected from the wild. An additional 10 birds from wild eggs were added to the captive breeding program in 1997 (The Peregrine Fund 1996, 1997).

Maintaining a large captive-breeding program encompassing 90 percent of the original genetic variation of the wild population, although ideal, may not be necessary for puaiohi. A small captive flock may be sufficient for several reasons: (1) a wild reproducing population still exists (~200 females), (2) the newly-established population of puaiohi is not genetically isolated, dispersal distances of captive-reared released birds are long enough to link subpopulations, and pairings between captive-bred and wild birds have been observed, and (3) additional founder stock can be collected from the wild in the future, if necessary, to augment the genetic diversity in captivity. If genetic diversity of the captive flock drops below 90 percent, and funding, prioritization of facility use, and concurrence is reached by the Captive Propagation Partnership, the captive population may be augmented with wild-collected eggs.

The release of captive-bred birds into the wild was begun in 1999, when The Peregrine Fund released 8 females and 6 males into the Kawaikōī drainage, western Alaka`i, and monitored them using radio telemetry for 30 days. One-hundred percent of the birds survived the first 30 days post-release, and appeared to be adept at foraging in the wild (Kuehler *et al.* 2000). Follow-up monitoring by the U.S. Geological Survey demonstrated that all 14 birds survived at least 9.5 weeks after release, and 7 established breeding territories in the Kawaikōī, while the rest dispersed to other drainages (Tweed *et al.* 2003). Both captive-captive and captive-wild pairings were documented (Tweed *et al.* 2006).

On February 1, 2000, an additional 5 birds (4 females, 1 male) were released by The Peregrine Fund/Zoological Society of San Diego and an additional cohort of 15 birds was released in spring 2001 by the Zoological Society of San Diego. The overall release strategy for the first 3 consecutive years of releases (1999 to 2001) is considered highly successful, with 31 of 34 released birds surviving to 30 days after release and released animals breeding in the wild with nesting success comparable to that of wild birds (Zoological Society of San Diego 2001, Tweed *et al.* 2006). However, the Kawaikōī population appears not to have grown appreciably since the last release in 2001, based on limited surveys in 2003 of at least 5 birds in the general release area (T. Savre, pers. comm.).

A second release site for puaiohi was established in the Halehaha/Halepā`ākai stream drainage in good quality puaiohi habitat, and releases have been conducted there for 5 years. As of 2006, a total of 79 puaiohi (43 females, 36 males) have been released at this site by the Zoological Society of San Diego, including 8 birds in 2002, 18 birds in 2003, 17 birds in 2004, 17 birds in 2005, and 19 birds in 2006. This site differs from the Kawaikōī drainage in that the forest is considerably less degraded, and also that wild puaiohi exist there at medium densities.

For releases conducted from 1999 to 2002, 36 of 42 (85.7 percent) released birds survived to 30 days post-release, and survival during the subsequent 40 to 50 days ranged from 67 percent in 1999 to 71 percent in 2001 and 83 percent in 2002. However, only 20 to 43 percent of released birds established breeding territories in the target drainage each year, and the majority of released birds dispersed several kilometers away, often in the direction of high-density populations (Tweed *et al.* 1999, Monahan *et al.* 2001, Pratt *et al.* 2002). Of puaiohi released between 2003 and 2005, most released birds did not breed in the release drainage: no more than four puaiohi (in 2003) established breeding territories in the Halehaha/Halepā`ākai drainages. The maximum known dispersal distances of birds released between 2003 and 2006 averaged 3.0 to 3.8 kilometers (1.8 to 2.3 miles) (P. Roberts, Kaua`i Forest Bird Recovery Project, pers. comm.).

Periodic Surveys and Inventories. Regular surveys and inventories of Kaua`i forest bird populations and habitat conditions within the Alaka`i Wilderness Preserve have been conducted on established transects since the late 1960s. John L. Sincock, research biologist with the U.S. Fish and Wildlife Service, Kaua`i Field Station, conducted intensive status and distribution surveys of Kaua`i forest birds between 1968 and 1973 (Sincock 1982). Large-scale multi-agency surveys were conducted on established transects in 1981, 1985, 1989, 1994, 2000, and 2005 (Hawai`i Department of Land and Natural Resources, unpubl. data).

The Hawai`i Rare Bird Search Team made an intensive systematic effort to locate any surviving endangered Kaua`i forest bird populations in the mid-1990s (Reynolds and Snetsinger 2001). They were successful in locating puaiohi (55 to 70 individuals), providing the impetus for subsequent field studies, but no other endangered birds were recorded during the search (Reynolds and Snetsinger 2001). From 2002 to 2005, the Hawai`i Department of Land and Natural Resources, Division of Forestry and Wildlife, has conducted systematic surveys for puaiohi in all suitable habitat to better understand species distribution and total population, and this formed the basis for an improved population estimate, presented here.

Control of Feral Ungulates. The Hawai`i Department of Land and Natural Resources has maintained liberal public hunting seasons to minimize forest damage caused by feral pigs and goats within the Alaka`i Wilderness Preserve for several decades. Unfortunately, public hunting occurs only in the more accessible areas of the preserve, and ungulate populations in some remote areas remain quite high. Limited aerial reconnaissance and aerial shooting of feral goats and pigs has been attempted in the most remote regions, but has not been economically effective. Long-term protection of the Alaka`i from feral ungulates will require creativity, commitment, political savvy, improved public relations, and significant financial support.

Small Mammal Control. Rat control using registered rodenticides and snap traps might increase nesting success in some areas. Reduced rat predation of nests in the Mōhihi drainage where rats were actively trapped supports this idea, although overall nest success was high (Snetsinger *et al.* 2005). Logistical obstacles to rodent control may be especially great in the Alaka`i, given the difficulty of maintaining bait stations without disturbing native plants in the steep terrain, and the challenges of placing bait near the vertical rock faces on which puaiohi nest.

Information and Education. Materials featuring Kaua`i's endangered forest birds, as well as those found on other islands, have been published and provided to schools to assist in the effort to inform the public and gain support for funding to conserve endangered species. Privately funded filmmakers, including The British Broadcasting Company and National Geographic Society, have filmed and publicized the plight of endangered forest birds. Several articles have appeared in popular nature magazines and local newspapers to tell the story of the endangered Hawaiian forest birds, including those on Kaua`i. Audubon magazine featured the puaiohi recovery effort in its February 1999 issue. Staff directly involved with the puaiohi recovery project have made presentations at public fairs on Kaua`i as well as at scientific conferences.

RECOVERY STRATEGY

Habitat Protection. Prospects for recovery of the puaiohi lie in maintaining and restoring forest habitat by developing, testing, and applying broad-scale habitat restoration measures, including: control of feral ungulates through a combination of hunting, fencing, snaring, and possibly development of lethal non-toxicant devices for use in areas inaccessible to hunters, or in areas closed to hunters; controlling the encroachment of noxious weed plants and insects through tested bio-control, and where feasible, mechanical and chemical measures; and continuing enforcement of State and Federal laws that protect against destructive human activities and development.

Predator Control. A need exists to develop, test, register, and apply toxicants for control of introduced rodents and feral cats in remote forested habitat. The prevention of additional introductions of exotic plants, insects, mammals (especially the small Indian mongoose *Herpestes auropunctatus*, currently a resident on other Hawaiian islands), and alien birds that may act as predators on, or competitors with, native birds is necessary.

Captive Propagation and Reintroduction Programs. Augmentation of natural dispersal and recolonization of recovering habitat through reintroduction of captive-bred puaiohi in selected areas is desirable. Such reintroductions increase the range of the species and increase the probability that the species will survive future catastrophes such as hurricanes or disease outbreaks.

Population Surveys and Monitoring. Continued monitoring of the status of forest bird populations and their habitats to measure the effectiveness of management actions is necessary.

Research and Identification of Limiting Factors. Demographic research to obtain better information on survival, reproduction, and recruitment rates is needed to better understand how to best manage the species, and to help determine whether the release of captive-bred birds provides a significant long-term benefit. Evaluating the relative importance of disease, predators, food, and habitat change in restricting the puaiohi's range and population growth would benefit the development of long-term strategies for conserving the species. The current limited range size renders the species extremely vulnerable to hurricanes, new diseases, and other catastrophic habitat changes. Increasing the range and/or total population size would mitigate these risks.

Other. Continued public information sharing is needed to help generate support for the Kaua`i Forest Bird Project and for habitat management.

5. Kaua`i `Ō`ō, *Moho braccatus*

DESCRIPTION AND TAXONOMY

One of few photographs of the Kaua`i `ō`ō. Photo © Rob Shallenberger.

The Kaua`i `ō`ō or `ō`ō `ā`ā is one of four known Hawaiian species of the genus *Moho* and one of five known Hawaiian bird species within the honeyeater family, Meliphagidae (Sykes *et al.* 2000). It is 19.5 centimeters (7.7 inches) long, shorter-tailed, and somewhat smaller than the `ō`ō species on the other islands, hence the "`ā`ā," meaning dwarf `ō`ō. It is glossy black on the head, wings, and tail; smoky brown on the lower back, rump and abdomen; and rufous-brown on the upper tail coverts. It has a prominent white patch at the bend of the wing. The throat feathers are black with a subterminal bar of white, giving a barred or scaled effect. The thigh feathers are golden yellow in adults, but black in immatures. The iris is dull yellow. The bill and feet are black, and the soles of the feet pale yellow (Berger 1972).

The song consists of loud whistles that have been described as flute-like, hollow, echoing, and haunting. A call note was described as a distinct "took-took" (Munro 1944). Nesting birds are reported to use a "beep beep" call (Scott *et al.* 1986).

LIFE HISTORY

Much of what is known about the life history of the Kaua`i `ō`ō was learned by John L. Sincock who spent many months between 1967 and 1978 searching for and studying Kaua`i's rare birds (Sincock 1982). Its last known habitat was dense native `ōhi`a (*Metrosideros polymorpha*) forest in the deep stream valleys of the central Alaka`i Wilderness Preserve. The only known nests were located in cavities of large dead `ōhi`a snags. One nest was described as being 12 meters (40 feet) above the ground in a dead `ōhi`a tree (Berger 1972). There is little information on the extent of the nesting season, but two nestlings were reported in a single nest in June 1971, and two other nests were monitored in late May and early June (Sincock 1982).

The diet is reported to be insects, spiders, millipedes, moths, crickets, snails, `ōlapa (*Cheirodendron*) fruits, and nectar from `ōhi`a, lobelia, and other flowering plants (Richardson and Bowles 1964; Sincock 1982). Early ornithologists reported that `ō`ō fed heavily on the flower bracts of `ie`ie (*Freycinetia arborea*), which was abundant in formerly occupied low elevation forest habitat, but is not found in the upper elevation forests that were last occupied.

HISTORICAL AND CURRENT RANGE AND STATUS

The Kaua`i `ō`ō was reportedly very common from near sea level to the high interior forests of Kaua`i up to the end of the 19th century, but after only 3 decades it was thought to be close to extinction (Figure 7, page 2-21; Munro 1944). Except for inconclusive reports of possible vocalizations, it went without observation until rediscovered by Donagho (1941) and again by Richardson and Bowles (1961). Sincock located and described the first nest in a tree cavity in 1971, and followed subsequent nests in 1972 and 1973. Upon rediscovery during the late 1960s, the Kaua`i `ō`ō population was estimated at only 36 birds (Sincock 1982). Only a single pair was found during an intensive survey made in 1981 (Scott *et al.* 1986). Two hurricanes that struck Kaua`i in 1982 and 1992 caused much forest damage and possibly eliminated the remnant population. The last plausible record of a Kaua`i `ō`ō was a vocal response to a recorded vocalization played by a field biologist on April 28, 1987, in the locality of Halehaha/Halepā`ākai Stream (J. Krakowski, Hawai`i Department of Land and Natural Resources, pers. comm.). It is likely that the Kaua`i `ō`ō is now extinct; no subsequent sightings or vocalizations have been documented despite extensive forest bird surveys in 1989, 1994, 2000, and 2005, and a rare bird search conducted in 1996 (Reynolds and Snetsinger 2001). The vocalizations of this species are loud and distinctive, and are unlikely to be overlooked.

REASONS FOR DECLINE AND CURRENT THREATS

As with several other endangered Kaua`i forest birds, the Kaua`i `ō`ō was once considered a very common species in the lowlands as well as in upland forests. The rather sudden decline in numbers noted during the first two decades of the 20th century (Munro 1944) points to a limiting factor that had an acute impact on the species. Unfortunately, the Kaua`i `ō`ō is now so rare, or possibly extinct, that identification of threats and reasons for its decline is difficult, if not impossible. Habitat destruction by agricultural development obviously reduced their lowland range, but does not explain the sudden decline noted in the interior uplands as well. After the turn of the century, a large number of alien birds were introduced as many of the native lowland birds disappeared. Some of these alien species may have harbored foreign diseases or parasites for which the `ō`ō had little or no immunity. The mosquito vector of blood-borne diseases was already well established, and could have brought about a rapid decimation of a highly susceptible endemic bird. The fact that *Moho* on other islands suffered a similar fate during approximately the same period suggests disease as a major limiting factor, coupled with the fact that the last `ō`ō were found only at higher mosquito-free elevations. It is possible that the remote high elevation forests of Kaua`i where the `ō`ō persisted was marginal habitat that may have lacked suitable cavities for nest sites.

The use of large old-growth snags for nesting and the paucity of any large-timbered forests after the turn of the century may have limited the `ō`ō's ability to find suitable nest sites, particularly after two hurricanes struck Kaua`i in 1982 and 1992. Cavity nests may also be more susceptible to foraging rats known to be numerous in Hawai`i's forests. Polynesian rats (*Rattus exulans*) are presumed to have become established in the islands with the arrival of the first Polynesian settlers (Tomich 1969). The black rat (*Rattus rattus*) evidently established itself in Hawai`i after the advent of the European explorers in the late 1700s. The demise of many of Hawai`i's forest birds seemed coincident with the arrivals of various new alien fauna, yet the Kaua`i `ō`ō decline was apparently quite sudden, suggesting a particular susceptibility to a single potent limiting factor. Other impacts on their habitat, such as forest damage by feral pigs, goats, and the spread of invasive plants, likely had a supplemental negative impact on the species.

CONSERVATION EFFORTS

The Kaua`i `ō`ō was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Kaua`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1983b). The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. Later strengthened and re-titled, "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104, Rules Regulating Activities Within

Forest Reserves," it protects native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the value of the pristine forest of that area and the need to control potential degrading factors.

A multi-agency research project aimed at the recovery of the critically endangered puaiohi was initiated in 1995 (see puaiohi account). Information about other endangered Kaua`i forest birds has been gained incidentally, but unfortunately no Kaua`i `ō`ō have been observed during this project. Other research by U.S. Geological Survey personnel is examining the threat from alien diseases and alien vectors of disease, such as mosquitoes, on native forest birds on Kaua`i (C. Atkinson, U.S. Geological Survey, unpubl. data). The Hawai`i Rare Bird Search Team made an intensive systematic effort to locate any surviving endangered forest birds on Kaua`i, but no `ō`ō were recorded during the search (Reynolds and Snetsinger 2001).

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

6. \`Ō\`ū, *Psittirostra psittacea*

DESCRIPTION AND TAXONOMY

One of few photographs of the \`ō\`ū. Photo © Rob Shallenberger.

The \`ō\`ū is a heavy-bodied Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) approximately 15.5 to 17.5 centimeters (7 inches) in total length. The upper parts are dark olive-green, and the under parts are a lighter olive-green grading to whitish on the undertail coverts. The wings and tail are a darker brownish olive. \`Ō\`ū are sexually dichromatic, males having a bright yellow head that contrasts sharply with the back and breast, and females having an olive-green head similar in color to the back. Juveniles are similar to the female in color but somewhat darker. In both sexes the bill is pale pink to straw-colored, with a hooked, parrot-like upper mandible. The legs are pinkish (Munro 1960, Berger 1981, Pratt *et al.* 1987). Males are slightly larger than females.

The \`ō\`ū is a member of the thick-billed Hawaiian honeycreeper tribe (Psittirostrini) and was described by J. G. Gmelin in 1789 from a specimen collected in 1779 (Bryan and Greenway 1944). \`Ō\`ū were found historically on the islands of Hawai\`i, Maui, Moloka\`i, Lāna\`i, O\`ahu, and Kaua\`i, with no known geographic variation (Amadon 1950).

LIFE HISTORY

Although common early in the 20th century throughout most of its range, little has been reported on the life history of the \`ō\`ū (see Snetsinger *et al.* 1998 for a summary of available life history information). Nesting of the \`ō\`ū has never been described and little is known of its breeding habits. Females collected from late March to mid-May had enlarged ovaries, and large numbers of fledglings were noted in June by Perkins, suggesting a peak in nesting during April and May (Rothschild 1893 to 1900, Perkins 1903, Banko 1986).

Collectors in the late 1800s noted that \`ō\`ū fed mainly on the large inflorescences of *Freycinetia arborea* or \`ie\`ie, were fond of the yellow fruits of arboreal *Clermontia* species, and took fruits from many other native trees

(Henshaw 1902, Perkins 1903). Perkins (1903) noted them feeding exclusively on caterpillars (Geometridae), feeding them to young during the summer months in the Ka`ū/Kīlauea area of the Big Island. `Ō`ụ are also known to feed on young koa (*Acacia koa*) leaves, nectar, and on alien fruits such as guava, mountain apple, banana, peach, and mulberry (Henshaw 1902, Perkins 1903, Munro 1960, Scott *et al.* 1986).

Perkins (1903) reported that `ō`ū followed fruit ripening along elevational gradients in the Kona area. He observed them moving from the "wet belt" to the high, dry forests when `ie`ie fruits were scarce and occasionally moving down slope to feed on alien fruits. The `ō`ū is a strong flier and at times was observed flying in small flocks high over the forest canopy to feeding sites (Perkins 1893, Berger 1981).

HABITAT DESCRIPTION

Historically `ō`ū were known from a wide range of forests extending from sea level to alpine areas, but dense `ōhi`a (*Metrosideros polymorpha*) forest with `ie`ie was considered to be preferred habitat (Perkins 1903, Bryan 1908). Although wide elevational movements from the upland māmane (*Sophora chrysophylla*) forests to lowland forests to feed on guava and kukui were observed seasonally in the past (Perkins 1903), recent sightings on Kaua`i (Engilis and Pratt 1989) and Hawai`i (U.S. Fish and Wildlife Service, unpubl. data) show `ō`ū to be confined to mid-elevation (900 to 1,500 meters [3,000 to 5,000 feet]) mesic and wet `ōhi`a forests with 1,200 to more than 2,500 millimeters (47 to 98 inches) annual rainfall. In this area the canopy is dominated by `ōhi`a 10 to 25 meters (33 to 82 feet) high, with a subcanopy of `ie`ie, hāpu`u tree fern (*Cibotium* spp.), `ōlapa *(Cheirodendron* spp.), kāwa`u (*Ilex anomala*), kōlea (*Myrsine* spp.), and pilo (*Coprosma* spp.). These elevations are well within the "mosquito zone" where most native forest birds have been extirpated by mosquito-borne avian malaria and avian pox (Scott *et al.* 1986).

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, `ō`ū habitat extended from lowland dry and mesic forests to montane mesic and wet forests on all of the major Hawaiian Islands (Figure 10;

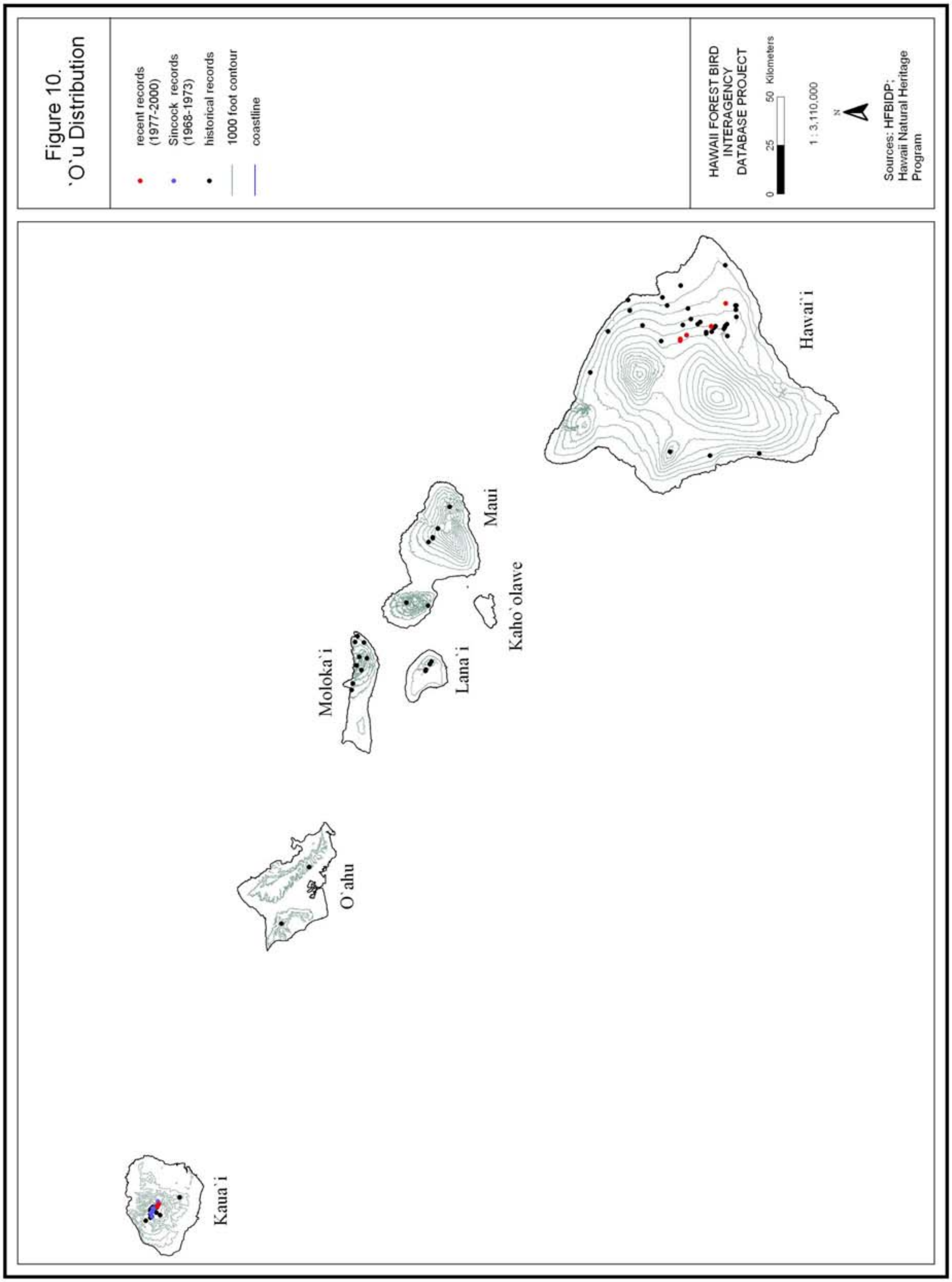


Figure 10.
`O`u Distribution
recent records (1977-2000)
Sincock records (1968-1973)
historical records
1000 foot contour
coastline
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0 25 50 Kilometers
1 : 3,110,000
N
Sources: HFBIDP; Hawaii Natural Heritage Program
Hawai`i
Maui
Kaho`olawe
Lana`i
Moloka`i
O`ahu
Kaua`i

Perkins 1903, Scott *et al.* 1986). The `ō`ū is currently one of the rarest birds in Hawai`i, and may possibly be extinct, although past survey efforts have been insufficient to determine its status (Reynolds and Snetsinger 2001). The most recent observations indicate any remaining populations are extremely localized in occurrence, and are restricted to only a fraction of their former range in the mid-elevation `ōhi`a forest on the islands of Kaua`i and Hawai`i only (Figure 10). During the Hawai`i Forest Bird Survey from 1976 to 1981 (Scott *et al.* 1986), fewer than 40 `ō`ū were detected during 13,500 count periods on Hawai`i Island. `Ō`ụ̄ were detected during the Hawai`i Forest Bird Survey on the eastern slopes of Mauna Kea and Mauna Loa on Hawai`i and in the Alaka`i Wilderness Preserve on Kaua`i. Population estimates during the Hawai`i Forest Bird Survey in the late 1970s indicated 400 ± 300 (95 percent confidence interval) birds on Hawai`i Island and 3 ± 6 (95 percent confidence interval) birds on Kaua`i (Scott *et al.* 1986). More recent surveys have failed to detect any `ō`ū on either island, although occasional unconfirmed sightings are reported (Reynolds and Snetsinger 2001; U.S. Fish and Wildlife Service, unpubl. data). Reexamination of past survey data indicates the level of survey effort has to date been insufficient to confirm the status of the species (Scott *in litt*. 2006), and Reynolds and Snetsinger (2001) concluded that important habitat areas for `ō`ū were not searched adequately or under appropriate weather conditions during the Hawai`i Rare Bird Search in the mid-1990s. Additional targeted searches are needed to confirm the status of the `ō`ū, especially in the Ka`ū, Upper Waiākea, and Pu`u Maka`ala Districts of Hawai`i (Reynolds and Snetsinger 2001, Scott *in litt*. 2006).

REASONS FOR DECLINE AND CURRENT THREATS

Modification and loss of habitat have played a significant role in the decline of the `ō`ū. Forest degradation by introduced ungulates has reduced or eliminated forest habitat and food resources by converting vast areas of koa and `ōhi`a forest to pasturelands. Feral pigs have caused degradation of the understory in wet forests, destroyed food plants such as `ie`ie and *Clermontia* species, and have created mosquito breeding sites (Stone 1985).

`Ō`ū primarily inhabited the lower to mid-elevation forests (Perkins 1903), where the impact on native forest birds from introduced diseases transmitted by mosquitoes was most severe (Warner 1968, van Riper *et al.* 1986). `Ō`ū also moved seasonally to lower elevations to take advantage of abundant food resources (Perkins 1903), which may have increased their exposure to mosquitoes and hastened their decline.

Predation by cats and rats on eggs, young, and adults has contributed to the decline of many forest birds, probably including the \`ō\`ū. Herbivory by introduced black rats on the fruits and flowers of \`ie\`ie and other native fruiting plants also may have reduced food resources for native birds in forests throughout Hawai\`i (Banko and Banko 1976).

Recent natural disasters may have affected some of the last remaining \`ō\`ū populations. On the Island of Hawai\`i, a large portion of the Upper Waiākea Forest Reserve, location of some of the last observations of \`ō\`ū and considered prime habitat for the species, was inundated by the 1984 Mauna Loa lava flow, destroying thousands of acres of forest and creating a treeless corridor over a kilometer (0.62 mile) wide. On Kaua\`i, two strong hurricanes, Iwa in 1982 and Iniki in 1992, had devastating effects on native forest habitat and native bird species. Three native bird species, \`ō\`ū, \`ō\`ō, and kāma\`o, have not been seen since Hurricane Iniki.

CONSERVATION EFFORTS

The \`ō\`ū (*Psittirostra psittacea*) was federally listed as an endangered species on March 11, 1967 (U.S. Fish and Wildlife Service 1967), and it became protected under the State of Hawai\`i endangered species law on March 22, 1982.

No conservation efforts have been initiated specifically targeting \`ō\`ū, but several research projects and Federal and State land management programs aimed at removing limiting factors for endangered birds and plants have been undertaken since 1985, and these provide some benefits to \`ō\`ū. On Hawai\`i Island, large tracts of State and federally owned land are being intensively managed for habitat restoration. Hawai\`i Volcanoes National Park, Hakalau Forest National Wildlife Refuge, Pu\`u Maka\`ala Natural Area Reserve, and the \`Ōla\`a/Kīlauea Forest Partnership area have been known to harbor \`ō\`ū in the past 25 years, and each area currently has management programs aimed at removing feral ungulates to restore native forest habitat and ongoing research into eliminating other threats.

On Kaua`i, liberal public hunting has been in place for many years, which has assisted in the control of feral pigs and goats in the more accessible western Alaka`i. Unfortunately, public hunting succeeds only in the more accessible areas of the preserve, and ungulate populations in more remote areas remain quite high. Alternatives are of limited effectiveness, expensive, and logistically difficult. Very limited aerial reconnaissance and aerial shooting of feral goats and pigs has been attempted in the most remote regions, but has not been economically effective. The Alaka`i Wilderness Preserve was established by the State of Hawai`i in 1964. It recognizes the fragile pristine ecosystem there and has provided some legal protection from potentially damaging developments as well as regulating unnecessary human activity. On Kaua`i, no large scale management actions have taken place in the Alaka`i Wilderness Area, primary habitat for the `ō`ū. The Hawai`i Rare Bird Search Team made an intensive systematic effort to locate any surviving endangered forest bird populations, but no `ō`ū were found during this search project (Reynolds and Snetsinger 2001).

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

7. Palila, *Loxioides bailleui*

DESCRIPTION AND TAXONOMY

The palila was first collected in the Kona region of Hawai`i by T. Ballieu in 1876, and was scientifically described in 1877 by Oustalet (Wilson and Evans 1890 to 1899). Amadon (1950) included the genus in *Psittirostra*, but *Loxioides* was restored later (American Ornithologists' Union 1983). Similarities in bill structure between *Loxioides* and *Telespiza* may warrant merging the two genera (James and Olson 1991). The palila is in the family Fringillidae, subfamily Drepanidinae.

Male palila. Photo pending permission.

The palila is one of the larger Hawaiian honeycreepers with an overall length of 15.0 to 16.5 centimeters (6.0 to 6.5 inches) and an adult weight of 38 to 40 grams (1.3 to 1.4 ounces). Adult palila have a yellow head and breast, greenish wings and tail, and are gray dorsally and white ventrally (Jeffrey *et al.* 1993). Adult females have less yellow on the nape and the lores are gray rather than black as in males. The head and upper breast of both sexes of juvenile birds are dull yellow-green, and juveniles have double wingbars formed by pale green tips on the greater and middle coverts until the first prebasic molt (Jeffrey *et al.* 1993).

LIFE HISTORY

The palila is an extreme food specialist, preferring unhardened māmane (*Sophora chrysophylla*) seeds in green pods or in pods that are just beginning to turn brown (Banko *et al.* 2002). Seeds in small developing pods and in hardened brown pods are rarely eaten, but very small pods with unexpanded seeds are sometimes eaten whole. Palila also eat māmane flowers, buds, and leaves, and naio (*Myoporum sandwicense*) berries, especially when other foods are in short supply. Seeds, fruits, flowers, and leaves of other species are rarely eaten (U.S. Geological Survey, unpubl. data). Caterpillars and other insects are important in the diet of nestlings and are eaten frequently by adults (Perkins 1903; U.S. Geological Survey, unpubl. data). Preliminary studies suggest that māmane seeds are nutritious, but they contain high levels of alkaloids that are generally toxic to vertebrates (U.S. Geological Survey, unpubl. data). Observations indicate that birds are selective about which trees they exploit for seeds, suggesting that levels of alkaloids may vary significantly among individual trees (U.S. Geological Survey, unpubl. data).

Palila move in response to the availability of māmane seeds, and fledglings and hatch-year birds sometimes disperse widely in search of food (Hess *et al.* 2001; U.S. Geological Survey, unpubl. data). Nevertheless, there is no evidence that birds move more than about a third of the way around Mauna Kea during their entire lives, and those hatched on the western slope may travel even less (U.S. Geological Survey, unpubl. data). Home range sizes and movement distances, therefore, are small relative to the potential mobility of the species, and palila have poor recolonization potential (Fancy *et al.* 1993).

Male palila feeding on māmane seed pod. Photo permission pending.

Nesting may begin in January or February, but palila usually start nesting from March to early May; egg-laying continues through August or mid-September (van Riper 1980a; Pletschet and Kelly 1990; Pratt *et al.* 1997a; U.S. Geological Survey, unpubl. data). From 1996 to 2000, mean length of the egg-laying season was 113 ± 25.1 days (range 53 to 205 days) (U.S. Geological Survey, unpubl. data). Peak nesting usually occurs in May or June (U.S. Geological Survey, unpubl. data). The number of nesting attempts each year is strongly influenced by the availability of green māmane pods. In years of poor māmane pod production, initiation of nesting may be delayed, fewer palila attempt to nest, and fewer re-nesting events occur (Pratt *et al.* 1997a; U.S. Geological Survey, unpubl. data). Forest composition also affects nesting behavior: from 1996 to 2000, nesting density averaged 6 ± 2 nests per 100 hectares (247 acres) in māmane-dominated forest, whereas 4 ± 1 nests per 100 hectares (247 acres) were found in mixed naio/māmane forest (U.S. Geological Survey, unpubl. data).

Palila are monogamous, but other adult males often help the pair by feeding the female and chicks (Pratt *et al.* 1997a; Miller 1998; U.S. Geological

Survey, unpubl. data). It is not yet known whether male helpers copulate with the female and sire some of the nestlings they help raise, but some male helpers are chased by the nominal male. Although the nominal male defends a small territory around the nest tree, the pair forages over a larger area. Male home range size during nesting averaged 9.5 ± 1.96 hectares (23.4 ± 4.8 acres), and the mean distance between the center of daytime locations and the nest was 73 ± 12.1 meters (241 ± 40 feet; n = 6 males in māmane-dominated forest, n = 2 in naio-dominated forest) (U.S. Geological Survey, unpubl. data). The female selects the nest site and constructs the nest, which takes from 1 to 3 weeks to complete. Preferred nest sites are in forks near the ends of higher branches in medium to large māmane trees; however, nests have been found in a variety of sites within relatively small māmane trees, in other tree and shrub species, and even in a clump of grass on the ground (van Riper 1980a; Pletschet and Kelly 1990; U.S. Geological Survey, unpubl. data). Materials used for the body of the nest are usually grass and large dead twigs; lichens and rootlets form the lining (van Riper 1980a). The use of sheep's wool in some palila nests (van Riper 1977) has been used by some to justify maintaining feral animals in palila habitat; however, the notion that birds require this material is false, and there is no evidence to suggest or reason to believe that productivity is higher at nests containing wool. Lichen may be important in helping to maintain humidity in the arid conditions often encountered on Mauna Kea, but temperature and humidity are unlikely to contribute to nest failure except during heavy storms (Pratt *et al.* 1997a).

Modal clutch size is two eggs (usual range one to three; four reported in one nest). Eggs require 16 to 17 days to hatch, and nestlings fledge at 25 days (Pletschet and Kelly 1990). Palila may re-nest after failure, and some palila are able to raise two broods during the same year. Palila show high nesting site fidelity, particularly among females. Subsequent nests of individual females within nesting seasons range on average from 120 to 141 meters (394 to 463 feet) of each other, but distances between years tends to be greater (Pratt *et al.* 1997a; U.S. Geological Survey, unpubl. data).

Male palila have a 1-year delay in plumage maturation (Jeffrey *et al.* 1993). Males do not begin breeding until at least their third year (0 percent of second years breed; n = 99), but about 10 percent of females breed in their second year (n = 111; Pratt *et al.* 1997a). Both sexes are productive until at least 11 years of age, and a male ≥ 13 years of age helped at a nest. Annual survival averages

0.63 ± 0.05 (standard error), which is similar to other Hawaiian honeycreepers (Lindsey *et al.* 1995). Survival of juveniles is significantly lower than that of adults. Using plumage characteristics to determine sex, the sex ratio of adults was thought to be male-biased (Lindsey *et al.* 1995); however, recent genetic studies suggest that the sex ratio is probably even in all age classes ranging from embryos to adults (U.S. Geological Survey, unpubl. data).

Palila have relatively low productivity due to their small population size, great annual variation in the number of pairs attempting to nest, small clutch size, and long nesting cycle. In his study area, van Riper (1980a) found 14.8 pairs per 100 hectares (247 acres) and 1.8 young per pair a year, resulting in a productivity of 26.1 young per 100 hectares (247 acres) a year. By comparison, the productivity of the Hawai`i `amakihi (*Hemignathus virens virens*) was 203.5 young per 100 hectares (247 acres) a year in the same study area. Although the number of pairs nesting varies greatly from year to year, at least half of all eggs successfully hatched in nests that were active when discovered: 54 to 66 percent from 1989 to 1993 (Pratt *et al.* 1997a), and 64 to 83 percent from 1996 to 2000 (U.S. Geological Survey, unpubl. data). Infertility of eggs was 4 to 11 percent from 1996 to 2000, suggesting that infertility is not a major problem for this species (U.S. Geological Survey, unpubl. data). At least one third of active nests produce a fledgling each year: 39 to 55 percent from 1989 to 1993 (Pratt *et al.* 1997a), and 33 to 67 percent from 1996 to 2000 (U.S. Geological Survey, unpubl. data). The year of lowest fledgling production was 1997, when cool wet weather contributed significantly to nestling mortality. On average, 1.5 ± 0.05 chicks (range 1.3 to 1.6) fledged from productive nests from 1996 to 2000 (U.S. Geological Survey, unpubl. data).

HABITAT DESCRIPTION

Palila are dependent on the māmane and māmane/naio forests for all their needs. The highest densities of palila occur in areas of greater crown cover, taller trees, and higher proportion of native shrubs near 2,300 meters (7,550 feet) elevation in māmane-dominated or mixed māmane-naio forest (Scott *et al.* 1984, 1986), and annual and seasonal density of birds is strongly related to māmane pod availability (Scott *et al.* 1984, 1986; Hess *et al.* 2001). Most nesting occurs in māmane trees (Pletschet and Kelly 1990), but naio is more frequently selected for roosting (U.S. Geological Survey unpubl. data). Up to 96 percent of the current palila population and nearly all of the successful breeding occurs on the southwestern slope of Mauna Kea, where the elevation range of the forest and habitat quality is greatest (Scott *et al.* 1984, 1986; Jacobi *et al.* 1996; Banko *et al.* 1998; Gray *et al.* 1999). The elevation range of forest was the most important variable in the analysis by Scott *et al.* (1984) of palila response to available habitat. This results from the phenological variation of māmane trees along a gradient of elevation. At different elevations, māmane trees produce flowers and fruits at different times during the year (U.S. Geological Survey, unpubl. data). A wide belt of māmane forest results in more consistent availability of seeds within the range of daily movements typically made by palila, especially during the breeding season.

HISTORICAL AND CURRENT RANGE AND STATUS

Fossil remains of palila have been found at sea level on O`ahu (Olson and James 1982a,b), suggesting that the species once occurred over a much larger range than was known historically. Before the first Polynesians arrived around 400 A.D., the lowlands of the main islands supported extensive dryland forests suitable for palila (Scott *et al.* 1984). Historically, the palila was known only from the Island of Hawai`i, were it occurred in māmane/naio forests on the upper slopes of Mauna Kea, the northwestern slope of Mauna Loa, and probably the southern and eastern slopes of Hualālai (Figure 11). In the 1890s, Perkins (1903) found the palila to be "extremely numerous" in the māmane belt of the Kona region between 1,210 and 1,830 meters (4,000 to 6,000 feet) elevation. Palila were still locally common in the 1940s between 2,360 and 2,530 meters (7,800 to 8,350 feet) on the western and northeastern slopes of Mauna Kea (Richards and Baldwin 1953). The range of palila apparently contracted relatively quickly in the early 1900s to a small area on the upper slopes of Mauna Kea, because Munro (1944) determined that the species was in danger of extinction.

In recent decades the distribution of palila has remained fairly constant (Figure 11). The upper elevation limit appears to coincide with tree line at about 2,850 meters (9,400 feet) and the lower elevation limit is approximately 2,000 meters (6,600 feet) at the transition from māmane or māmane/naio forest to scrub forest or grassland (Scott *et al.* 1984). In the early 1980s palila occupied about 139 square kilometers (53.7 square miles) or 25.6 percent of the 545 square kilometers (212 square miles) of māmane woodlands remaining on Mauna Kea

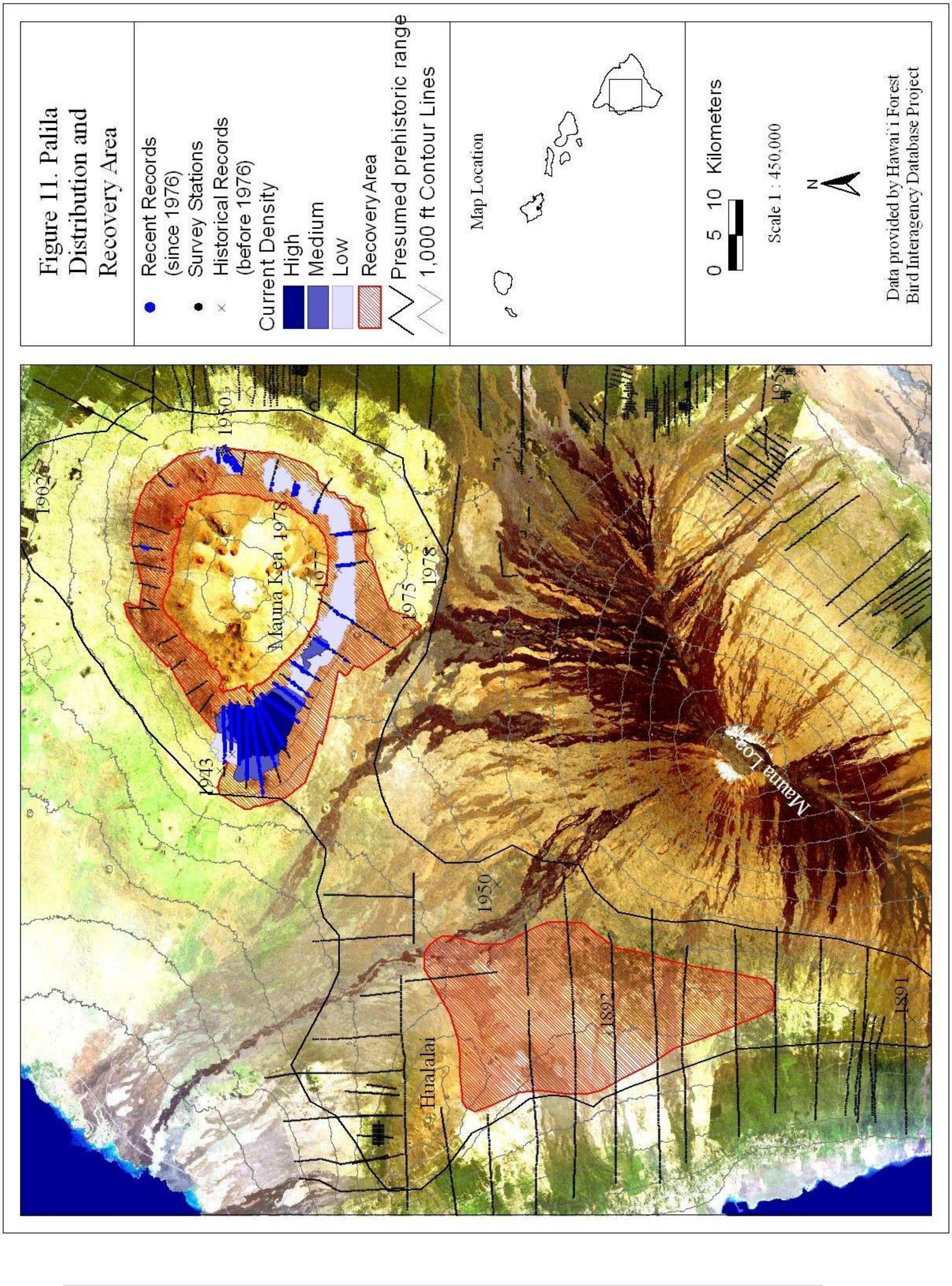


Figure 11. Palila Distribution and Recovery Area

(Scott *et al.* 1984). The range as of 2001 was essentially the same, although declining populations on the eastern and southern slopes would suggest some further range contraction.

Because the small populations on the eastern and southern slopes of Mauna Kea have been declining since 1980, estimates of the palila population depend heavily on counts centered near Pu`u Lā`au on the western slope. Annual surveys from 1980 to 1995 yielded a mean population estimate of 3,390 ± 333 (standard error) (Figure 12). From 1998 to 2005, the mean population estimate was 3,172 ± 194.6 (standard error), with a range of 2,206 to 3,901 (Banko *et al.* 2005). Much of the apparent variation in numbers of palila may be due to differences in vocal activity. Most palila detected on annual counts are heard rather than seen; therefore, population estimates are potentially sensitive to rates of singing and calling, which in turn may be affected by courtship and nesting. Annual counts are conducted prior to the nesting season, usually in January or February (Jacobi *et al.* 1996), but the timing of nest initiation and proportion of birds breeding varies greatly each year, as discussed above. Although reported declines in population size are possible due to starvation and other factors, the more dramatic increases reported could not have occurred. The reproductive potential of palila is insufficient to have produced the apparent population increases by factors of 2.9 (1986 to 1987), 2.4 (1992 to 1993), or 2.0 (1995 to 1996) (Jacobi *et al.* 1996). To understand why this is so, consider the improbable conditions that must occur for the population to double in a single year: 1) all adult birds must nest and produce two fledglings per pair, and 2) all adults and fledglings must survive until the next survey. There is some indication that annual variation in the population since 1996 may be dampening (Banko *et al.* 1998, Gray *et al.* 1999), but analyses of 1999 to 2001 data are needed to confirm this (Figure 12).

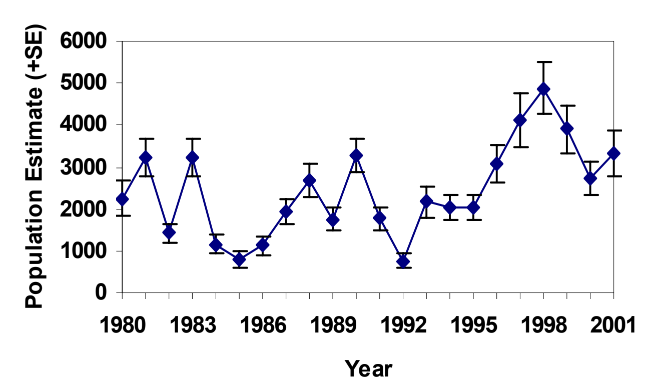


Figure 12. Population trend of palila.

REASONS FOR DECLINE AND CURRENT THREATS

Habitat loss and modification, avian disease, and predation by introduced mammals are thought to have caused the palila population to become endangered, and these factors continue to limit the palila population today (Scott *et al.* 1984, 1986; Jacobi *et al.* 1996; Pratt *et al.* 1997a). Feral ungulates first became established in the māmane forest in the early 1800s and have since caused widespread loss and modification of palila habitat. Cattle, feral sheep, mouflon (*Ovis musimon*), and feral goats all have contributed to the destruction and modification of the māmane/naio forest. Feral sheep became established on Mauna Kea in the 1820s and the sheep population had reached about 40,000 animals by the early 1930s (Bryan 1937). Heavy browsing effectively lowered the tree line and reduced tree density in other areas (Scowcroft and Giffin 1983; Scott *et al.* 1984). In addition, browsing removed lower branches of māmane trees, thus lowering the productivity of individual trees and reducing the availability of palila food resources.

Following legal rulings under section 9 of the Endangered Species Act (see Conservation Efforts), threats from feral ungulates have been reduced in palila critical habitat. As a result, recruitment of māmane and other native plants has increased and the forest is beginning to recover (U.S. Geological Survey unpubl. data). Nevertheless, palila habitat continues to be threatened by alien weeds and fire (Hess *et al.* 1999). The abundance, distribution, and impact of weeds are under investigation by the U.S. Geological Survey, but management is needed soon on species that are spreading rapidly or whose impacts are already known. Especially worrisome is the spread of alien species of annual grasses and the accumulation of fine fuels that may carry large, destructive fires. Many weeds are now established in areas where soils were highly disturbed by large populations of ungulates. Some alien species may decline in abundance as native species increase and soil disturbance by ungulates has been reduced. Other species, however, must be controlled before they spread further. For example, fountain grass (*Pennisetum setaceum*), a fire-promoting grass, is one of the most aggressive and potentially damaging introduced plants in Hawai`i. It has already become the dominant ground cover in large areas of Kona and the area between Mauna Kea, Mauna Loa, and Hualālai; colonies have also become established on the southern and western slopes of Mauna Kea (U.S. Geological Survey, unpubl. data). Cape ivy (*Delairea odorata*) is another pernicious weed that threatens palila habitat by climbing on and smothering native trees and shrubs. It was discovered as a sporadic infestation over about 500 hectares (1,235 acres) near Pu`u Lā`au (Scott *et al.* 1984) and has since spread widely on the western slope of Mauna Kea. Gorse (*Ulex europaeus*) is a highly invasive shrub that threatens māmane forest on the eastern slope. Efforts to control gorse have not been encouraging, and it will spread into palila habitat from pastures below Mauna Kea Forest Reserve unless concerted measures are taken. The threats posed by many other weed species are less known, but some likely help support invertebrate pests that threaten the insect prey of palila.

Fire is an ever-present threat to the dry forest habitat of palila, and the risk of large destructive fires is increased by the accumulation of fine leaves and stems of alien annual grasses and other weeds. The chief concern about fire is that palila could be deprived of critical food resources over large areas for several years before recovery and regeneration of māmane and other native plants occurred. Although māmane can recover quickly after fire (T. Tunison, National Park Service, pers. comm.; U.S. Geological Survey, unpubl. data), alien grasses and other weeds are likely to increase in abundance and distribution, thus increasing the potential frequency and intensity of fires. Fire-adapted fountain grass and orchard grass (*Dactylis glomerata*) are especially apt to spread; however, native grasses and shrubs may also increase after fire. For example, the native lovegrass *Eragrostis atropioides* almost completely dominated the vegetation following fires that started along Saddle Road on the western slope of Mauna Kea during the 1990s (U.S. Geological Survey, unpubl. data). Although *Eragrostis* burns readily and hotly (T. Tunison, pers. comm.), it may be less fire-prone than fountain grass.

Now that ungulate damage has been reduced, the forest must be monitored for signs of diseases that may debilitate or kill māmane. There are many dead and dying māmane trees of all age classes around the mountain, but especially on the western and southern slopes. Demographic patterns of māmane mortality are being investigated by the U.S. Geological Survey, but additional research may be warranted to identify pathogens.

Avian malaria and avian pox have had devastating effects on the numbers and distribution of Hawai`i's native birds (Warner 1968, van Riper *et al.* 1986). These diseases are spread by mosquitoes, which are uncommon at the high elevations where palila are now found. Palila are highly susceptible to malaria (van Riper *et al.* 1986), and although it is not thought to be an important mortality factor for palila because of the elevation of their current range, avian disease may prevent palila from recolonizing their former range at lower elevations, including Pōhakuloa Flats.

Predation by black rats (*Rattus rattus*), feral cats (*Felis catus*), and the Hawaiian short-eared owl or pueo (*Asio flammeus sandwichensis*) is another important factor limiting the palila population, particularly through its effects on the distribution of nesting by palila. Pletschet and Kelly (1990) attributed 5 percent of palila nest mortality to egg depredation and 35 percent to nestling depredation by black rats and feral cats, and thought that predation might have contributed to the high rate of nest abandonment they observed. Snetsinger *et al.* (1994) found that 68 percent of cat scats collected near Pu`u Lā`au contained bird remains, and thought that feral cats were an important predator on native birds. Studies by van Riper (1980a) and Pratt *et al.* (1997) have also shown that feral cats prey on palila nests and adults. Amarasekare (1993) concluded that predation had little effect on the palila, but her study focused on rat predation either in the core palila nesting area, where few rats occur, or in naio-dominated forests, where few palila attempt to nest. Rats are associated primarily with naio trees, presumably because these trees provide greater food and cover for rats, and occur only in low densities in the core palila nesting area where māmane predominates (Amarasekare 1993). Successful nesting by palila is rare where naio is the dominant tree species, and mammalian predation is thought to be the major reason.

The absence of palila in the Pōhakuloa Flats (downslope, southeast from existing populations) remains unexplained. Scott *et al.* (1984) suggested site tenacity, thermal stress, or avian disease as plausible hypotheses. However, recent studies indicate that alien ants and predatory wasps are established in the area, and other alien wasps heavily parasitize native caterpillars that are eaten by palila (U.S. Geological Survey, unpubl. data). Disturbance from military activities in the Pōhakuloa Training Area may also affect palila distribution.

Severe weather may be an important mortality factor in certain years. Populations are restricted to the higher elevations where freezing temperatures occur frequently during part of the nesting season. Rains are infrequent but can be heavy and cause eggs or chicks to die of exposure. In other years, droughts lead to low levels of māmane pod production that result in fewer nesting attempts and delayed breeding by palila. High winds can blow young out of nests, especially those placed in the terminal forks of trees (van Riper 1980a), or cause nests to disintegrate (U.S. Geological Survey, unpubl. data).

CONSERVATION EFFORTS

The palila received Federal recognition as an endangered species in 1966, and was formally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967). The primary reasons for this classification status were: (1) a significant portion of its historical range was no longer occupied; (2) its present habitat was being adversely modified by feral ungulate browsing; and (3) the total palila population at that time was estimated to be in the low hundreds.

The vulnerability of palila to extinction has been recognized since the mid-1900s (Munro 1944). Although relatively little conservation or research effort was directed specifically at the palila until recently, feral ungulate control was initiated in the early 1900s to protect the māmane woodland and watershed of the Mauna Kea Forest Reserve (Bryan 1947). The removal of over 46,000 feral sheep and smaller numbers of feral cattle, goats, and pigs retarded the severe deterioration of the forest and allowed the recruitment of a cohort of māmane seedlings that has sustained palila to the present. Populations of sheep were allowed to rebuild and mouflon sheep were introduced to promote sport hunting (Tomich 1969), again causing widespread damage to the māmane forest (Warner 1960).

Critical habitat for the palila was designated on August 8, 1977 (U.S. Fish and Wildlife Service 1977). In 1978, a ruling by the Hawai`i District Court under section 9 of the Endangered Species Act required that all feral sheep and goats be removed from palila critical habitat (Palila *et al.* v. Hawai`i Department of Land and Natural Resources *et al.*, CIV No. 78-0030; Nelson 1982). A similar ruling by the Federal Court of Appeals for the Ninth Circuit in 1987 ordered the eradication of mouflon sheep (Palila *et al.* v. Hawai`i Department of Land and Natural Resources and Hawaii Rifle Association, No. 87-2188; Pratt *et al.* 1997a). Subsequently, goats have been eliminated and sheep and mouflon have been reduced to low numbers. However, immigration and recruitment of lambs make it unlikely that sheep and mouflon will be eradicated in the near future unless more effective control measures are taken. Fencing along the southern boundary of Mauna Kea to prevent entry by feral ungulates has been improved, but animals can readily gain access to the forest reserve in many places (J. Giffin, Hawai`i Department of Land and Natural Resources, pers. comm.). In addition, animals may become increasingly difficult to control from helicopters as they learn avoidance tactics, and public hunting has been ineffective at removing significant numbers of these popular game animals from remote areas or when populations occur in low numbers (J. Giffin, pers. comm.). Therefore, new strategies and tactics are needed to comply with court-ordered eradication of sheep and mouflon.

A popular but erroneous rationale for maintaining cattle, sheep, and other ungulates in palila habitat is that they limit fire threats by reducing fine fuels. The problem with using ungulates to suppress fire fuels in native forest is that grasses and other fine fuels are reduced appreciably only when ungulates exist in such high densities that māmane and other native plants are heavily damaged and recruitment is essentially eliminated. Many fires on Mauna Kea start in pastures where grazing has reduced or extirpated native plants (U.S. Fish and Wildlife Service, unpubl. data). The principal benefit of grazing, therefore, would seem limited only to reducing fire intensity. The principal liabilities of using grazing to reduce fuels are that native plants are destroyed and soil is disturbed, increasing opportunities for undesirable grasses and other weeds to spread. Indeed, most problematic weeds proliferated on Mauna Kea when feral ungulates were abundant and widespread (Scowcroft and Conrad 1992).

Since being listed as endangered, considerable research has been conducted on the palila, including its physical characteristics (Jeffrey *et al.* 1993), population size and distribution (van Riper *et al.* 1978, Scott *et al.* 1984, Banko 1986, Jacobi *et al.* 1996, Banko *et al.* 1998, Gray *et al.* 1999), home range and movements (Fancy *et al.* 1993, Hess *et al.* 2001), breeding biology (Berger 1970, van Riper 1980a, Pletschet and Kelly 1990, Miller 1998), limiting factors and demography (Amarasekare 1993; Fleischer *et al.* 1994; Lindsey *et al.* 1995, 1997), conservation (Berger 1981, Scott *et al.* 1986, Fancy *et al.* 1997, Pratt *et al.* 1997a), and habitat characteristics (van Riper 1980b, Scowcroft 1983, Scowcroft and Giffin 1983, Scowcroft and Sakai 1983, Scowcroft and Conrad 1992, Juvik *et al.* 1993, Hess *et al.* 1999). Population size and distribution were first estimated systematically in 1975 (van Riper *et al.* 1978), and annual censuses have been conducted since 1980, allowing biologists to monitor population trends longer than for any other Hawaiian forest bird (Scott *et al.* 1984, Jacobi *et al.* 1996, Banko *et al.* 1998, Gray *et al.* 1999).

The original recovery plan for the palila was completed in 1978 and revised in 1986 (U.S. Fish and Wildlife Service 1986). These recovery plans identified a series of actions aimed at both the direct conservation of the palila and at gathering information for that purpose. Many of these actions have since been implemented, at least in part. Notable among these are increased efforts to control feral ungulates, specifically feral sheep and goats, resulting in significant habitat improvement (Scowcroft and Conrad 1992, Hess *et al.* 1999).

Building on research results of the 1970s and early 1980s, the U.S. Geological Survey Pacific Island Ecosystem Research Center began studies in 1986 that are expected to continue through 2010. This research continues investigating the basic ecology and factors limiting the palila population, including predation, disease, food availability and threats to food resources, small population genetics and demography, and habitat quality and threats. The U.S. Geological Survey will also develop restoration techniques and facilitate their implementation. Most of the updated information in this recovery plan has been collected during these studies, and much more information about palila and their habitat will be forthcoming.

In 1993, an experimental translocation of adult palila to Kanakaleonui on the eastern slope of Mauna Kea was conducted to determine whether birds would remain and breed in a new area. Although at least half of the birds returned to the western slope near Pu`u Lā`au within 1 year, two pairs successfully nested at Kanakaleonui and the density of palila there was higher after the translocation (Fancy *et al.* 1997). Additional translocations of birds from the western slope were undertaken from 1997 to 2006 with the goal of testing techniques for reestablishing a population on the northern slope of Mauna Kea, near Pu`u Mali. While 53 birds were translocated in 3 early trials, there was little to suggest that birds remained in the new area (U.S. Geological Survey, unpubl. data). Although some birds stayed in the target area for over a year, most returned to their original home ranges within a few months. Another trial was completed in 2004, when 32 birds of different age groups were translocated to test the hypothesis that a more natural social environment and a large pool of potential mates would encourage more birds to stay longer and breed. In fact, one pair formed and nested successfully, fledging two chicks. In conjunction with the 2004 translocation, 10 captive-reared palila were released near Pu`u Mali in late 2003 to compare the survival, breeding, and other behavior between the two groups. Captive-bred palila were supplied by the Zoological Society of San Diego from the Keauhou Bird Conservation Center from stock originating from wild eggs collected in 1996 and 2000 (The Peregrine Fund 1996, The Peregrine Fund and the Zoological Society of San Diego 2000). Six of the 10 captive-released birds survived through the breeding season at or near the release site and one pair formed, laying a single infertile egg. Translocations and releases of captive-raised birds were also conducted in late 2004 and 2005. Prior to translocating and releasing captive-reared birds near Pu`u Mali, predators were removed and food and habitat conditions were assessed to increase chances of success. Ten of the 21 captive-raised palila released on Pu`u Mali from 2003 through 2005 have been seen in 2006, and there have been multiple breeding events in each of the last 3 years (2004 to 2006) of both translocated and captive-bred palila, with at least 4 fledglings surviving to independence. These results suggest a combination of translocation and captive-releases has been successful at forming a second breeding population, though the number of birds in this incipient population is still very small and its long-term viability remains to be seen.

In 1996, a captive propagation program was initiated as a collaborative effort between the National Biological Survey (now the Biological Resources Discipline of the U.S. Geological Survey) and The Peregrine Fund (and later by the Zoological Society of San Diego), with the collection of wild-laid eggs, artificial incubation, and hand-rearing. A total of 11 palila and 3 palila were reared in 1996 and 2000, respectively, at the Keauhou Bird Conservation Center. In 1999, one pair of these captive-reared birds began to breed, with one chick hatched that did not survive. In 2000, 11 captive-bred palila were hatched from 2 pairs with 100 percent survival. In 2001, three chicks were reared in captivity from one pair of palila. Some progeny of the captive-propagation program were released in 2003 and there are plans for future releases of palila produced by the near Pu`u Mali and other recovery areas.

Although māmane and other native trees and shrubs have regenerated prolifically following the removal of feral ungulates, alien grasses and other factors may be suppressing regeneration in some areas (Hess *et al.* 1999). Experimentation to regenerate māmane forest by planting saplings has demonstrated that māmane grows readily near tree line and where competing ground cover is sparse. Māmane has not yet been planted where grass cover is thick.

Despite a growing list of technical and semi-technical publications about palila, a relatively limited amount of effort has gone into information and education since 5,000 copies of a small poster about palila with a description of their habitat were distributed in the 1980s (J. M. Scott, University of Idaho, pers. comm.). Presentations have been given by U.S. Geological Survey researchers and others at scientific, professional, and public venues at an increasing rate. Increasing numbers of students, from grade school to university levels and including law students, have asked for information about palila and the court orders relating to feral ungulate removal for classroom projects. Increasingly, information about palila is available on the worldwide web, and U.S. Geological Survey biologists are in the process of greatly expanding the amount and quality of information available through the internet.

RECOVERY STRATEGY

The primary problem confronting palila conservation is that the population is highly concentrated: as much as 96 percent of the population occurs within about 30 square kilometers (11.6 square miles) of forest on the western slope of Mauna Kea (Gray *et al.* 1999). Although recent estimates indicate that the western population may be stabilizing, the very small, scattered southern and eastern populations seem to be declining and heading towards extinction (U.S. Geological Survey, unpubl. data). The geographic expansion of the high-density population cell, if it is occurring at all, is imperceptibly slow, and few if any birds seem to move between the different slopes. Whether because of site tenacity or preference for more favorable habitat conditions on the western slope, immigrants from the western slope are unlikely to bolster the declining populations or recolonize vacant habitats in the near future. The most urgent goal for recovery, therefore, is to bolster or reestablish one or more self-sustaining populations while managing the primary population on the western slope for stability or increase.

The intent of both downlisting and delisting recovery criteria is that relatively large and viable (self-sustaining) populations exist in at least three areas (on the western and either the northern, eastern, or southern slopes of Mauna Kea and at least one other location on Mauna Loa or Hualālai) over sufficiently long periods to account for perturbations in weather and other environmental variables.

Determining when to downlist or delist the species depends on the reliability of population monitoring. Annual estimates (variable circular plot method) of the population since 1980 vary considerably (Jacobi *et al.* 1996), but it is difficult to know how estimates are affected by sampling error, variation in detection probability, or population change. For example, procedures for training and calibrating observers have varied over the years, although since 1997, methods have been standardized to a much greater degree. In addition, observers now count all species detected, whereas observers focused only on palila and a few other species prior to 1997. A potentially large source of variation in annual estimates is the amount of vocal activity, which may be affected by the timing of breeding and number of birds attempting to breed, as discussed above. Therefore, it cannot always be assumed that dramatic changes in annual population estimates reflect actual numbers of birds. Evaluating population status and trends by estimating the number of breeding pairs in the population is difficult because the number of pairs nesting each year varies greatly depending on the availability of māmane pods; in very dry years few birds nest because pods are scarce (Pratt *et al.* 1997a; U.S. Geological Survey, unpubl. data). Problems in determining whether populations are stable (recovery criterion 2a) can be more easily overcome if lambda (population growth rate) is known (criterion 2b).

Recovery criteria for palila are based partly on the perception that the main population on the western slope of Mauna Kea may be starting to benefit from increased māmane tree recruitment and growth, which has resulted from reductions of populations of feral sheep and goats and mouflon sheep since 1980. Ungulate eradication, removal of cattle from critical habitat (Ka`ohe Lease), and protection from fire, weeds, predators, food competitors, and disturbance likely will result in population growth and expansion over the next 10 years. However, populations in other areas on Mauna Kea will become self-maintaining only if habitat is actively restored and relict populations are vigorously protected. Populations must be reestablished in suitable areas of former range, such as the northern slope of Mauna Kea, by releasing captive-reared or translocated birds. It may also be necessary to bolster relict populations on the southern and eastern slopes. Managing these small or incipient populations should involve nearly complete eradication of major predators, particularly feral cats. Some threats to food resources (e.g., ants and predatory wasps) should be controlled to the extent possible, but there are no methods available for controlling parasitoids that reduce the availability of caterpillars. In addition, factors that destroy or alter habitat, especially feral ungulates, fire, and highly invasive weeds, must be suppressed. Māmane and other native species should be planted where regeneration is sparse.

In the long-term, restoring palila populations will be possible only if sufficient habitat is available and it is distributed along gradients of elevation or rainfall such that food resources are available throughout the year. An opportunity to expand the size and extend the elevation gradient of habitat near Pu`u Mali has arisen as part of the mitigation settlement for realigning Saddle Road through palila critical habitat in the Pōhakuloa Training Area on the southern slope of Mauna Kea. Land below the Mauna Kea Forest Reserve will be fenced and cattle will be withdrawn, beginning in late 2004 and early 2005. Natural reforestation is likely to occur in upper pastures where some māmane and other native species persist. However, lower pastures may require planting, and alien grasses and other weeds may pose a variety of management challenges. Funds for reforestation, weed control, and fire management near Pu`u Mali are limited under the terms of the Saddle Road realignment mitigation settlement; thus, supplementary funding is necessary. Cattle will also be withdrawn from critical habitat (Ka`ohe Lease) on the western slope as part of the mitigation for realigning Saddle Road. Again, extra funds will be needed to manage this area for maximum benefit of palila and other native species. In addition to funding for habitat restoration, commitments are needed to manage lands for forest and palila recovery beyond the 10-year period covered by mitigation.

Opportunities to reforest pastures on the eastern slope of Mauna Kea are limited because the lands are held privately and a large area is heavily infested with gorse. Nevertheless, it may be possible to acquire conservation easements that would extend the availability of habitat to areas below the existing forest reserve. Acquiring this habitat will only be worthwhile, however, if resources and methods are available for controlling the spread of gorse.

Privately owned pastures and gorse also are important challenges to restoring forest habitat on the southern slope. In addition, efforts to recover palila on the southern slope are hindered by military training and the realignment of Saddle Road through critical habitat. Predator populations on the southern slope are uncontrolled and insect food resources used by palila and other native birds are heavily threatened by alien parasitoids and predators, including, for example, Argentine ants (*Linepithema humile*) and yellow jackets (*Vespula pensylvanica*). The forest should be protected from ungulates, fire, weeds, and unnecessary disturbance, even though Pōhakuloa Flats cannot be managed primarily for palila recovery. It may be possible to maintain a limited population of palila on the southern slope if the forest at Pōhakuloa Flats is managed carefully and the forest above continues to recover from ungulate browsing damage.

Prospects for restoring palila to areas of its former range on Hualālai and Mauna Loa are less certain. Although māmane forest remains over relatively large areas, particularly to the south of Hualālai on the western flank of Moana Loa, habitat conditions are just now being evaluated more carefully to determine their recovery potential. Except for areas controlled by the military, lands once occupied by palila in Kona are privately owned, and conservation easements or other arrangements will be needed to carry out ungulate control and other management activities. The habitat at Kīpuka `Alalā within the Pōhakuloa Training Area may be rehabilitated sufficiently to warrant reintroducing palila. Although military training creates some disturbance in this remote, isolated area, greater impediments to recovery are posed by large herds of feral ungulates that have essentially eliminated māmane regeneration for decades, and fires. As part of the Saddle Road mitigation, however, the diverse dry forest found at Kīpuka `Alalā is being managed with the idea that palila might be reintroduced in a few decades. Palila occupied the area into the 1950s (Banko 1986); thus, the serious challenges of forest restoration should not completely discourage the notion of reestablishing a population. If areas such as Kīpuka `Alalā are not considered for long-term recovery, conservation efforts may become too focused on short-term goals.

The Saddle Road mitigation provides a valuable bridge between short-term and long-term recovery goals. It provides funding to develop and implement techniques for reintroducing palila to former habitat and for managing the primary population and habitat. It also continues research into limiting factors and habitat requirements, and it initiates research into fire ecology and behavior so that a fire management plan can be formulated. In addition, strategies and techniques for controlling predators are being developed for the western and northern slopes of Mauna Kea. Without the Saddle Road mitigation, large areas of former habitat would continue to be grazed. However, this mitigation stops well short of recovering palila.

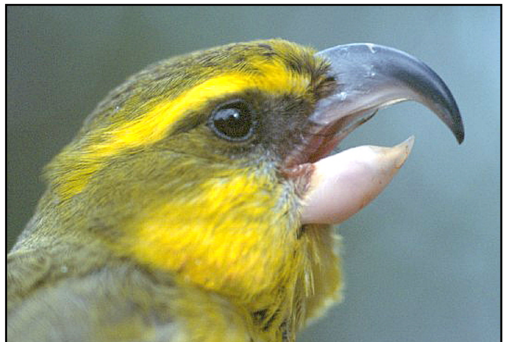
To fully recover palila, long-term funding and effort are needed to manage ungulates, fire, weeds, predators, and food competitors over large areas of suitable habitat. Recovery can be accelerated by planting māmane and other appropriate native species in areas where alien grasses suppress regeneration (Hess *et al.* 1999), or where native forest is unlikely to regenerate quickly. Palila recovery will be enhanced if the public is constructively engaged in the process. If, for example, citizens think of palila habitat on Mauna Kea only in terms of its value for public hunting and livestock grazing, there will be little impetus for changing land-use policy, and protecting endangered species and native ecosystems will continue to be an afterthought, at best. Many areas of habitat are accessible by 4-wheel-drive vehicle and the environment is not especially difficult or harsh. In fact, commercial ecotours are regularly conducted on Mauna Kea (with observing palila as a major goal) and substantial numbers of hunters roam the slopes during game bird season. A large cross-section of the public could potentially be involved in habitat protection, restoration, and monitoring in a variety of ways and over large areas. With supervision and logistical support, citizens could contribute significantly towards palila recovery by controlling and monitoring weeds, pests, and predators; planting trees and other native species, and assisting with fuels management and fire education. There are significant opportunities to incorporate environmental education and recreation into habitat restoration activities, such as creating one or more sites on Mauna Kea as centers for education, recreation, management, and research. However, involving the public effectively in restoration will require planning, coordination, organization, and fundraising. There are few models in Hawai`i on which to base a citizen program, but among the programs that should be reviewed for insights into this approach are: the Auwahi dry forest restoration project on Maui, the koa reforestation program at Hakalau Forest National Wildlife Refuge, the silversword planting program on Mauna Kea (Silversword Alliance), the Kona TREE (Tree Restoration, Ecology, and Education) project, and the weed control program at Pu`u Huluhulu Natural Area Reserve.

Studies on fire ecology and behavior in subalpine dry forests on Mauna Kea were initiated in 2005, to provide fire management recommendations. In the meantime, there are a number of actions that should be taken to reduce the threat of fire in palila habitat. Foremost among these is controlling human activity in areas of high fire risk, in particular: 1) preventing vehicles from parking where grass can be ignited by the catalytic converter, 2) restricting access when fire conditions are extreme, and 3) educating the public about ways of preventing fire (e.g., not smoking). A forest ranger program is needed to provide a basic level of fire prevention, detection, reporting, and suppression. Maintenance of roads, fuel breaks, and water dip tanks also is important in permitting rapid access of fire fighting equipment and personnel and in limiting fires to relatively small units. As part of the mitigation for realigning Saddle Road through the Pōhakuloa Training Area, the opportunity for ignition of roadside fires will be minimized and emergency phones will be installed to enhance fire reporting. In addition, military fire suppression capabilities are being increased. Until fire and other threats become manageable on the western slope, a high priority should be placed on establishing at least one other viable population of palila on Mauna Kea.

Recovery of palila requires not only that management actions be carried out, but also that monitoring and research are used to support and assess management decisions. Although palila ecology is relatively well-known, subalpine dry forests on Mauna Kea are rebounding from severe browsing damage, and the relationship between bird populations and their habitat will likely be dynamic. Systematic monitoring to detect new threats that will inevitably emerge in this changing environment will be critically important to recovery. Reporting the results of research and monitoring will also be important in maintaining the public's interest and concern for palila and their habitat.

8. Maui Parrotbill, *Pseudonestor xanthophrys*

DESCRIPTION AND TAXONOMY



Male Maui parrotbill. Photo © Eric VanderWerf.

The Maui parrotbill is one of the larger (20 to 25 grams [0.68 to 0.85 ounce]) and more unique of the extant Hawaiian honeycreepers (family Fringillidae, subfamily Drepanidinae). It has a large head, thick, muscular neck, a massive curved, parrot-like bill, stout legs, and short wings and tail. Adult Maui parrotbills of both sexes are olive-green on the crown, back, wings, and tail, yellow on the cheeks, breast, and belly, grading into paler yellowish and white towards the vent, with a contrasting bright yellow supercilium (line above the eye). The hooked upper mandible is dark gray, and the chisel-like lower mandible is a pale ivory color. The sexes are clearly dimorphic in size; males are heavier, larger-billed, and longer-winged than females. Males also tend to be more brightly colored than females, but not all individuals of each sex can be accurately distinguished by color (Mountainspring 1987, Simon *et al.* 1997, Berlin *et al.* 2001). Juvenile plumage can be confused with some female plumages, but usually young are duller grayish-green above and light gray ventrally instead of yellow like adults.

The Maui parrotbill is a monotypic species with no known geographic variation in plumage or morphology. Based on morphology and molecular genetics (Simon *et al.* 1997, Fleischer *et al.* 1998), it is most closely related to the `akiapōlā`au and the life histories of these two species are similar in many respects (Simon *et al.* in press).

LIFE HISTORY

The Maui parrotbill is insectivorous and often feeds in a deliberate manner, using its massive hooked bill to dig, tear, crack, crush, and chisel the bark and softer woods on a variety of native shrubs and small- to medium-sized trees, especially `ākala (*Rubus hawaiensis*), kanawao (*Broussaisia arguta*), and `ōhi`a (*Metrosideros polymorpha*). Parrotbills also pluck and bite open fruits, especially those of kanawao, in search of insects, but do not eat the fruit itself. Especially preferred are larvae and pupae of various beetles and moths (Perkins 1903, Mountainspring 1987, Simon *et al.* 1997). The specialized foraging behavior of the parrotbill requires each pair of birds to defend a relatively large territory year-round, averaging 2.3 hectares (5.7 acres) in size (Pratt *et al*. 2001a), thus the population density of this species is relatively low. This low density translates into a small population size, since at present there is only limited habitat available for the species that is not too small and/or degraded to support parrotbills.

The ecology of the Maui parrotbill has been little studied, but recently Lockwood *et al.* (1994) and Simon *et al.* (1997) investigated aspects of its reproductive biology, reported below. Maui parrotbills are socially monogamous, and both sexes play a role in the selection of the nest site between November and June. The open cup nest composed mainly of lichens (*Usnea* sp.) and pukiawe (*Styphelia tameiameiae*) twigs is built by the female an average of 12 meters (40 feet) above the ground in a forked branch just under the outer canopy foliage. Only single egg clutches have been documented (Simon *et al.* 1997). Re-nesting occurs only after nest failures, and pairs will not raise more than one brood in a season. Only females incubate and brood. The incubation period is 16 days, and the nestling period is approximately another 20 days. Breeding males feed incubating and brooding females. Females feed nestlings with the food provided by males. Once fledged, the young are frequently fed directly by the male. Development of the large bill and specialized feeding techniques proceed slowly, and fledglings depend on their parents for 5 to 8 months (Simon *et al*. 1997). Parrotbills frequently occur in family groups due to this prolonged dependency.

Vocalizations of the Maui parrotbill include a loud song of repeated, descending "chewy" notes, and three calls given by both sexes: sharply defined chip notes, a soft "wit" contact call, and an upslurred two-part whistle (Simon *et al.* 1997). Singing occurs throughout the year, but most often in winter and spring when the birds breed. The chip notes are very similar to the chip notes of the Maui `alauahio (*Paroreomyza montana*), which occur with parrotbills in mixed-species flocks, although call delivery rates for the species can differ. The possibly extinct po`ouli (*Melamprosops phaeosoma*) also produces chip notes very similar to those of the parrotbill.

HABITAT DESCRIPTION

At present, Maui parrotbills survive in mid- to upper-elevation montane wet forest dominated by \`ōhi\`a, and in a few mesic areas dominated by \`ōhi\`a and koa (*Acacia koa*), with an intact, dense, diverse native understory and subcanopy of ferns, sedges, epiphytes, shrubs and small to medium trees. The topography in these areas is generally steep and highly dissected by deep gulches and narrow ridges. The climate is cool year-round, with frequent clouds, mist, and rain. Annual precipitation may reach as much as 8,500 millimeters (335 inches) a year. Maui parrotbills are sympatric with several other honeycreeper species, and their distribution is now limited to high elevation areas with relatively little alteration by feral ungulates (Mountainspring 1987) or encroachment of nonnative vegetation, and the absence of disease-carrying mosquitoes (Scott *et al.* 1986).

HISTORICAL AND CURRENT RANGE AND STATUS

Currently the Maui parrotbill is found only on Haleakalā Volcano in East Maui, in 50 square kilometers (19 square miles) of wet montane forests from 1,200 to 2,350 meters (4,000 to 7,700 feet) elevation (Scott *et al.* 1986, Mountainspring 1987, Simon *et al.* 1997). The current range includes the Waikamoi Drainage west of Ko\`olau gap to Haleakalā National Park lands in Kīpahulu Valley and the Manawainui Drainage (Figure 13). Based on collections of subfossil bones, the current geographic range is much restricted compared to the known prehistoric range, which included dry leeward forests and low elevations (200 to 300 meters [660 to 1,000 feet]) on East Maui as well as Moloka\`i (James and Olson 1991).

In 1980, the number of Maui parrotbills was estimated by the Hawai\`i Forest Bird Survey at 500 ± 230 (95 percent confidence interval) birds with an average density of 10 birds per square kilometer (0.39 square mile) (Scott *et al.* 1986). Repeat surveys of the same transects conducted in 1992 (Hawai\`i Department of Land and Natural Resources, unpubl. data) and limited surveys conducted from 1995 to 1997 by U.S. Geological Survey biologists indicated approximately the same densities of birds, but with perhaps some range constriction at lower elevations.

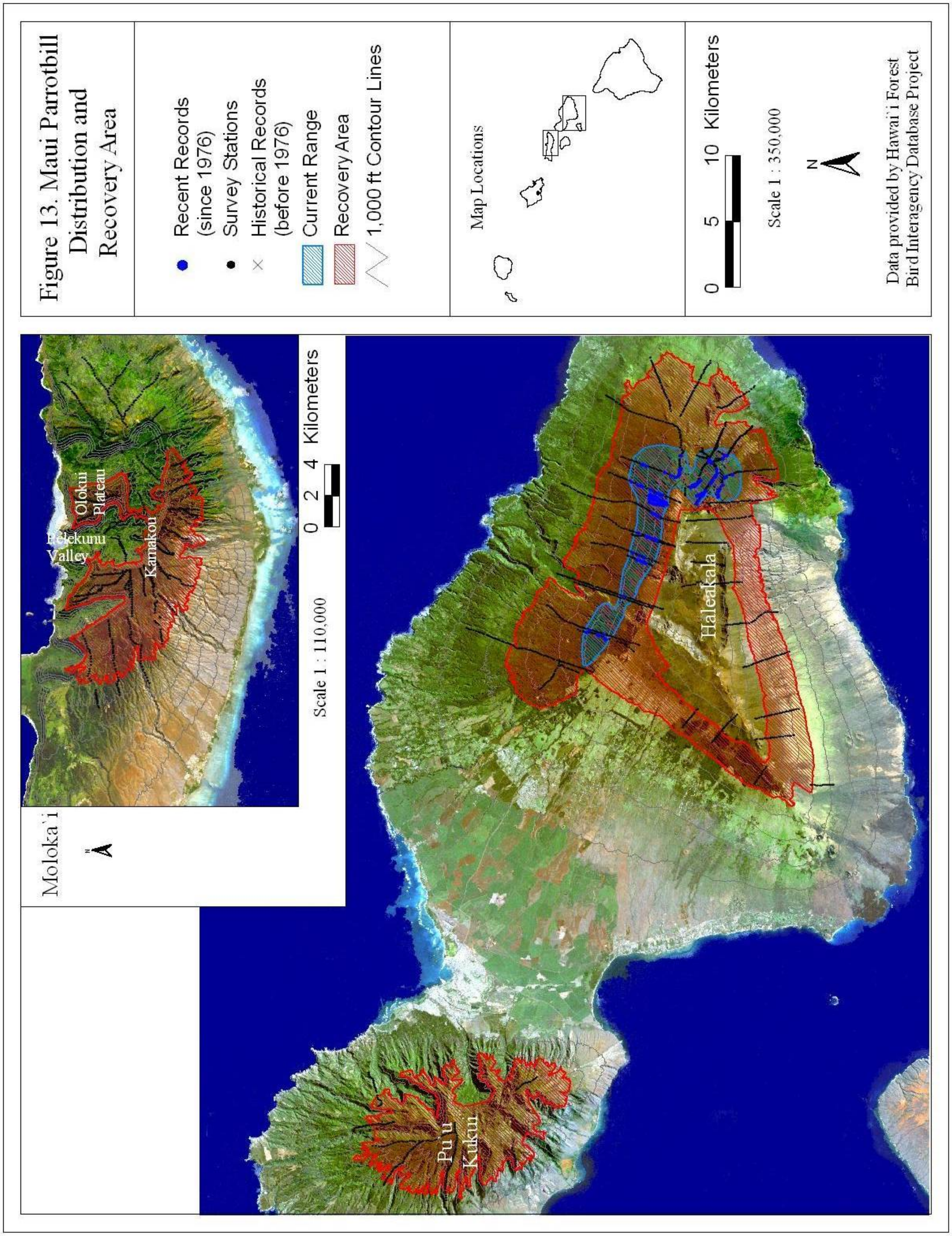


Figure 13. Maui Parrotbill Distribution and Recovery Area
Recent Records (since 1976)
Survey Stations
Historical Records (before 1976)
Current Range
Recovery Area
1,000 ft Contour Lines
Map Locations
0 5 10 Kilometers
Scale 1 : 350,000
N
Data provided by Hawai`i Forest Bird Interagency Database Project
Moloka`i
N
Olokui Plateau
Pelekunu Valley
Kamakou
0 2 4 Kilometers
Scale 1 : 110,000
Haleakala
Pu`u Kukui

REASONS FOR DECLINE AND CURRENT THREATS

The Maui parrotbill is subject to the same threats that negatively affect other forest birds on Maui, including habitat loss and degradation, predation, and introduced diseases. The parrotbill has a very low reproductive rate (see Life History), which makes it particularly vulnerable and slow to recover. Other factors, such as competition from introduced avian and arthropod insectivores, have not been documented, but purposeful and accidental introduction of alien species remains a persistent threat.

Habitat Loss and Degradation. Historically, Maui parrotbills were reported to favor koa for foraging (Perkins 1903). Widespread habitat destruction of koa forests due to logging and ranching has significantly reduced the species' range, and has been particularly severe in more mesic areas that formerly supported high densities of koa. The species' current range is restricted to wet forest areas where koa densities are relatively low. Thus, occupied habitat may be suboptimal compared to portions of the former range. Within its current range, habitat damage to the understory vegetation by feral pigs may be a significant factor contributing to reduced food availability, large territories, and low reproduction. Unoccupied but potential habitat that is currently degraded because of pigs may be suitable for reestablishment of parrotbills once pigs are removed and the areas have recovered. Low quality or damaged habitat may exacerbate the negative effects of severe weather events such as rainstorms, which are common in East Maui and have been linked to failure of parrotbill nests (Mountainspring 1987, Simon *et al.* in press).

Predation. The importance of predation in limiting parrotbill populations is not clear. However, predation of nests and adults by rats, cats, mongooses, and owls is suspected to have a significant impact on many native Hawaiian bird species (Atkinson 1977, VanderWerf and Smith 2002). Recent surveys indicate rat densities are very high in the Hanawī area where much of the parrotbill population currently occurs (Sugihara 1997; T. Malcolm, Maui Forest Bird Recovery Project, pers. comm.).

Introduced Diseases. Most Hawaiian forest birds are susceptible to introduced mosquito-borne diseases, and the Maui parrotbill may be limited to its current high-elevation distribution by these diseases (Scott *et al.* 1986, Mountainspring 1987). Despite the availability of apparently suitable habitat, parrotbills are absent from most areas below 1,350 meters (4,500 feet), where mosquitoes are common. This pattern contrasts with that of some unlisted species, suggesting that parrotbills and other endangered species are especially susceptible to disease.

CONSERVATION EFFORTS

The Maui parrotbill was federally listed as an endangered species on March 11, 1967 (U.S. Fish and Wildlife Service 1967). It became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Maui-Moloka`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1984a).

Declines of the Maui parrotbill, Maui `ākepa, Maui nukupu`u, `ākohekohe, and especially the po`ouli prompted conservation agencies to protect the habitat in which these birds persisted. Reserves were created at Hanawī by the State of Hawai`i Department of Land and Natural Resources and at Waikamoi on private lands by The Nature Conservancy of Hawai`i. In 1991, the State of Hawai`i, The Nature Conservancy, Haleakalā National Park, Hāna Ranch, Haleakalā Ranch, Alexander and Baldwin (East Maui Irrigation Company) and the Maui County Department of Water Supply joined together to protect 40,486 hectares (100,000 acres) of wet forest in East Maui under the East Maui Watershed Partnership. This large watershed area encompasses the entire current range of the Maui parrotbill.

Through ongoing fencing and feral ungulate control, the State, Haleakalā National Park, and The Nature Conservancy of Hawai`i have reduced or removed feral pigs on much of their lands ranging from Waikamoi to Kīpahulu. Recent East Maui Watershed Partnership fencing, research, and ungulate management in the State forest reserves continue to protect and restore native forest. These actions and improvements should benefit the Maui parrotbill and other forest birds. The Hawai`i Department of Land and Natural Resources and U.S. Fish and Wildlife Service jointly fund the Maui Forest Bird Recovery Project, which conducts research and habitat management in Hanawī Natural Area Reserve and other areas that will benefit Maui parrotbill and other endangered species in the Hanawī Natural Area Reserve and adjacent habitat. Activities undertaken by this project include predator and ungulate control, surveying, mist-netting, banding, and monitoring of forest birds, optimization of predator control methods, and assessment of management actions on native forest bird populations.

In 1997, a captive breeding program for the Maui parrotbill was initiated when an egg was taken to the Maui Bird Conservation Center, following the recommendations of Ellis *et al.* (1992). In 1999, two additional wild eggs were collected, hatched, and reared (The Peregrine Fund 1999). One pair formed from these eggs and this pair produced two chicks in 2000 (The Peregrine Fund and Zoological Society of San Diego 2000). In 2001, three additional chicks were produced and one wild adult male, injured in the field, was added to the captive breeding program (Zoological Society of San Diego 2001). The number of captive birds now numbers 10 (3 males and 7 females). Additional eggs may be collected in future years to enhance the captive breeding program, with the intent of producing more birds for reintroduction into managed recovery areas.

RECOVERY STRATEGY

The recovery strategy for the Maui parrotbill centers on the protection, restoration, and management of native high elevation forests on East Maui (Haleakalā), research to understand threats from disease and predation, and captive propagation to produce birds for reestablishment of wild populations. Reestablishment of parrotbills on West Maui or East Moloka`i is needed to provide a minimum of two viable populations, or to allow for a single viable metapopulation, in order to reduce the risk of extinction due to catastrophes such as hurricanes and epizootics of disease. Reestablishment in southern or western areas of Haleakalā is needed to promote natural demographic and evolutionary processes.

Recovery Areas. Parrotbills are currently restricted to the windward forests of East Maui from Waikamoi to Kaupō (Figure 13). State and Federal agencies and the East Maui Watershed Partnership have been successful in protecting much of the remaining parrotbill habitat. However, extensive work is still needed to fence and protect the lower elevation areas from Hanawī Natural Area Reserve to Waikamoi; this area is with the species' range, and also contains potential habitat. Additional fencing and ungulate eradication in this area will facilitate the recovery of an intact and diverse native subcanopy vegetation which may in turn increase food availability. This work may also help to reduce levels of mosquito vectors.

On southern and western exposures of East Maui (Haleakalā), a continuous "lei" or ring of suitable forest should be reconnected around the mountain, especially at upper elevations where mosquitoes are rare. Although the current parrotbill population is restricted to the wet `ōhi`a forests of windward East Maui, this may represent a contraction of range into marginal habitat following widespread habitat loss and degradation (Simon *et al.* 1997). Parrotbills were once found throughout leeward areas and are thought to prefer koa for foraging (Perkins 1903). Habitat restoration and reestablishment of a population on the leeward or western exposures of East Maui is needed to help reduce extinction risk, and to increase the ecological breadth of the species to help buffer against climatic fluctuations. The restoration of koa to these montane regions is a key element of habitat restoration in these areas.

A small amount of unprotected, remnant mesic koa forest currently exists on State Forest Reserve and Department of Hawaiian Homelands properties in the Kahikinui region of southern Haleakalā. This area holds great potential to provide suitable habitat for the parrotbill. The completion of fencing projects and initiation of programs to eradicate ungulates are needed to restore the native canopy and understory. Fencing of over 2,000 acres (800 hectares) has already begun, and long-term plans involve protection of over 20,000 acres (8,000 hectares). The subsequent removal of feral ungulates would allow the natural regeneration of koa and other plant species, and ground scarification and outplanting may be used to speed habitat restoration. This work could proceed to the east and west, eventually relinking the remnant Kahikinui Forest to other forests on East Maui, possibly including Manawainui, Kaupō, and remnant koa forests near Kula.

Most of the remaining leeward montane forests on southern slopes, while believed to be largely mosquito-free, currently are degraded by ungulates. These areas, in addition to fencing and ungulate control, will require more intensive, long-term restoration to be suitable for endangered forest birds.

Although much of the potential parrotbill habitat on West Maui and East Moloka`i is mostly free of ungulates, the suitability of these areas with respect to the presence of introduced mosquito-borne diseases is not clear. Much of this habitat lies at elevations below 1,350 meters (4,500 feet), and thus likely holds mosquitoes. Ongoing habitat management and removal of ungulates may reduce mosquito densities, but surveys of mosquitoes and disease prevalence are needed prior to the reintroduction of endangered forest birds in these areas. This work should be integrated into an evaluation of the amount of suitable habitat available, estimates of the size of the population that could be supported, and a population viability analysis of the hypothetical population that would aid plans to reestablish populations in those areas. In addition, control of mammalian predators is needed at a large enough geographic scale to protect new populations.

Predator Control. An important component of parrotbill recovery should be an evaluation of the effect of rodent control on parrotbill reproduction and survival, and an expansion of the scale of work if warranted. Control of small mammalian predators may be needed throughout recovery areas and may be especially important for parrotbill populations, because this species has a low reproductive rate and thus is particularly sensitive to high rates of nest loss and adult mortality (Simon *et al.* 2000).

Disease. Protecting and restoring habitat in upper elevation disease-free areas is crucial to parrotbill recovery. The identification of disease-resistant individuals and incorporation of these individuals into captive breeding and translocation programs could greatly enhance recovery efforts. Resistance or tolerance to disease appears to be evolving in populations of some birds (Cann and Douglas 1999, Woodworth *et al*. 2005), and resistant parrotbills may exist too. Parrotbills may occur at lower elevations in Kīpahulu Valley than elsewhere, but the reasons are not clear, and this pattern may be related to habitat rather than disease resistance. Further research into the causes of this pattern is needed.

Captive Propagation and Reintroduction Programs. Captive propagation may play a significant role in the recovery of the Maui parrotbill, and there are plans to increase the captive population. Initial efforts at captive propagation of the Maui parrotbill have been successful, with the hatching of three wild eggs (one male, two females) that have bred in captivity, producing four eggs with the subsequent rearing of three chicks. Research and development of reintroduction techniques and evaluation of sites for experimental releases are needed for this species.

9. Kaua`i `Akialoa, *Hemignathus procerus*

DESCRIPTION AND TAXONOMY

Kaua`i `akialoa. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

The Kaua`i `akialoa is a large (17 to 19 centimeters [6.7 to 7.5 inches] total length), short-tailed Hawaiian honeycreeper with a very long, thin decurved bill, the longest bill of any historically known Hawaiian passerine. Both sexes are olive-green; males are more brightly colored, slightly larger, and have a somewhat longer bill. The species was originally described by Gray in 1859, and its taxonomy and nomenclature have changed repeatedly (Olson and James 1995, Pratt 2005). It is in the Hawaiian honeycreeper family, subfamily Drepanidinae of the family Fringillidae.

LIFE HISTORY

The life history of the Kaua`i `akialoa is poorly known, based mainly on observations from the end of the 19th century (Wilson and Evans 1890 to 1899, Rothschild 1893 to 1900, Perkins 1903). The species used its long bill to probe for arthropods in bark crevices, decaying wood, epiphytes, and debris accumulated in the treetops. It also took nectar from `ōhi`a and lobelia flowers. Nothing was ever discovered about its nesting biology. The song was described as either a thin trill or canary-like, and the call as being louder and deeper than that of the Kaua`i `amakihi (*Hemignathus kauaiensis*).

HABITAT DESCRIPTION

The species was widespread on Kaua`i and occupied all forest types above 200 meters (660 feet) elevation (Perkins 1903).

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range included nearly all forests on Kaua`i visited by naturalists at the end of the 19th century (see Figure 7 on page 2-21). After a hiatus of many decades, the species was seen again in the late 1960s, and one specimen was collected (Richardson and Bowles 1964). It has not been seen since, despite efforts by ornithologists (Conant *et al.* 1998), birders, and intensive survey efforts by wildlife biologists in 1968 to 1973, 1981, 1989, 1994, 2000, and 2005 (Sincock 1982; Hawai`i Department of Land and Natural Resources, unpubl. data; Reynolds and Snetsinger 2001). The Kaua`i `akialoa may be extinct, but recent reexamination of the survey data for this species indicates that additional survey effort is required to confirm its status. If the remaining population is very small, fewer than 50 individuals, the likelihood that an individual bird would be detected given the level of survey effort thus far is relatively low (Scott *in litt*. 2006). There is some possibility that the species still survives in some small, remote area, particularly given the difficulty of the terrain and the inaccessibility of many of the sites where the species would be most likely to persist. The location of one of the last reports of the species, on private land, has not been revisited. Additional targeted surveys are needed to determine the status of the species with confidence.

REASONS FOR DECLINE AND CURRENT THREATS

The Kaua`i `akialoa vanished before anything could be learned of its plight. Presumably it succumbed to the same causes responsible for the decline and extinction of other forest birds on Kaua`i: introduced avian diseases transmitted by mosquitoes, depredation of adults and nests by rats, and habitat destruction by feral ungulates. Perkins (1903) noted that it was "grievously affected by… swellings on the legs and feet, as well as on the head at the base of bill, and on the skin around the eyes," which probably were caused by pox. Avian pox lesions are also present on many old specimens (J. Lepson and E. VanderWerf, unpubl. data).

CONSERVATION EFFORTS

The Kaua`i `akialoa was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967), became protected under the State of

Hawai`i endangered species law on March 22, 1982, and was included in the Kaua`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1983b).

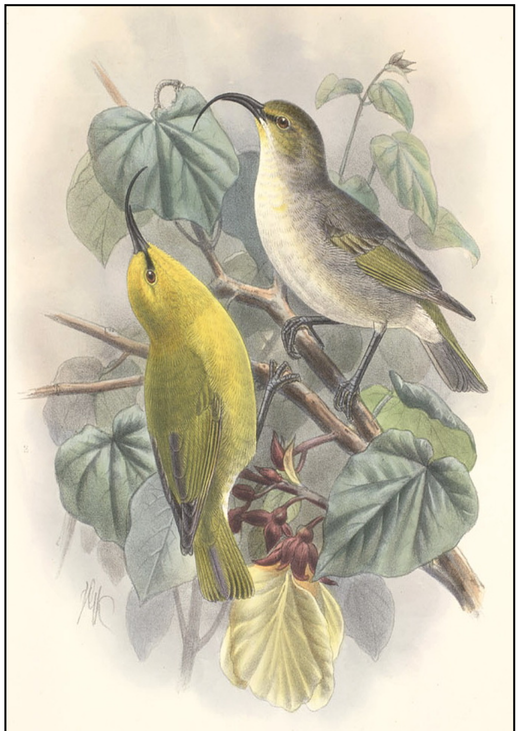
No conservation efforts have been initiated specifically for the Kaua`i `akialoa, but if the species still exists it could benefit from habit protection (see puaiohi species account). The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. It was later strengthened and re-titled "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104, Rules Regulating Activities Within Forest Reserves," which protects native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the value of the pristine forest of that area and the need to control potential degrading factors.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

10. Kaua`i Nukupu`u, *Hemignathus lucidus hanapepe*

DESCRIPTION AND TAXONOMY



Kaua`i nukupu`u pair. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

The Kaua`i nukupu`u is a long-billed Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae), larger than the similar Kaua`i `amakihi (*Hemignathus kauaiensis*), and with an extraordinarily thin, curved bill, slightly longer than the bird's head. The lower mandible is half the length of the upper mandible and follows its curvature rather than being straight as in the related `akiapōlā`au (*Hemignathus munroi*) of Hawai`i Island. Adult males are olive green with a yellow head, throat, and breast, whereas adult females and immatures have grayish green upper parts and whitish under parts. First- and second-year males resemble females. Kaua`i nukupu`u (*H .l. affinis*) differ from Maui nukupu`u by their larger size and subtle differences in plumage (see Maui nukupu`u species account).

The Kaua`i nukupu`u is one of two subspecies of nukupu`u that may still survive (the other is the Maui nukupu`u). The Kaua`i nukupu`u was described by Wilson (1889). Evidence is mounting that the Kaua`i, O`ahu, and Maui forms of nukupu`u are distinct species (Pratt 2005; R. Fleischer, unpubl. data).

LIFE HISTORY

The historical record provides little information on the life history of the Kaua`i nukupu`u (Rothschild 1893 to 1900, Perkins 1903). Nothing is known of its breeding biology, which is likely similar to its closest relative, the `akiapōlā`au (see `akiapōlā`au species account). Kaua`i nukupu`u extract or excavate invertebrates from epiphytes, bark, and wood using their unusual bill in a manner similar to that of the `akiapōlā`au. Nukupu`u often join mixed species foraging flocks, especially with the Kaua`i creeper (*Oreomystis bairdi*). The song of the Kaua`i nukupu`u resembles the warble of a house finch (*Carpodacus mexicanus*), and both the song and the "kee-wit" call resemble those of `akiapōlā`au (Perkins 1903).

HABITAT DESCRIPTION

Historical records from the turn of the last century indicate that the Kaua`i nukupu`u was found in a small area of diverse montane mesic and wet forest at elevations of 610 to 1,220 meters (2,000 to 4,000 feet) on the southwestern slope of Kaua`i Island (Banko 1984b). All subsequent sightings, many of them doubtful, have been from the same habitat (Pratt and Pyle 2000).

HISTORICAL AND CURRENT RANGE AND STATUS

No subfossils of Kaua`i nukupu`u have been reported, so our understanding of the original distribution of this subspecies is limited to the historical record. Since 1960, the nukupu`u has been reported infrequently from Kōke`e and the Alaka`i (see Figure 7 on page 2-21; Scott *et al.* 1986, Pratt and Pyle 2000). However, some of these descriptions better match the similar Kaua`i `amakihi. Several recent intensive surveys (1981 to 2000) have failed to find the Kaua`i nukupu`u (Pratt and Pyle 2000). However, skilled observers reported three (unconfirmed) sightings of Kaua`i nukupu`u in 1995. Search results for nukupu`u on Kaua`i are currently considered inconclusive (Reynolds and Snetsinger 2001), and additional survey efforts are needed to confirm the status of the species.

REASONS FOR DECLINE AND CURRENT THREATS

In the absence of information pertaining to this species, reasons for decline and current threats are presumed to be the same as for other endangered birds on Kaua`i (see puaiohi species account).

CONSERVATION EFFORTS

The Kaua`i nukupu`u was federally listed as an endangered species on March 11, 1967 (U.S. Fish and Wildlife Service 1967), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Kaua`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1983b).

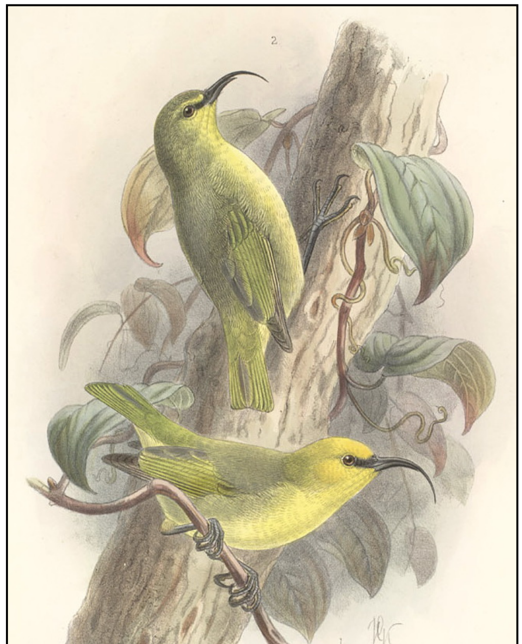
No conservation efforts have been initiated specifically for the Kaua`i nukupu`u, but if the species still exists it could benefit from habit protection (see puaiohi species account). The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. It was later strengthened and re-titled "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104, Rules Regulating Activities Within Forest Reserves," which protects native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the value of the pristine forest of that area and the need to control potential degrading factors.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

11. Maui Nukupu`u, *Hemignathus lucidus affinis*

DESCRIPTION AND TAXONOMY



Maui nukupu`u. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

The Maui nukupu`u is a medium-sized, approximately 23 gram (0.78 ounce), Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) with an extraordinarily thin, curved bill, slightly longer than the bird's head. The lower mandible is half the length of the upper mandible and follows its curvature rather than being straight as in the related `akiapōlā`au (*Hemignathus munroi*) of Hawai`i Island. Adult males are olive green with a yellow head, throat, and breast, whereas adult females and immatures have an olive-green head and yellow or yellowish gray under-parts. Females and first- and second-year males are nearly identical and have a noticeably pale superciliary line. Maui nukupu`u differ from Kaua`i nukupu`u (*H. l. hanapepe*) by their smaller size, yellowish rather than whitish vent, and grayish-green rather than yellowish-green back.

The Maui nukupu`u is one of three subspecies. The Maui and Kaua`i subspecies may still survive, but *H. l. lucidus* of O`ahu is extinct. Evidence is mounting that the Kaua`i, O`ahu, and Maui forms of nukupu`u are distinct species (Pratt 2005; R. Fleischer, unpubl. data). The Maui nukupu`u was described by Rothschild (1893 to 1900).

LIFE HISTORY

The historical record provides little information on the life history of the Maui nukupu`u (Rothschild 1893 to 1900, Perkins 1903). Nothing is known of its breeding biology, which likely was similar to its closest relative, the `akiapōlā`au (see `akiapōlā`au species account). Maui nukupu`u tap and probe bark, lichen, and branches to extract insects, and thus their foraging behaviors resemble those of `akiapōlā`au. Diet of the Maui nukupu`u was reported by Perkins (1903) to be small weevils and larvae of coleoptera (beetles) and Lepidoptera (butterflies and moths). Apparently they seldom forage for larvae and adults of longhorn beetles (Cerambycidae) and thereby compete little with Maui parrotbills. There is scant evidence that Maui nukupu`u take nectar from flowers.  Maui nukupu`u often join mixed species foraging flocks (Perkins 1903). Their song resembles the warble of a house finch (*Carpodacus mexicanus*), but is lower in pitch. Both the song and the "kee-wit" call resemble those of `akiapōlā`au and Maui parrotbill (Perkins 1903).

HABITAT DESCRIPTION

The first historical records, at the turn of the last century, indicate that the Maui nukupu`u inhabited mixed koa/`ōhi`a (*Acacia koa*/*Metrosideros polymorpha*) forest from 1,220 meters (4,000 feet) to timberline (Perkins 1903, Banko 1984b, Hawai`i Natural Heritage Program Database) on the northwestern slope of Haleakalā. Sightings since the 1967 rediscovery of the Maui nukupu`u have been in mixed shrub montane wet forest (Jacobi 1985) in Kīpahulu Valley and the northeast slope of Haleakalā at 1,100 to 2,100 meters (3,600 to 6,720 feet), though most have been above 1,700 meters (5,500 feet; Banko 1984b). Discovery of subfossil nukupu`u on Moloka`i and Maui show that the species once inhabited dry forests (James and Olson 1991).

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, the Maui nukupu`u is known only from Maui, but subfossil bones of a probable Maui nukupu`u from Moloka`i show that the species formerly inhabited that island (James and Olson 1991).  A nukupu`u specimen from Hawai`i Island does not represent the Maui form and was shown genetically to be a mislabeled O`ahu bird (Olson and James 1994; Pratt 2005). All records prior to 1967 were from locations most accessible to naturalists, above Olinda on the northwest rift of Haleakalā (Figure 14; Banko 1984b). Observers at the time noted the restricted distribution and low population density of Maui nukupu`u. As on Kaua`i, introduced mosquitoes (Hardy 1960) and avian diseases may have already limited these birds to forests at higher elevations. We can presume that the Maui nukupu`u once had a much wider geographic range.

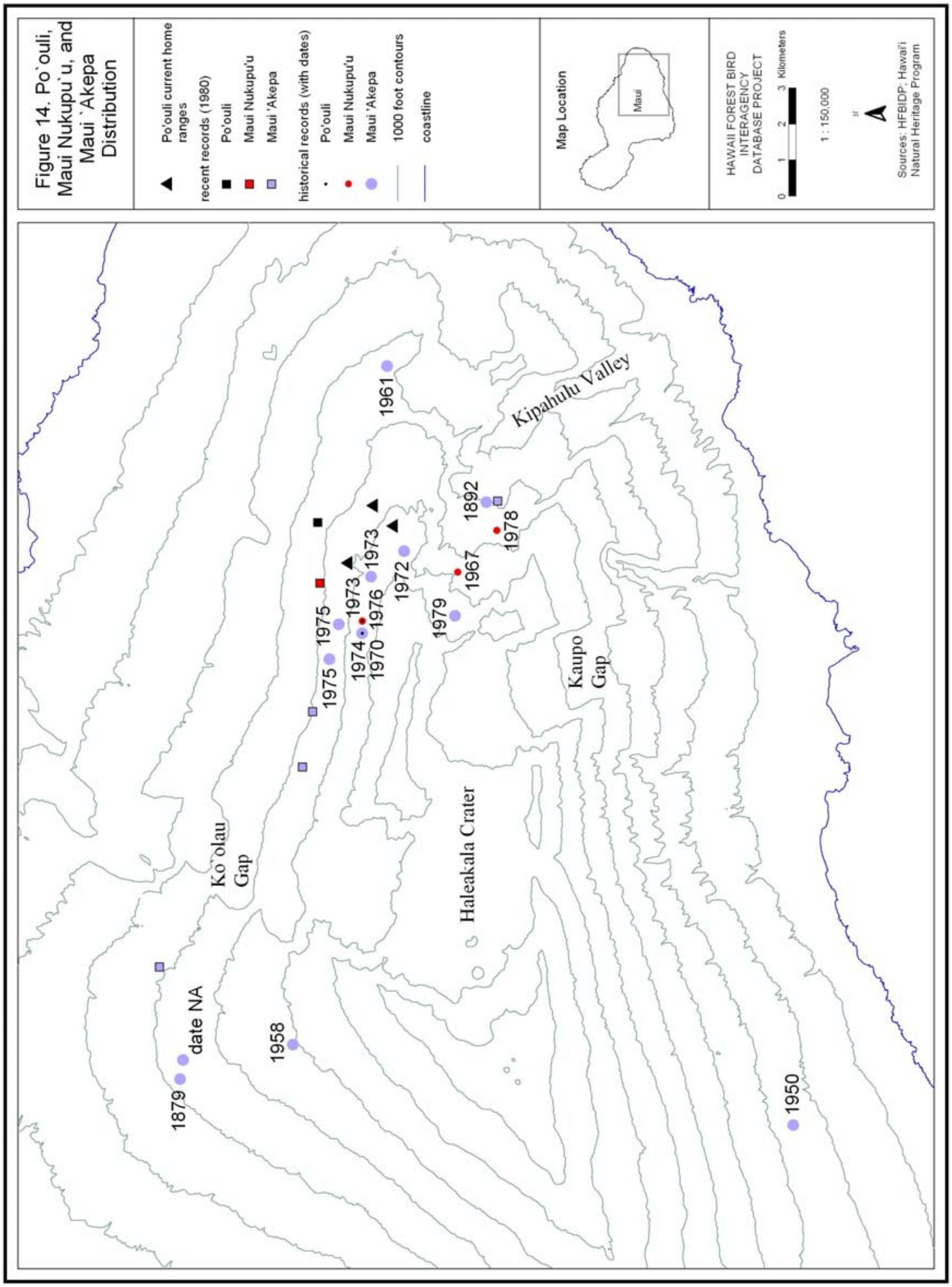


Figure 14. Po`ouli, Maui Nukupu`u, and Maui `Akepa Distribution

In 1967, W. Banko rediscovered Maui nukupu`u in the upper reaches of Kīpahulu Valley on the eastern slope of Haleakalā (Banko 1968). Since then, isolated sightings have been reported on the northern and eastern slopes of Haleakalā from below Pu`u `Alaea east to Kīpahulu Valley (Pratt and Pyle 2000). Because most of these sightings were uncorroborated by behavioral information or follow-up sightings, the recent status of the Maui nukupu`u is difficult to evaluate. Scott *et al.* (1986) estimated a population of 28 ± 56 birds based on a single sighting. One bird was detected in 1994, and was resighted in 1995 and a second time in 1996, on the northeast slope of Haleakalā (Reynolds and Snetsinger 2001). However, most recent intensive surveys (1995 to 1999) did not detect nukupu`u at locations of previous sightings (Baker 2001; Hawai`i Department of Land and Natural Resources, unpubl. data). Although it is possible the Maui subspecies may be extinct (Pratt and Pyle 2000), the relatively recent sightings of nukupu`u on Haleakalā and extensive habitat area that still exists for nukupu`u led Reynolds and Snetsinger (2001) to conclude that the nukupu`u is still extant on Maui. Further targeted surveys will be required to confirm the status of this species.

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for decline and current threats are presumed to be the same as for other endangered Maui birds. See po`ouli species account.

CONSERVATION EFFORTS

The Maui nukupu`u was federally listed as an endangered species on March 11, 1967 (U.S. Fish and Wildlife Service 1967), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Maui-Moloka`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1984a). Until 1995, no efforts had been initiated in the field specifically for Maui nukupu`u. The species has since benefited, or could benefit, from thorough surveys of the best habitat, predator control, and habitat restoration at locations where the last sightings were reported (see po`ouli species account).

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

12. `Akiapōlā`au, *Hemignathus munroi*

DESCRIPTION AND TAXONOMY

Male (right) and female `akiapōlā`au.
Photo © Eric VanderWerf

The `akiapōlā`au is a medium-sized (14 centimeter [5.5 inch], 28 gram [0.9 ounce]), stocky, short-tailed Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) endemic to the Island of Hawai`i. Its most remarkable feature is the extraordinary bill, which has a long, sickle-shaped upper mandible and a short, straight lower mandible that is only half as long as the upper. Males are larger and heavier than females and have a slightly longer bill. Adult males have a bright yellow head and underparts, a greenish back and wings, and black lores. Adult females differ in color, with a yellowish-white chin, throat, and upper breast that contrasts with a pale yellowish-gray lower breast and belly (Pratt *et al.* 1994). Fledglings have a mottled yellowish-gray or green juvenile plumage with pale under parts. Within a few months of fledging juveniles molt into a similar but unmottled first basic plumage. Most birds molt into definitive basic (adult) plumage in their second year (Pratt *et al.* 1994).

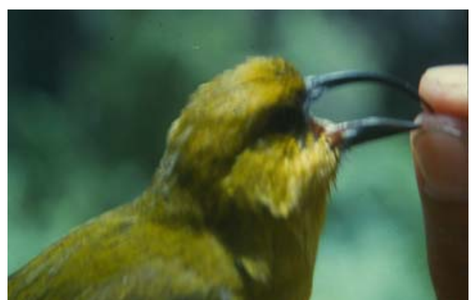
The species was described by Rothschild (1893 to 1900), who named it *Heterorhynchus wilsoni*. The `akiapōlā`au was later grouped with the `amakihi and renamed *Hemignathus munroi* (Pratt 1979, American Ornithologists' Union 1983). The `akiapōlā`au is closely related to the nukupu`u (*H. lucidus*; Olson and James 1994). There is no notable morphological variation with elevation or locality.

LIFE HISTORY

Ralph and Fancy (1994c, 1996) and Pratt *et al.* (2001) described most of what is known about the life history of the `akiapōlā`au, and important new information on habitat use and demography was reported recently by Pejchar (2004).

The aspect of `akiapōlā`au life history most important to conservation is the low intrinsic rate of reproduction, which puts a premium on success of nesting events and on adult survival. Usually only one young is fledged, followed by an extended period (more than 4 to 5 months) of juvenile dependency, so that only a single brood is typically produced per year. Annual productivity was found to be 0.86 young per pair in a declining population (Ralph and Fancy 1996), and 0.96 ± 0.79 in closed, open, and koa plantation habitats combined (Pejchar 2004).

Breeding and molting occur mainly from February to July, but `akiapōlā`au can be found breeding or molting during any month of the year. Such broad overlap of these activities is unusual among birds, and research is needed to clarify the annual cycle of the `akiapōlā`au. The majority of nests have been found in the leafy, terminal branches of tall `ōhi`a (*Metrosideros polymorpha*) trees. The nest is cup-shaped and characterized by strips of `ōhi`a bark incorporated into the exterior surface. Clutch size is either one or, rarely, two eggs (Banko and Williams 1993). The female performs all incubation and brooding, while the male provides most of her food and that of the nestlings.



Male `akiapōlā`au exhibiting cranial kinesis that allows bill manipulation. Photo © Eric VanderWerf.

The `akiapōlā`au is mainly insectivorous. Moth larvae are the most common food item in `akiapōlā`au fecal samples, followed by spiders and long-horned beetle larvae (Ralph and Fancy 1996). The bird uses its unusual "Swiss-army knife beak" as two tools deployed separately or together. With the jaws gaped open, the short, robust lower mandible is used to rapidly tap branches to locate prey beneath the bark or in the wood. Once prey is located, the lower mandible is used as a chisel in a manner reminiscent of woodpeckers. The long, curved upper mandible is used as a probe to extract insect larvae and spiders from crevices or insect borings. Despite their different lengths, a remarkable degree of cranial kinesis allows the two mandibles to work in concert as pliers or tweezers for ripping away bark and epiphytes or for handling prey.

Lichen-covered and dead branches are preferred as foraging substrates. Males tend to select taller trees and to forage more often on the trunk and larger branches, whereas females and young are more often observed foraging on small branches and twigs (Ralph and Fancy 1996). The cause of sexual foraging differences is unknown. Tree species preferred for foraging include koa (*Acacia koa*), kōlea (*Myrsine* spp.), māmane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*), while `ōhi`a is not favored. The foraging behavior of `akiapōlā`au is very specialized compared with that of other forest birds, and foraging sites and food may be limiting.

This species rarely takes nectar from flowers, but it recently has been discovered to drink sap from small wells it drills in the bark of `ōhi`a trees. Only a few trees in a bird's territory are used for this purpose, and they are defended against other `akiapōlā`au. On average sap trees are larger, have thinner bark, greater sap flow, and tend to occur on convex slopes with more light (Pejchar and Jeffrey 2004).

`Akiapōlā`au often join mixed species foraging flocks, perhaps to enhance detection of predators. In montane mesic forests, they most frequently associate with Hawai`i creeper (*Oreomystis mana*) and `ākepa (*Loxops coccineus*), whereas in subalpine dry forest they are found with Hawai`i `amakihi (*Hemignathus virens*) and palila (*Loxioides bailleui*). The importance of these flocks to `akiapōlā`au has not been studied, but may prove relevant to the conservation of this species.

The primary song is a loud, rapid warble. Calls include a loud "pit-er-eoo" and an ascending "chu-wee," louder and deeper than similar calls of other species. While `akiapōlā`au sing year round, the seasonal frequency of singing appears to vary greatly. Current survey methodology, which relies on point counts of vocalizing birds, may be accurate when birds are vocal, but may considerably underestimate population density at times when birds are quiet. It would be useful to investigate seasonality of singing so that surveys and censuses can be planned to coincide with periods of peak singing.

Home range size varies from approximately 5 to 40 hectares (12 to 100 acres), with no difference between males and females, which remain together in pairs most of the time (Pratt *et al.* 2001a). Home ranges are defended as territories, and there is little evidence of daily or seasonal movements. Some birds appear temporarily in areas where they are usually not seen, suggesting some seasonal movement; others remain on territory year-round. The factors that influence the huge range in territory size, and therefore population size, are poorly known, but recent work by Pejchar (2004) showed that home range size varied from 23.0 ± 7.2 hectares (56.8 ± 17.8 acres) in open forest to 12.3 ± 7.2 hectares (30.4 ± 17.8 acres) in closed forests, and 11.7 ± 4.3 hectares (28.9 ± 10.6 acres) in young koa plantations. Furthermore, home ranges overlapped more in koa plantations (41.2 percent), than in closed forest (22.6 percent) or open forest (9.2 percent), resulting in even higher population densities in koa plantations (13 pairs per 100 hectares), than in closed forest (10 pairs per 100 hectares) or open forest (5 pairs per 100 hectares; Pejchar 2004). With so little disease-free habitat available to this species, this information is promising because it suggests it may be possible to increase the population size of the species by increasing population density.

HABITAT DESCRIPTION

Essentially all recent observations of `akiapōlā`au have been in montane mesic and wet forest dominated by koa and `ōhi`a or in subalpine dry forest dominated by māmane and naio. Although koa/`ōhi`a forest occurs below 1,300 meters (4,000 feet) elevation, few `akiapōlā`au are found there, presumably because of the presence of mosquitoes that transmit avian malaria and avian pox. Until recently, `akiapōlā`au extensively inhabited wet montane forest dominated by `ōhi`a, with no koa. Some birds are still found in that habitat at middle elevations in Hāmākua. The recent documentation of `akiapōlā`au inhabiting young koa plantations demonstrates that this species is not restricted to old growth (Pejchar 2004). These results indicate the need for a better understanding of the ways that silviculture practices and plantation forest structure affect food availability for `akiapōlā`au, and the need for follow-up studies that document the demography of `akiapōlā`au populations inhabiting these habitats.

Habitat preference of `akiapōlā`au in primary forest is well documented, but the use and persistence of successional habitats and habitat mosaics needs further study. This is evermore important in a landscape subject to lava flows and to changing patterns of agricultural and conservation use. These environments, mainly in Upper Waiākea, Kapāpala, and Kona, could be managed to expand and connect the existing core populations of `akiapōlā`au. `Akiapōlā`au will cross gaps of 100 meters (330 feet) or more, but the frequency with which they do so and the maximum width of gaps that they regularly cross is unknown. Study of habitat use is needed at the individual and metapopulation level.

HISTORICAL AND CURRENT RANGE AND STATUS

The \`akiapōlā\`au is endemic to Hawai\`i Island and is presently unknown from the fossil record (James and Olson 1991). Historically, the \`akiapōlā\`au was much more common and widespread than it is today, being found virtually island-wide in native forest (Figure 15; Pratt *et al.* 2001a). Perkins (1903) reported that they were abundant and occurred as low as 500 meters (1,650 feet) in forests near Hilo. In the 1940s, they were still present above 1,700 meters (5,500 feet) in Hawai\`i Volcanoes National Park (Baldwin 1953), but by 1970 they had disappeared from Hawai\`i Volcanoes National Park and were less common elsewhere (Conant 1975, Banko and Banko 1980).

In the 1970s, \`akiapōlā\`au were found in 5 disjunct populations with a total estimated population size of 1,500 ± 400 birds (95 percent confidence interval; Scott *et al.* 1986). Four of these populations inhabited koa-dominated montane forests in Hāmākua south to the upper Waiākea kīpuka, Kūlani, and Keauhou, in Ka\`ū and Kapāpala, in southern Kona, and in central Kona (Figure 15). A fifth population occupied subalpine dry forest on Mauna Kea. Originally these populations were all connected, but they have since been isolated by clearing of forest, mainly due to grazing.

Although the most recent population estimate, based on surveys from 1990 to 1995, is 1,163 birds with a 90 percent confidence interval of 1,109 to 1,217 birds (Fancy *et al.* 1995), new survey data indicate the population may be somewhat larger than this. The largest population has long been thought to occur in the Hāmākua region, which supports an estimated 793 birds in koa-dominated forests. This population appears to be relatively stable. In the Ka\`ū/Kapāpala area, the population reportedly decreased from an estimated 533 to 44 individuals since the 1970s (Fancy *et al.* 1995), but a more recent and intensive survey revealed a population in this region of more than 1,000 birds (U.S. Geological Survey, unpubl. data). The population in the Kūlani and Keauhou Ranch area was estimated at 312 birds. Thus the island-wide population for the species may actually be about 2,100 birds. Three \`akiapōlā\`au remained in the māmane forest on Mauna Kea in 2000, but all three of these birds are now gone. Another few

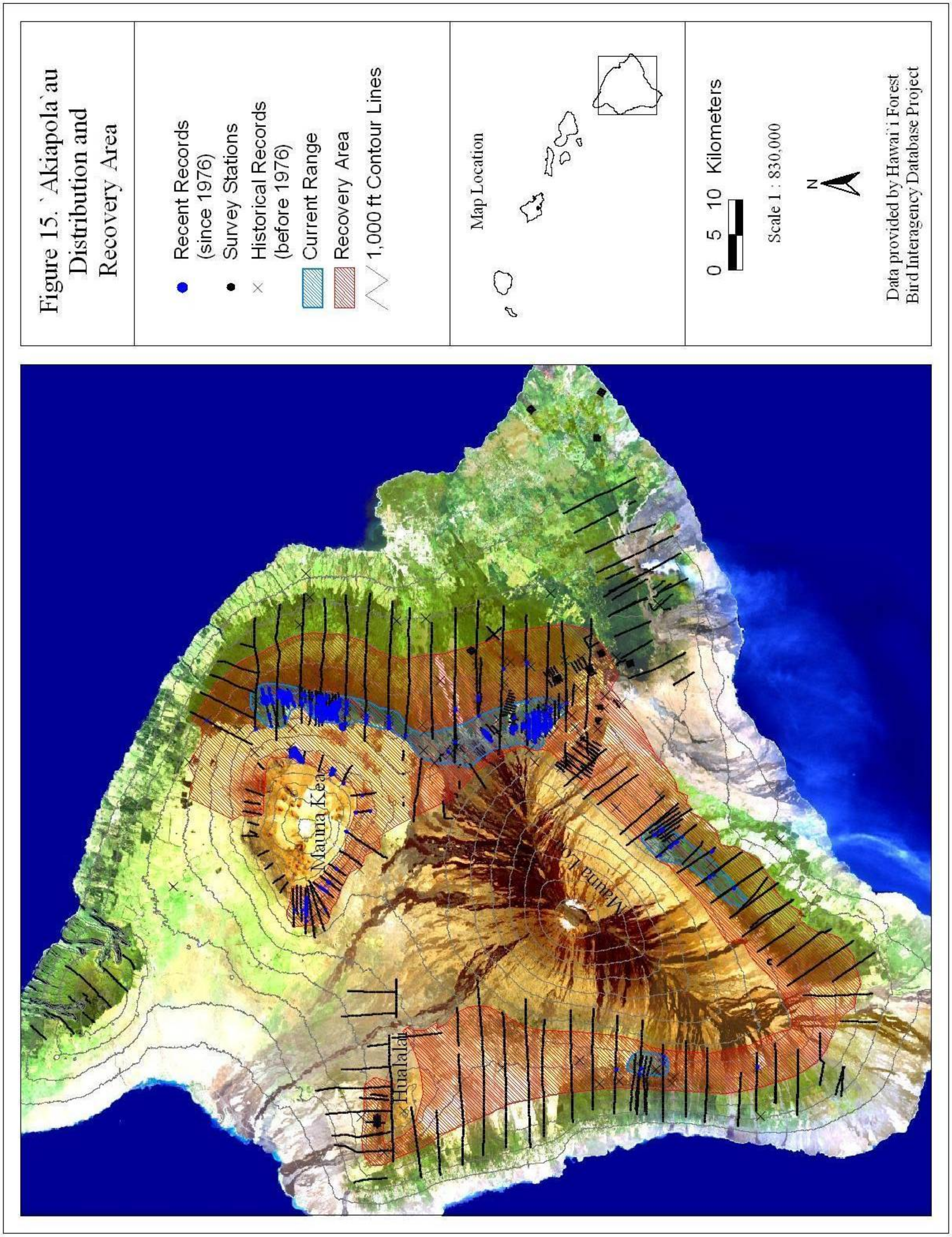


Figure 15. `Akiapola`au Distribution and Recovery Area

birds until recently inhabited koa/`ōhi`a forests of central Kona, but the current status of the birds in southern Kona is unknown.

The above-mentioned estimates serve to give an overall picture of the species' distribution and numbers. However, their precision and accuracy are poor because of the potential for inadequate sampling when birds are not singing and because of analytical problems associated with low population densities. Furthermore, the small Kona populations have never been adequately surveyed. Planning for this species' recovery would benefit from improved, up-to-date surveys and censuses. This can be achieved by determining when `akiapōlā`au vocalize most, by exploring additional survey or census methods to supplement standard point-counts, and by investigation of any metapopulation dynamics.

REASONS FOR DECLINE AND CURRENT THREATS

The `akiapōlā`au is subject to the same threats that negatively impact other forest birds on Hawai`i, including habitat loss and degradation, predation, and introduced diseases, but due to its low reproductive rate (see Life History), this species may be particularly vulnerable to these threats and slow to recover. Other factors, such as competition from introduced avian and arthropod insectivores, have not been documented, but purposeful and accidental introduction of alien species remains a constant threat.

Habitat Loss and Degradation. Destruction and degradation of forest habitat from development, logging, and ranching has greatly reduced the range of the `akiapōlā`au, and has been particularly severe in mesic and dry forest areas. Dry high elevation māmane-naio forest habitat on the slopes of Mauna Kea has been severely degraded by decades of browsing by feral goats and sheep. Designation of critical habitat for the palila (see account for that species) and subsequent court orders to remove ungulates has resulted in regeneration of this habitat, but `akiapōlā`au have already been extirpated from this area. Widespread loss and alteration of forest habitats has also led to fragmentation of the remaining suitable forest. The dispersal behavior of `akiapōlā`au is poorly known, but habitat fragmentation may isolate the remaining populations, decrease the effective population size, and hinder recolonization of areas that were formerly inhabited.

Predation. Predation of nests and adults by rats, cats, mongooses, and owls is suspected to have a significant impact on many native Hawaiian bird species (Atkinson 1977, VanderWerf and Smith 2002), but the significance of predation in limiting \`akiapōlā\`au populations is not clear. Recent surveys indicate rat densities are high at Hakalau Forest National Wildlife Refuge, which contains a significant portion of the largest remaining \`akiapōlā\`au population (U.S. Geological Survey, unpubl. data). The low population density of this species has made it difficult to locate sufficient nests for evaluating the effects of predator control. Mostello (1996) found the upper mandible of a juvenile \`akiapōlā\`au in a pellet from an introduced barn owl (*Tyto alba*). Juvenile \`akiapōlā\`au may be especially vulnerable to predators during the post-fledging period because their loud, persistent begging call makes them easy to locate. Predation, especially on adults, may impact \`akiapōlā\`au more than other native birds because the low reproductive rate of this species makes adults demographically more valuable (Ralph and Fancy 1996).

Introduced Diseases. Most Hawaiian forest birds are susceptible to introduced mosquito-borne diseases, and the \`akiapōlā\`au may be limited to its current high-elevation distribution by these diseases (Scott *et al.* 1986, van Riper *et al.* 1986, Atkinson *et al.* 1995). Despite the availability of apparently suitable habitat, \`akiapōlā\`au are absent from most areas below 1,350 meters (4,500 feet), where mosquitoes are common. This pattern contrasts with that of unlisted species, such as \`apapane (*Himatione sanguinea*) and Hawai\`i \`amakihi (*Hemignathus virens*), suggesting that \`akiapōlā\`au and other endangered species are especially susceptible to disease.

CONSERVATION EFFORTS

The \`akiapōlā\`au was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967), became protected under the State of Hawai\`i endangered species law on March 22, 1982, and was included in the Hawai\`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1983a).

Surveys to document status and trends in the \`akiapōlā\`au population at Hakalau, \`Ōla\`a/Kīlauea, the Kona Unit of Hakalau Forest National Wildlife Refuge, and in subalpine dry forest on Mauna Kea are conducted annually, but surveys elsewhere have been infrequent and less complete. Studies of factors limiting populations of endangered Hawaiian forest birds have been conducted sporadically since the late 1980s, and a research project dedicated specifically to `akiapōlā`au was conducted from 2000 to 2003 (Pejchar 2004).

Conservation efforts for the species have focused primarily on protection and management of high-elevation native forests. The Hakalau Forest National Wildlife Refuge was established in 1985, primarily to protect and manage habitat for native birds, including the `akiapōlā`au. Almost 45 percent of the refuge has been fenced, and feral pigs and cattle have been removed or reduced greatly within fenced areas at the refuge. Planting of koa and other native plants began in early 1989, and over 350,000 koa seedlings and 30,000 other native species have been planted (U.S. Fish and Wildlife Service, unpubl. data). The `Ōla`a/Kīlauea Partnership and Kona Unit of Hakalau Forest National Wildlife Refuge provide protection and management of forest for habitat. Removal of sheep and mouflon from Mauna Kea, following lawsuits and court orders regarding critical habitat for the palila, has permitted regeneration of māmane forest habitat. Two other relevant conservation actions were the removal of cattle and fencing of the Kapāpala Forest Reserve and the Pu`u Wa`awa`a Forest Bird Sanctuary; although the latter does not hold `akiapōlā`au, it could serve as a site for reintroduction. Plans to remove ungulates from the Kīpāhoehoe Natural Area Reserve and from lands at Honomalino, owned by The Nature Conservancy of Hawai`i, would protect this recovery area and could serve as sites for reintroducing `akiapōlā`au. The recent purchase of the Kahuku Ranch area of the Big Island also holds promise for long-term restoration of mesic and subalpine habitat that is expected to support `akiapōlā`au.

RECOVERY STRATEGY

Recovery of the `akiapōlā`au will require protection, management, and restoration of native forests above 1,350 meters (4,500 feet), research to gain key information that is presently lacking for this species, management of threats such as predation and disease, and possibly captive breeding and release of birds to augment or reestablish wild populations.

Research. Studies are needed in four main areas: (1) testing of survey methodology, followed by surveying and mapping of all populations and long-term monitoring in representative areas in Hāmākua, upper Waiākea kīpukas, Kūlani/Keauhou, Ka`ū/Kapāpala, and southern and central Kona; (2) demographic studies to measure life history parameters such as population structure, dispersion, dispersal, adult survivorship, clutch size, nesting success, social system, and phenology of nesting and molting; (3) habitat selection and foraging ecology, including diet and food availability, particularly in regenerating forest, as well as the role that koa silviculture practices play in the creation of suitable habitat; and (4) response of `akiapōlā`au populations to control of mammalian predators, particularly in low-stature dry forests where the species has difficulty maintaining itself. This information is needed to understand the dynamics of `akiapōlā`au populations, predict the densities of birds achievable across the species' geographic range, and enhance efforts to restore and reconnect declining populations and re-establish new populations in portions of the former range.

Recovery Areas. The most important component of the recovery strategy for the `akiapōlā`au is protection, management, and restoration of koa/`ōhi`a forests above 1,350 meters (4,500 feet) elevation. High elevation forest is of primary importance because it provides the greatest refuge from mosquito-borne diseases, but forests at lower elevation also could be valuable if a means of controlling mosquitoes can be found.

Fencing and/or removal of feral ungulates from the remaining high elevation forests will protect these areas and allow natural regeneration. In previously grazed or logged areas it may be necessary to replant with koa while allowing `ōhi`a and other native species to regenerate as well, as has been done in the upper portions of the Hakalau Forest National Wildlife Refuge. It is important that this action include all recovery areas (Figure 15). Several numbers reinforce this point: the current average density of `akiapōlā`au is one pair per 20 hectares (49 acres). By comparison, the Hakalau Forest National Wildlife Refuge currently offers about 8,500 hectares (21,000 acres) of suitable habitat above 4,500 feet (1,350 meters), although additional areas are being reforested, which could support approximately 425 pairs. The identified recovery areas encompass 238,000 hectares (588,000 acres; Figure 15), much of which requires extensive restoration.

Old-growth koa/`ōhi`a forest on many parcels in the recovery areas is deteriorating due to browsing and rooting by feral pigs, sheep, or mouflon, singly or in combination. Control of these animals would improve forest conditions and possibly increase density of `akiapōlā`au populations.

To maintain or reestablish connectivity of habitat and bird populations among the currently fragmented patches of `akiapōlā`au habitat, cattle should be removed from key parcels and stock ponds should be drained to reduce mosquito breeding. Priority should be given to reforesting upper drainages of the Wailuku River, upper Keauhou Ranch, Kapāpala Forest Reserve, and numerous parcels in Kona between Hōnaunau and Manukā Natural Area Reserve. A corridor between the koa/`ōhi`a forest of Hakalau Forest National Wildlife Refuge and the dry māmane forest at Kanakaleonui upslope from the refuge could be created by removing cattle from pastures above the refuge and replanting the area with koa and māmane, and would reestablish a valuable connection between native bird populations in these two areas and habitat types.

Predator control. Control of alien predators, especially rats, has been shown to be an effective method of increasing reproduction and survival in other Hawaiian forest birds (VanderWerf and Smith 2002). However, the degree of threat from alien rodents may vary among species and locations, and rodent control programs initially should be conducted in an experimental way to document their effect on `akiapōlā`au populations. Ground-based methods of rodent control using snap traps and diphacinone bait stations have been effective on a small scale, but are labor intensive. Effective large-scale rodent control likely will require aerial broadcast methods. Registration of aerial broadcast of diphacinone for rodent control with the U.S. Environmental Protection Agency should be actively pursued and supported.

Captive Propagation and Reintroduction. Natural recovery of `akiapōlā`au and reestablishment of wild populations in portions of the former range may be slow due to the low reproductive capacity of this species. Captive propagation techniques such as collection of eggs from the wild, artificial incubation and hand-rearing, captive-breeding, and reintroduction may be required to speed recovery. Translocation of wild birds also may be valuable, but captive propagation may be a more cost-effective means of reestablishing or augmenting wild populations. Previous translocations with Hawaiian forest birds have shown that young birds are more likely to remain in an area after release

(Fancy *et al.* 2001), and `akiapōlā`au nests are difficult to locate and reach, so it may be difficult to obtain a sufficient number of young wild birds.

Feasibility should be determined for reintroducing `akiapōlā`au into now-protected areas of its former range, particularly at the Pu`u Wa`awa`a Forest Bird Sanctuary, the Kona Unit of the Hakalau National Wildlife Refuge, Mauna Loa Strip of Hawai`i Volcanoes National Park, and, if it is managed as planned, the upper forests of Kīpāhoehoe Natural Area Reserve.

13. Hawai`i Creeper, *Oreomystis mana*

DESCRIPTION AND TAXONOMY

The Hawai`i creeper is a small Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) 10.8 to 13.0 centimeters (4.3 to 5.1 inches) in length and 13.7 grams (0.48 ounces) average weight (Lepson and Woodworth 2001). It is predominantly olive green on the back and dull greenish-buff below, with a white chin and throat. The brownish-white bill is almost straight, the iris is dark hazel, and the legs and feet are dark brown. Immatures are paler below, with less contrast between the throat and breast, and they usually have a prominent yellowish-white superciliary line. Field identification is complicated by its similarities in appearance and behavior with the Hawai`i `amakihi (*Hemignathus virens*), Hawai`i `ākepa (*Loxops coccineus coccineus*), and Japanese white-eye (*Zosterops japonicus*) (Scott *et al.* 1979).

Adult Hawai`i creeper foraging on `ōhi`a trunk. Photo pending permission.

At the time of European discovery, each of the six main Hawaiian Islands harbored a small, straight-billed, simple-tongued, insectivorous bird. The Hawai`i creeper was first described as *Himatione mana* by Wilson (1891a). Subsequent nomenclature has been problematic (reviewed in Pratt 1992b, 2001), and the species has variously been considered a full species (Perkins 1903), a subspecies of *Paroreomyza bairdi* (Bryan and Greenway 1944) and a subspecies of *Loxops maculata* (Amadon 1950). It is currently classified as *Oreomystis mana* (American Ornithologists' Union 1998) following Pratt (1979, 1992b), but recent evidence (Olson and James 1995, Fleischer *et al.* 2001) supports its inclusion as a full species in the genus *Loxops.*

LIFE HISTORY

Hawai`i creepers defend a small, 10 to 20 meter (33 to 66 feet) radius area immediately surrounding the nest, and forage over a 4 to 7 hectare (9.9 to 17.3 acre) home range during the breeding season (Ralph and Fancy 1994a, VanderWerf 1998b). Females do all or most of the nest building and incubate, brood, and feed the chicks; males assist by feeding the female both on and off the nest and by feeding the young (Sakai and Johanos 1983; VanderWerf 1998b; J. Nelson, U. S. Geological Survey, unpubl. data). During the nonbreeding season, pairs range over a wider area of about 11 hectares (27.2 acres) and join other forest birds in mixed-species flocks (VanderWerf 1998b).

The Hawai`i creeper generally feeds on insects, spiders, and invertebrates that are gleaned from the trunks and branches of mature trees (Scott *et al.* 1986). During the breeding season in Hakalau Forest National Wildlife Refuge, Hawai`i creepers foraged at a mean height of 13 meters (43 feet). Most foraging maneuvers were gleans (59 percent) or hangs (24 percent); they also probed, pecked, flaked, pried, and pulled substrates to obtain prey (n = 579 maneuvers, 35 individuals; U.S. Geological Survey, unpubl. data). Foraging took place primarily on the branches (63.7 percent of maneuvers), trunks (13.3 percent) and foliage (12.4 percent) of live `ōhi`a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees; the remainder of maneuvers were in subcanopy trees (specifically, `ōlapa [*Cheirodendron trigynum*]), dead trees, or epiphytes (n = 579 maneuvers; U.S. Geological Survey, unpubl. data). Beetle larvae make up a large part of its diet (Amadon 1950, Conant 1981a), but no detailed information on prey taken is available.

Nests of Hawai`i creepers have been found from January to August (Sakai and Ralph 1980, Scott *et al.* 1980, Sakai and Johanos 1983, VanderWerf 1998b, Woodworth *et al.* 2001), but peak breeding occurs from February to May, and molt occurs from May to August (Ralph and Fancy 1994a, Woodworth *et al.* 2001). A small proportion (less than 5 percent) of individuals may overlap breeding and molting activities (Ralph and Fancy 1994a, Woodworth *et al.* 2001).

A total of 78 nests of this species have been documented (Sakai and Ralph 1980, Scott *et al.* 1980, Sakai and Johanos 1983, VanderWerf 1998b, Woodworth *et al.* 2001). Based on 61 nests found at Hakalau Forest National Wildlife Refuge from 1994 to 1999, Hawai`i creepers generally build cup nests at mid-canopy at about 13 meters (43 feet) in height (range 2.8 to 24 meters [9 to 79 feet]) and about 1.5 meters (5 feet) from the main bole of the tree (range 0 to 4.8 meters [0 to 16 feet]). Most (86 percent) are open cup nests but a few (14 percent) are cavity or pseudo-cavity nests. Clutch size is usually two eggs, nest building requires 11 to 19 days, incubation 13 to 17 days, and the nestling period is 18 days (Sakai and Johanos 1983, VanderWerf 1998b, Woodworth *et al.* 2001). Approximately one-third of recorded nesting attempts have been abandoned before egg-laying commenced (33 percent, n = 6, VanderWerf 1998b; 27.9 percent, n = 61, Woodworth *et al.* 2001). At Hakalau Forest National Wildlife Refuge from 1994 to 1999, daily survival rates of active creeper nests were 0.950 ± 0.011 (standard error), and an average of 1.7 chicks fledged from successful nests (Woodworth *et al.* 2001). Only a fraction of known-fate nesting attempts are successful (11 percent, n = 9, Sakai and Johanos 1983; 50 percent, n = 6, VanderWerf 1998b; 20.4 percent, n = 49, Woodworth *et al.* 2001). The relatively high rate of nest failure across studies is alarming, especially given the relatively inaccessible locations where these birds nest. Further study is needed to elucidate the causes of these failures.

Data from marked pairs suggest that Hawai`i creepers readily re-nest after failure, and two pairs have been recorded re-nesting after fledging young earlier in the season (U.S. Geological Survey, unpubl. data). Parent Hawai`i creepers feed fledglings for at least 3 weeks post-fledging, but within 1 month of leaving the nest young are foraging independently for food (although still following parents; VanderWerf 1998b, Woodworth *et al.* 2001).

Hawai`i creepers have relatively high annual adult survival of about 73 to 88 percent (Ralph and Fancy 1994a, Woodworth *et al.* 2001), and juvenile survival of about 33 percent (Woodworth *et al.* 2001). The high survival rate of Hawai`i creepers in Hakalau in part may reflect the rarity of disease in this high-elevation refugium, above the level of mosquito populations.

In general, the reproductive potential of the Hawai`i creeper appears to be low due to its small clutch size, relatively long developmental period, and limited breeding season. This low reproductive potential is exacerbated by the high rate of nesting failures, possibly due to the introduction of mammalian nest predators. High adult and juvenile survival rates may compensate to some extent for low annual productivity, but if disease were to reach the upper elevation rain forests, it could have devastating effects. More detailed demographic data are needed to assess the implications for population persistence of the Hawai`i creeper.

Hawai`i creepers are non-migratory, but during the nonbreeding season they range more widely; the average nonbreeding home range size of 10 Hawai`i creepers was 11.9 ± 7.7 hectares (29.4 ± 19.0 acres) (range 4.3 to 27.1 hectares [10.6 to 66.9 acres]), and individual banded birds have been observed in different locations 1 to 4 kilometers (0.62 to 2.48 miles) apart (VanderWerf 1998b). Snetsinger (1995) observed a Hawai`i creeper in māmane (*Sophora chrysophylla*) forest 7 kilometers (4.35 miles) from the nearest known population.

HABITAT DESCRIPTION

Hawai`i creepers are most common in mesic and wet forests above 1,500 meters (5,000 feet) elevation (Scott *et al.* 1986). The species prefers relatively undisturbed koa/`ōhi`a forests (Sakai and Johanos 1983), and the highest densities occur in areas least modified by logging and grazing (Scott *et al.* 1986). The largest population (see Range and Status below) exists on the windward slope of Mauna Kea in the vicinity of Hakalau Forest National Wildlife Refuge. Annual rainfall at Hakalau averages 2,500 millimeters (98 inches), and the forest canopy is dominated by `ōhi`a and koa. The subcanopy is composed of `ōlapa, pūkiawe (*Styphelia tameiameiae*), `ōhelo (*Vaccinium calycinum*), `ākala (*Rubus hawaiiensis*), kolea (*Myrsine sandwicensis*), kāwa`u (*Ilex anomala*), and *Cibotium* tree ferns (U.S. Geological Survey, unpubl. data). Hawai`i creepers also have been observed occasionally in māmane forest at higher elevations, and may have been more widespread in this habitat historically (Figure 16; Snetsinger 1995).

Hawai`i creeper, along with `akiapōlā`au (*Hemignathus munroi*) and Hawai`i `ākepa, show a decreasing population density gradient from south to north across three sites in Hakalau Forest National Wildlife Refuge (2.18 ± 0.50 birds per hectare in the south at Pua `Ākala, compared with 0.57 ± 0.23 birds per hectare in the north at Maulua). The causes for the density gradient are not completely understood, but cavity availability was lower in the Pedro area than at Pua `Ākala (Hart 2001), food availability was one-third lower at Maulua than at Pua `Ākala (Fretz 2002), and prevalence of pox virus was higher at Maulua than at Pua `Ākala (VanderWerf 2001a), all of which may partially explain the lower population density to the north. Feral pig sign was negatively correlated with Hawai`i creeper density across the three sites. The frequency of disease epizootics in different sections of the refuge should be investigated.

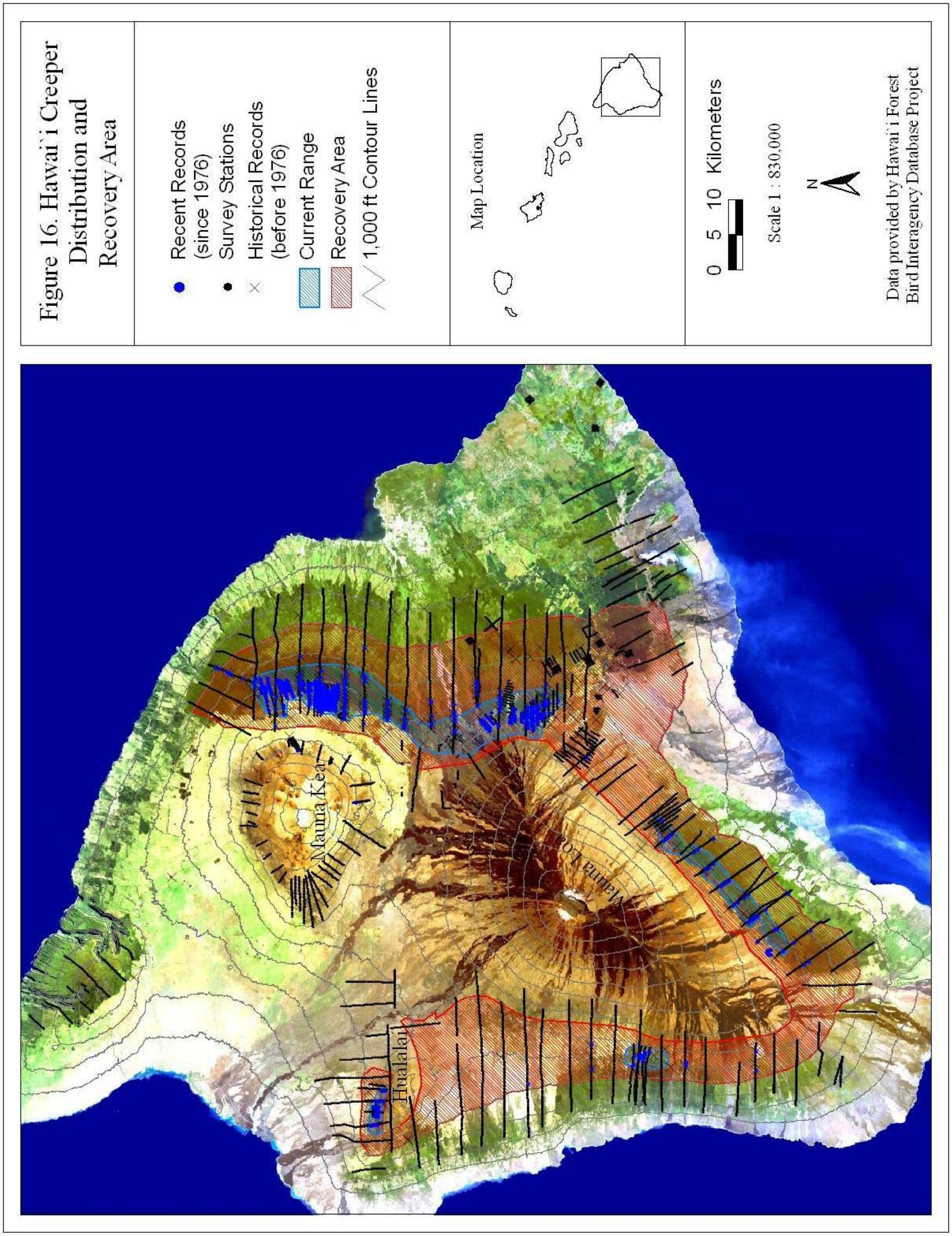


Figure 16. Hawai`i Creeper Distribution and Recovery Area

HISTORICAL AND CURRENT RANGE AND STATUS

In the 1890s, Hawai`i creepers were found in `ōhi`a and `ōhi`a/koa forests throughout the island of Hawai`i, usually above 1,070 meters (3,600 feet) elevation (Perkins 1903). Creepers were recorded in the Kona and Ka`ū districts as well as the forests above Hilo (Figure 16). Perkins noted that they were very abundant and generally distributed but had some puzzling gaps in their distribution, especially at lower elevations. In general, the creeper's decline was not well documented, perhaps in part due to difficulties of field identification (Scott *et al.* 1979). However, a drastic decline in numbers in Hawai`i Volcanoes National Park during the 1930s and 1940s was noted, and the species had virtually disappeared from the park by about 1960 (Conant 1975, Banko and Banko 1980).

As of 1979, the Hawai`i creeper was confined to four disjunct populations in wet and mesic forests, primarily above 1,500 meters (5,000 feet) (Figure 16; Scott *et al.* 1986). Two populations near Kona totaled only about 300 birds, and a third, near Ka`ū, consisted of about 2,100 birds. The Hāmākua coast on the windward side of Mauna Kea, where 10,000 ± 1,200 birds reside, supports the largest remaining population of Hawai`i creepers (Scott *et al.* 1986). A population recorded on Kohala Mountain in 1972 by Van Riper (1982) could not be relocated during the Hawai`i Forest Bird Survey in the early 1980s (Scott *et al.* 1986).

REASONS FOR DECLINE AND CURRENT THREATS

Modification and loss of habitat, avian disease, predation by introduced mammals, and competition with introduced birds all probably played a part in the decline of the Hawai`i creeper. Many areas of `ōhi`a/koa forest have been logged or grazed, severely degrading the quality of remaining habitat. Hawai`i creepers are rarely found below about 1,500 meters (5,000 feet), probably because of the distribution of mosquitoes that transmit avian malaria and avian pox (Warner 1968, van Riper *et al.* 1986). Nest success rates for Hawai`i creepers are alarmingly low (11 to 50 percent), which may reflect the invasion of alien nest predators, particularly black rats (*Rattus rattus*), into their habitat. Hawai`i creeper nests may be especially vulnerable to rat predation because of their proximity to the main trunk of nest trees (Woodworth *et al.* 2001), where rats may be more likely to encounter them. It has also been suggested that the Hawai`i creeper may be negatively impacted by competition from the insectivorous Japanese white-eye (Dunmire 1961, Mountainspring and Scott 1985). The Japanese White-eye is the most common introduced species on the island of Hawai`i. Based on mist-netting studies, 17 percent of the avian biomass at Hakalau Forest National Wildlife Refuge is made up of exotic species (primarily Japanese white-eyes and red-billed leiothrix [*Leiothrix lutea*]; U.S. Geological Survey, unpubl. data).

CONSERVATION EFFORTS

The Hawai`i creeper was federally listed as endangered on September 25, 1975 (U.S. Fish and Wildlife Service 1975), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Hawai`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1983a). Surveys to document the status and trends of Hawaiian forest birds are undertaken by the State of Hawai`i approximately every 5 years, and annual surveys are conducted at Hakalau.

Conservation efforts for the Hawai`i creeper have focused predominantly on the protection and management of high-elevation native forests. The Hakalau Forest National Wildlife Refuge was established in 1985 primarily to protect and manage habitat for native birds, including the Hawai`i creeper. Much of the refuge has been fenced and efforts are underway to remove feral pigs from the refuge. Planting of koa and other native plants began in early 1989, and over 350,000 koa seedlings and 30,000 other native species have been planted thus far. The `Ōla`a/Kīlauea Partnership and Kona Unit of Hakalau Forest National Wildlife Refuge also provide protection and management of forest for habitat. Two other relevant conservation actions were the removal of cattle and fencing of the Kapāpala Forest Reserve and the Pu`u Wa`awa`a Forest Bird Sanctuary. Plans to remove ungulates from the State Kīpāhoehoe Natural Area Reserve and from lands at Honomalino, owned by The Nature Conservancy of Hawai`i, would protect recovery areas that could serve as sites for reintroducing Hawai`i creeper.

Research on factors that limit populations of endangered Hawaiian forest birds has been ongoing since the late 1980s. The productivity, recruitment, and survival of the Hawai`i creeper was investigated as part of a larger study by the U.S. Geological Survey from 1994 to 1999 (Woodworth *et al.* 2001). In case captive propagation becomes necessary for the Hawai`i creeper (see Recovery Strategy), technology has been developed for the collection of wild eggs, artificial incubation of eggs, hand-rearing of chicks, maintenance of adult Hawai`i creepers in captivity, and captive-breeding of the species.

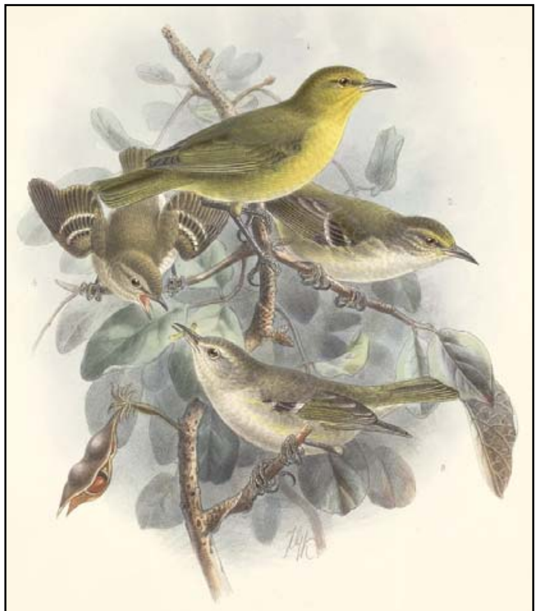
RECOVERY STRATEGY

The primary strategy for the recovery of the Hawai`i creeper is the protection and management of remaining `ōhi`a/koa forests above 1,500 meters (5,000 feet) elevation, and the restoration of degraded forests (Figure 16). To maintain connectivity and allow dispersal among fragmented patches of habitat, cattle should be removed from several key parcels and habitat restoration pursued, such as at the Kapāpala Forest Reserve and adjoining lands leased by the State for ranching. Management for avian disease should focus on reduction of breeding habitat for mosquitoes through drainage of stock ponds; public education and container removal in residential areas; and reduction in feral pig populations. Rodent control can be pursued through snap-trapping and diphacinone bait in bait stations in key parcels, but these methods are infeasible over large areas (Nelson *et al.* 2002). Therefore, registration for aerial broadcast of rodenticides should be aggressively pursued, and studies should be undertaken to determine its efficacy and public health implications (e.g., non-target effects, including accumulation in ungulate tissue and residue in water supplies). Reintroduction of captively propagated Hawai`i creepers into former habitat (e.g., the Mauna Loa Strip Road in Hawai`i Volcanoes National Park) could be undertaken after appropriate habitat management steps have been taken, and could be expected to speed the process of recolonization and recovery.

Because the population is relatively large and the threat of extinction is not imminent, recovery may be achieved more cost effectively through habitat management, therefore captive propagation currently is of lower priority for this species. Progeny from captive-propagation efforts would provide birds for reintroduction in order to establish and enhance populations of Hawai`i creeper in managed recovery areas.

14. O`ahu `Alauahio (O`ahu Creeper), *Paroreomyza maculata*

DESCRIPTION AND TAXONOMY



O`ahu creeper. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

Description. The O`ahu creeper, or O`ahu `alauahio, is a small, sexually dichromatic Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) approximately 11 centimeters (4.3 inches) in total body length. Males are olive-green above and bright yellow below, with a yellow forehead and superciliary line, and a dark eye line. Females and immatures are grayish-green above and yellowish-white below, with two prominent white wingbars. The bill is straight, relatively short, dark above, and pale below (Shallenberger and Pratt 1978).

Identification. The O`ahu creeper is very similar in appearance to the O`ahu `amakihi (*Hemignathus flavus*), and separating these two species in the field can be difficult (Shallenberger and Pratt 1978). O`ahu creepers have a shorter, straight bill, a more distinct pale superciliary, and a pale forehead. Female and immature creepers generally have larger and more prominent white wingbars than female and immature `amakihi, but this character is variable in both species (Shallenberger and Pratt 1978).

Taxonomy. The O`ahu creeper is a Hawaiian honeycreeper (family Fringillidae; subfamily Drepanidinae) endemic to the island of O`ahu. It is currently placed in the genus *Paroreomyza* (Olson and James 1982b, Pratt 1992b, American Ornithologists' Union 1998), but its generic designation has changed repeatedly and it has at various times been placed in the genera *Oreomyza* (Perkins 1903), *Oreomystis* (Stejneger 1903), and *Loxops* (Amadon 1950, Shallenberger and Pratt 1978). The closest relatives and only congeners of the O`ahu creeper are the Maui (*P. montana*) and Moloka`i (*P. flammea*) creepers, and all three taxa have been considered conspecific by some authors (e.g., Munro 1960).

LIFE HISTORY

Little is known about the life history of the O`ahu creeper, but it is thought to be similar in most respects to its close relative, the Maui creeper. Almost nothing is known of its breeding biology or nesting season. Only two nests and one set of eggs have ever been found, both in January 1901 (Bryan 1905). O`ahu creepers apparently formed foraging flocks during parts of the year. Perkins (1903) reported that as many as a dozen creepers often were seen together, and Swedberg (in Shallenberger and Pratt 1978) reported a flock of 30 to 50 birds at Poamoho Trail in September 1968, some of which were collected and proved to be O`ahu creepers.

The O`ahu creeper is insectivorous and forages by creeping methodically up and down the trunks and branches of large trees, probing the bark for insects. It rarely forages in foliage and does not visit flowers like the `amakihi (Perkins 1903, Shallenberger and Pratt 1978). Perkins (1903) reported that it fed largely on caterpillars and spiders, and that the stomach contents of specimens included large numbers of Carabid beetles.

The short, sharp call has been described as “chip,” “chick,” and “chirk.” (Perkins 1903, Shallenberger and Pratt 1978, Pratt *et al.* 1987). The song has never been described, but might be similar to that of the Maui creeper. Despite hundreds of observations of O`ahu creeper, Perkins (1903) never reported hearing its song, and it may sing very infrequently.

HABITAT DESCRIPTION

The preferred habitat of the O`ahu creeper may be mid-elevation koa/`ōhi`a (*Acacia koa*/*Metrosideros polymorpha*) forests in valleys or on side-ridges. Perkins reported that the species was partial to large koa trees, but that they also occurred in areas without koa. All three observations reported by Shallenberger and Pratt (1978) were in mixed koa/`ōhi`a forest at elevations from 300 to 600 meters (1,000 to 2,000 feet), not on summits.

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range and abundance of the O`ahu creeper are poorly known, partly because it may already have been uncommon and in decline when it was first observed by early naturalists (Figure 17). Perkins (1903) "found all species of *Oreomyza* (now *Paroreomyza* on O`ahu and Maui and *Oreomystis* on Kaua`i and Hawai`i) to be abundant" on their respective islands, but called the O`ahu form "less numerous than any." Perkins (1903) also described the O`ahu creeper as "a common enough species" and "found on both mountain ranges," but said, "it seems to have entirely disappeared from the mountains in the immediate neighborhood of Honolulu, where it formerly occurred." Similarly, Munro (1960) stated that O`ahu creepers were "fairly common in the 1890s," but that he had "tramped many miles of newly made C.C.C. [Civilian Conservation Corps] trails on O`ahu in 1935 and did not see a single individual." Palmer (in Rothschild 1893 to 1900) reported that he found O`ahu creepers "only in the upland region of Wailua" above 350 meters (1,500 feet) elevation.

The O`ahu creeper has undoubtedly declined very seriously since it was first observed, and at present no individuals have been seen in over 20 years. The current range, the rate and extent of decline, and even whether the species still exists are difficult to determine, however, due to the difficulty in distinguishing this species from the O`ahu `amakihi. Many reports may have been based on misidentifications, and the true historical and current status of this species is clouded. Shallenberger and Pratt (1978) compiled 41 supposed observations of O`ahu creeper reported in the journal `Elepaio, and judged that the identification was certain in only 3 cases, probable in 6, possible in 26, and unlikely in 6. In over 200 person-days of field work in the central Ko`olau Mountains, Shallenberger and Vaughn (1978) observed this species only three times, in north Hālawa Valley, Moanalua Valley, and in a valley south of Mānana Trail. The last well-documented observation was of two birds on December 12, 1985, on Poamoho Trail during the Waipi`o Christmas Bird Count (Bremer 1986). There have been several reports from different areas since, but details of the observations have been inconclusive and the birds were never relocated.

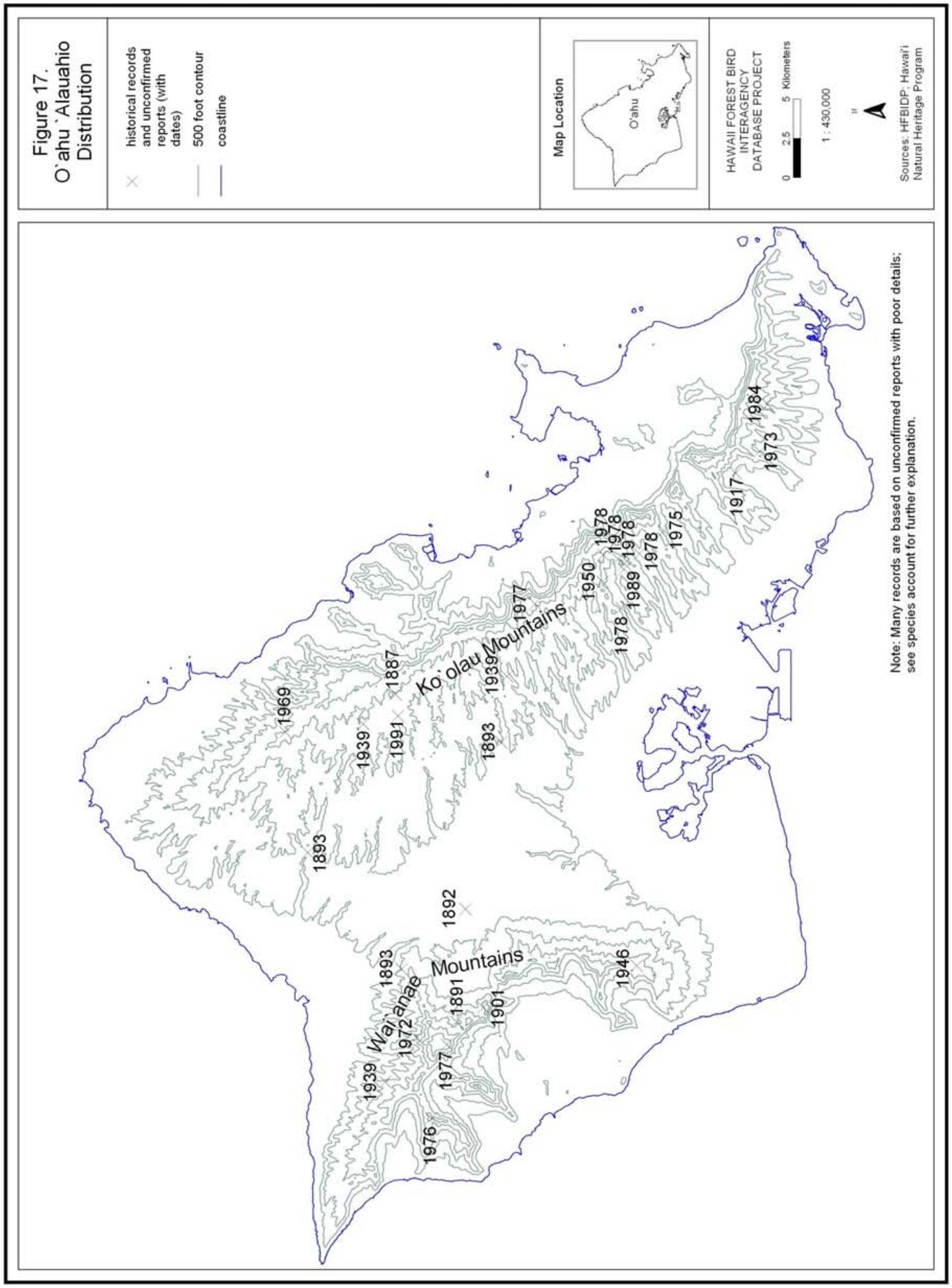


Figure 17. O`ahu `Alauahio Distribution

Small populations of `i`iwi have been rediscovered recently on O`ahu in both the Wai`anae and Ko`olau Mountains (VanderWerf and Rohrer 1996), and it is possible that isolated populations of the O`ahu creeper also still exist in remote areas of the island. O`ahu was not included in the Hawai`i Forest Bird Survey (Scott *et al.* 1986) or the Hawai`i Rare Bird Search (Reynolds and Snetsinger 2001), and relatively few qualified observers spend much time in the mid-elevation koa/`ōhi`a forests where O`ahu creepers are most likely to occur (Shallenberger and Pratt 1978). Given the lack of systematic surveys for the species, the status of the O`ahu creeper is presently unknown.

REASONS FOR DECLINE AND CURRENT THREATS

Much of the decline in distribution of forest birds on O`ahu can be attributed to habitat loss, especially at low elevations. O`ahu has the largest human population and is among the most disturbed of the Hawaiian Islands. Fifty-nine percent of the island has been developed for urban or agricultural use (Hawai`i Heritage Program 1991). Other than habitat loss, the specific reasons for the decline of the O`ahu creeper are poorly known, but it likely faces the same threats as many Hawaiian forest birds. Diseases carried by the introduced southern house mosquito (*Culex quinquefasciatus*), particularly avian malaria (*Plasmodium relictum*) and avian pox (*Poxvirus avium*), are known to be serious threats to many native Hawaiian forest birds (van Riper *et al.* 1986, Atkinson *et al.* 1995), and they likely have been a major factor in the disappearance of the O`ahu creeper. The threat of disease may be especially serious on O`ahu, because no parts of the island are high enough to provide refuge from the primary disease vector, mosquitoes, which cannot tolerate the cold temperatures at high elevations (Warner 1968). Predation by introduced mammals, particularly the black rat (*Rattus rattus*), has been a major factor in the decline of the O`ahu `elepaio (*Chasiempis sandwichensis ibidis*) (VanderWerf and Smith 2002), and also may have affected the O`ahu creeper.

CONSERVATION EFFORTS

The O`ahu creeper was federally listed as endangered on October 13, 1970 (U.S. Fish and Wildlife Service 1970), and thus receives protection under the Endangered Species Act. Species listed under the Federal Endangered Species Act were automatically added to the State of Hawai`i list of endangered species on March 22, 1982, and are thus also protected by State law. The recently created

O`ahu Forest National Wildlife Refuge protects a large area of native forest in the north-central Ko`olau Mountains near several of the most recent O`ahu creeper observations (U.S. Fish and Wildlife Service 2000a), but whether the species still occurs in the area is unknown.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

15. Kākāwahie (Moloka`i Creeper), *Paroreomyza flammea*

DESCRIPTION AND TAXONOMY

Moloka`i creeper. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

The kākāwahie, or Moloka`i creeper, was known only from Moloka`i, but is now thought by some to be extinct (Baker and Baker 2000). The last sighting of this sexually dimorphic honeycreeper occurred in April 1963 (Pekelo 1963). A detailed description of the species was made only by the early specimen collectors and observers; Munro (1944) described the adult males as mostly scarlet in various shades, adult females as brown with scarlet washes and markings, and juvenile males ranging from female-like brown to the adult males' scarlet with many gradations. The bill is short and straight. Its calls were described as chip or chirping notes similar to other creeper calls (Munro 1944, Pekelo 1963). Its closest relatives are the Maui creeper (*P. montana*) and the O`ahu creeper (*P. maculata*). The kākāwahie is in the Hawaiian honeycreeper family (family Fringillidae, subfamily Drepanidinae).

LIFE HISTORY

Only fragmentary information is available about the life history of the kākāwahie from the writings of early naturalists and the few notes reported in the 1960s (Perkins 1903, Munro 1944, Pekelo 1963). This species is an insectivore that gleans vegetation and bark in wet `ōhi`a (*Metrosideros polymorpha*) forests. Only minimal information exists about the nest and young (Munro 1944).

HABITAT DESCRIPTION

This species was known only from high elevation, boggy areas of Moloka`i (Munro 1944, Pekelo 1963). There is no detailed description of its habitat. The last detections, in the 1960s, were on the west rim of Pelekunu

Valley on the `Ōhi`alele Plateau in moss-shrouded `ōhi`a and `ōlapa (*Cheirodendron trigynum*) trees.

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, the species was recorded only from Moloka`i (see Figure 8 on page 2-29). There have been no sightings since 1963. The 1980 Hawaiian Forest Bird Survey failed to detect the species on Moloka`i, and reported similar failures of earlier searches (Scott *et al.* 1986). All surveys and special searches since 1988 have failed to detect this species (Reynolds and Snetsinger 2001; Hawai`i Department of Land and Natural Resources, unpubl. data). This species may possibly be extinct, but there was a significant gap in the area covered by the Hawai`i Rare Bird Search in the 1990s due to restrictions on access, and one of the largest areas of remaining pristine native forest, the Oloku`i Plateau, was not surveyed for kākāwahie. Additional surveys are needed to confirm the status of this species.

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for the decline and loss of the species are unknown, but presumably are the same as for other endangered forest birds on Moloka`i and Maui.

CONSERVATION EFFORTS

The Moloka`i creeper was federally listed as an endangered species on October 13, 1970 (U.S. Fish and Wildlife Service 1970), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Maui-Moloka`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1984a). No other specific conservation efforts for this species have been initiated.

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

16. Hawai`i `Ākepa, *Loxops coccineus coccineus*

DESCRIPTION AND TAXONOMY

The Hawai`i `ākepa is a small sexually dichromatic Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) endemic to the island of Hawai`i. Its total length is approximately 10 centimeters (3.9 inches) and its weight varies from 10 to 12 grams (0.34 to 0.41 ounces). Adult males are bright orange, while females are grayish green with a yellow breast-band. The male adult plumage is not obtained until the molt preceding the fourth year. Males have a female-like subadult plumage (without breast-band) during their second year and a male-like subadult plumage during their third year (Lepson and Freed 1995). The male-like subadult plumage varies from bright orange on the head and breast to dull brownish orange over the entire body. Females are entirely gray during their second year. Thereafter they acquire a variable amount of yellow and orange on the breast, throat, and head (Freed and Lepson, unpubl. data). Plumage brightness is loosely related to age, but most females never acquire extensive orange-yellow on the head. Juvenal plumage, similar in both sexes, is grayish green above, pale gray below, often with a whitish superciliary line (Lepson and Freed 1997).

Adult male Hawai`i `ākepa foraging in `ōhi`a foliage. Photo permission pending.

The Hawai`i `ākepa has a long notched tail. The bill is conical and generally pale yellow in color. The laterally-skewed tips of the asymmetrical bill are caused by the tip of the lower mandible curving to the right or left (Richards and Bock 1973). There also is an asymmetry in the legs, with a slightly longer tarsus on the side opposite to which the mandible crosses (Knox 1983). These are considered “handedness” adaptations for opening up leaf and flower buds for arthropod prey. The tongue shows adaptations for nectarivory with the brushy tip and the sides rolled up to form a tube (Gadow 1891).

Close-up showing asymmetrical bill of `ākepa. Photo © Eric VanderWerf.

The bird was originally described as *Fringilla coccinea* from specimens collected by the James Cook expedition of 1779 (Medway 1981). It was occasionally placed in the genus *Hypoloxias* (Wilson and Evans 1890 to 1899). Its current nomenclature is based on Rothschild (1893 to 1900). The Hawai`i `ākepa shares subspecific status with the Maui `ākepa (*Loxops c. ochraceus*) and the O`ahu `ākepa (*Loxops c. rufus*). The O`ahu subspecies is extinct and the Maui subspecies is probably extinct, meaning the Hawai`i `ākepa now likely comprises the entire species.

LIFE HISTORY

The Hawai`i `ākepa is an obligate cavity nester, with most nests found in large old-growth `ōhi`a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees (Lepson and Freed 1997, Freed 2001). It has a clearly defined breeding season, with nest-building from early March to late May, egg-laying from mid-March to late May, hatching in late March to early June, and fledging from April 2 to June 30 (Lepson and Freed 1997). Fledglings stay with their parents until September or October, and both adults and juveniles frequently join interspecific foraging flocks with other Hawaiian honeycreepers, particularly Hawai`i creepers (*Oreomystis mana*), and also `akiapōlā`au (*Hemignathus munroi*), Hawai`i `amakihi (*Hemignathus virens*), `i`iwi (*Vestiaria coccinea*), and `apapane (*Himatione sanguinea*). Only one brood can be raised per year. Studies of prey abundance indicate that breeding is initiated during a time of declining prey availability and that termination of parental care in September occurs during the annual peak in prey availability (Fretz 2000).

Females do all or most of the nest building and incubate, brood, and feed the chicks; males assist by feeding the female both on and off the nest and by feeding the young (Lepson and Freed 1997). Clutch size ranges from one to three eggs, with two as the modal number (Lepson and Freed 1997). Based on recent observations of accessible Hawai`i `ākepa nests, some eggs failed to hatch in four of six nests (L. Freed, University of Hawai`i, pers. comm.). No nestling mortality was detected. Nestlings 6 days old weighed as much as their parents, and those 12 days old weighed up to 1.5 times that of their parents. The productivity of nests, usually one fledgling, appears to be limited more by hatching success than by provisioning of nestlings. Despite the potential vulnerability of cavity nesting species to predators such as rats (Lack 1968, Nilsson 1986), nesting success is high at the Pua `Ākala tract of Hakalau Forest National Wildlife Refuge, in that 79 percent of nests of known fate over a 7-year period fledged young (Lepson and Freed 1995). However, based on captures of females without brood patches during June, not all females attempt to nest in a given year. In addition, predation on fledglings by `io (*Buteo solitarius*) has been documented (Lepson and Freed 1997). Adults have high annual survivorship ranging from 0.70 for Kīlauea/Keauhou (Ralph and Fancy 1994a) to 0.82 at Hakalau Forest National Wildlife Refuge (Lepson and Freed 1995).

The molting season is clearly defined. Molting in adults begins primarily in June (Lepson and Freed 1995). Molt is a post-nesting phenomenon that coincides with the fledgling period, and extends until October. The only exception is that second year males that do not attempt to breed begin their molt in March.

Intense competition occurs among males from October to March (Lepson and Freed 1995). The Hawai`i `ākepa is non-territorial, so dominance is the major form of aggression. Physical fights, chases, and group displays are part of the competition. Group displays may include up to six males perched in the same tree who take turns flying out, singing, and returning, all in the presence of a female. Aerial displays of up to eight males sometimes result in spectacular "dogfights" with birds rising as high as 100 meters (330 feet) in the air before breaking up.

It appears that variation in female plumage and fitness drives this competition. More colorful females have both higher survival and higher nesting success than duller females of the same age (Freed and Lepson, unpubl. data). Extensively orange-yellow females comprise only 11 percent of the population, and orange-yellow females comprise 25 percent. Thus, despite an even sex ratio (Lepson and Freed 1995), males are competing for only a fraction of females with above-average fitness.

The Hawai`i `ākepa feeds primarily on small insects, spiders, and caterpillars throughout the year. It rarely feeds on nectar. Foraging occurs mainly on the terminal leaf clusters of `ōhi`a, and to a lesser extent among koa leaves and seedpods (Perkins 1903, Conant 1981a, Fretz 2000). Food availability for `ākepa is closely associated with the structure and density of the terminal portions of the `ōhi`a canopy (Fretz 2002). During the dry summer of 1999, several birds were captured with `ākala (*Rubus hawaiiensis*) berry pulp dried on their bills. They may have been using the berries as a source of water. Birds also have been seen foraging occasionally in the leaves of naio (*Myoporum sandwicense*), `a`ali`i (*Dodonaea viscosa*), pūkiawe (*Styphelia tameiameiae*), pilo (*Coprosma* spp.), `ōhelo (*Vaccinium calycinum*), and `ākala (Perkins 1903).

Adults and juveniles are strongly philopatric to the breeding area (Lepson and Freed 1995). Maximum distance traveled was 5 kilometers (3.1 miles) for an adult female and the same distance for a juvenile (Lepson and Freed 1997). Both males and females, banded as juveniles, tend to breed within 250 meters (820 feet) of their natal nest. Hart (2000) reported home range sizes of 5.9 and 4.8 hectares (14.6 and 11.9 acres) for males and females, respectively, during the non-breeding season, and substantially smaller ranges during the breeding season. Ralph and Fancy (1994a) reported that the average home range of the Hawai`i `ākepa was 3.9 hectares (9.6 acres).

HABITAT DESCRIPTION

Hawai`i `ākepa are birds of old-growth `ōhi`a or `ōhi`a/koa forest (Freed 2001). Their density depends in part on the density of large trees because only large trees provide the cavities required for nesting (Hart 2000, 2001; Freed 2001). The average size of trees used for nesting is 1 meter (3.3 feet) in diameter at breast height (Freed 2001). `Ōhi`a appear to be more important to `ākepa than koa, because the highest density of Hawai`i `ākepa on Mauna Loa, in the Ka`ū Forest Reserve, is in an area without koa (Jacobi 1978, Scott *et al.* 1986). Large `ōhi`a trees provide both cavities for nest-sites and the preferred foraging substrate, whereas large koa trees provide mainly cavities (Freed 2001). The highest `ākepa density at Hakalau Forest National Wildlife Refuge on Mauna Kea exists in an area with large trees but heavily disturbed understory. Breeding densities of this population appear to be limited by the availability of nest sites (Hart 2000), and the population may be at or near carrying capacity with respect to food availability (Fretz 2000).

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range of the Hawai`i `ākepa once included much of the island of Hawai`i, presumably wherever there were large trees that provided nest cavities (shown in Freed 1999). The major change in distribution has been the complete loss of birds from lower elevations, below 1,300 meters (4,300 feet). However, the range has also contracted somewhat at upper elevations as well (Freed 1999, Scott *et al.* 1986).

Hawai`i `ākepa are currently found in 5 disjunct populations in `ōhi`a/koa forests in Hāmākua, Kūlani/Keauhou, Ka`ū, southern Kona, and Hualālai, totaling approximately 14,000 ± 2,500 birds in 1980 (Figure 18; Scott *et al.* 1986). The highest densities occurred in the southwestern portion of the Ka`ū Forest Reserve and in the Pua `Ākala Tract of Hakalau Forest National Wildlife Refuge (Scott *et al.* 1986), and these supported by far the largest populations, comprising 5,300 ± 1,500 birds and 7,900 ± 1,800 birds, respectively. The populations in southern Kona and Hualālai were much smaller; approximately 660 ± 250 birds combined (Scott *et al.* 1986), and apparently have declined since those surveys. Hawai`i `ākepa occur in a gradient of population density, with a small core area of highest density in the Pua `Ākala area and rapid decreases in density away from the core (Scott *et al.* 1986, Hart 2001). This pattern is more pronounced for `ākepa than for other endangered forest birds (Scott *et al.* 1986).

REASONS FOR DECLINE AND CURRENT THREATS

Modification and loss of habitat and avian disease are the main factors that have contributed to the decline of Hawai`i `ākepa. Predation by introduced mammals also may have played a role. Clearing of forest by logging and ranching has been extensive, greatly reducing the amount of suitable habitat for Hawai`i `ākepa and other forest birds, and resulting in fragmentation of the remaining forest habitat. Hawai`i `ākepa are especially sensitive to the loss of old growth forest due to their dependence on large trees with cavities for nesting (Freed 2001). Much old-growth forest has been cleared for pasture at upper elevations (Tomonari-Tuggle 1996).

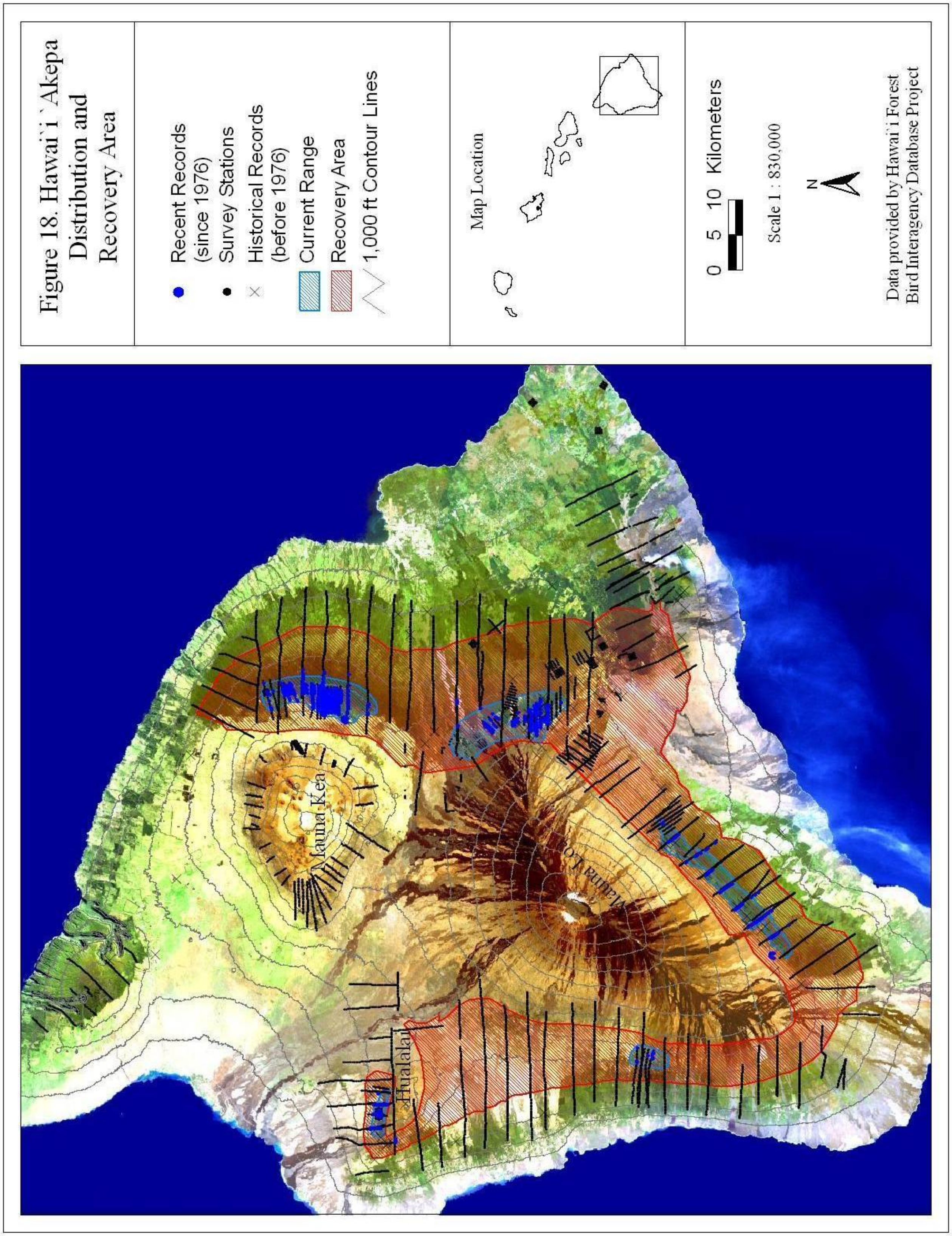


Figure 18. Hawai`i `Akepa Distribution and Recovery Area

The slow growth rate of `ōhi`a trees suggest that large trees are extremely old, and when a large tree with a cavity falls, it may require a long time before it is replaced (Freed 2001). This problem is magnified because large trees in disturbed areas are more susceptible to windfall than smaller trees. The areas of highest `ākepa density are in disturbed areas and trees large enough to provide nest sites are falling at a rate of 5 trees per square kilometer (13 per square mile) per year at Hakalau Forest National Wildlife Refuge. Reduction of nest sites in high-density areas is a major threat that is already decreasing the number of breeding pairs in the upper Pua `Ākala tract. In addition, the increased light under which `ōhi`a seedlings are germinating is producing trees with an almost exclusively sympodial (multi-trunked) growth form, which typically do not produce cavities suitable for `ākepa nests. The `ōhi`a trees used as nest sites by the birds are almost exclusively monopodial (straight and single-trunked) in form (Freed 2001).

`Ākepa are not found below 1,300 meters (4,300 feet), presumably because of the distribution of the introduced mosquito (*Culex quinquefasciatus*) that transmits avian malaria (*Plasmodium relictum*) and avian pox (*Poxvirus avium*) (van Riper *et al.* 1986, 2002). Both the mosquito and malarial parasite are limited in elevation by temperature (LaPointe 2000). Greater exposure of remaining `ākepa populations to vectors and pathogens is likely to occur with global climate change (Benning *et al.* 2002). The birds at upper elevations have not been under natural selection by disease and must be considered naive with respect to disease. While individual birds at the lower end of the range might have evolved tolerance or resistance to malaria or pox virus, the strong philopatry (low dispersal) makes it unlikely that the genotypes of tolerant individuals would extend into the range of naive birds. There is significant risk that there will not be enough time for relevant genotypes to evolve that could respond to natural selection from increased exposure to disease.

CONSERVATION EFFORTS

The Hawai`i `ākepa was federally listed as endangered on October 13, 1970 (U.S. Fish and Wildlife Service 1970), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Hawai`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1983a).

Conservation efforts for the species have focused primarily on protection and management of high-elevation native forests. The Hakalau Forest National Wildlife Refuge was established in 1985, primarily to provide protection and management of habitat for native birds, including the Hawai`i `ākepa. Much of the refuge has been fenced and efforts are underway to remove feral pigs from the refuge. Planting of koa and other native plants began in early 1989, and over 350,000 koa seedlings and 30,000 other native species have been planted thus far. The `Ōla`a/Kīlauea Partnership and Kona Unit of Hakalau Forest National Wildlife Refuge also protect and manage forest habitat. Two other relevant conservation actions were the removal of cattle and fencing of the Kapāpala Forest Reserve and the Pu`u Wa`awa`a Forest Bird Sanctuary. Plans to remove ungulates from the State Kīpāhoehoe Natural Area Reserve and from lands at Honomalino, owned by The Nature Conservancy of Hawai`i, would protect recovery areas that could serve as sites for reintroducing Hawai`i `ākepa. The recent purchase of the former Kahuku Ranch by the National Park Service will help protect and restore forest habitat adjacent to the area of highest `ākepa density in Ka`u.

Research using comparison of forest structure and `ākepa demography in areas of low and high population density has highlighted the significance of large trees with cavities to this bird (Hart 2000, 2001). Additional research with artificial cavities has shown that the birds will use artificial cavities attached to the outside of trees and successfully nest in them (Freed 2001). Artificial cavities are a promising conservation tool that can be used to increase nest site availability until a time when growth and recruitment of large `ōhi`a trees provide sufficient natural nest sites.

Hawai`i `ākepa are one of the few species of Hawaiian forest birds for which the significance of food availability has been quantitatively investigated. This work confirmed the strong reliance of `ākepa on terminal `ōhi`a foliage for food (Fretz 2000), showed that reproductive success is associated with food availability among years in the Pua `Ākala tract of the Hakalau Forest National Wildlife Refuge (Fretz *et al.,* in prep.), and suggests `ākepa populations may be at or near carrying capacity with respect to food even where nest sites are apparently limited (Fretz *et al.,* in prep.). Food availability is also closely associated with habitat structure, including subtle aspects of canopy foliage density. This type of variation in canopy structure may be common at regional scales and therefore has the potential to influence `ākepa densities (Fretz 2002). In addition, food availability is seasonal and the well-defined timing of breeding seen in `ākepa may be an adaptation to exploit this seasonality so that food is maximally available at the time of independence of the young (Fretz 2000; Fretz *et al.,* in prep.).

RECOVERY STRATEGY

Habitat Protection and Nest Site Management. The most important component of the recovery strategy for the Hawai`i `ākepa is habitat protection and nest site management. Protection of old-growth forest ecosystems is essential to the long-term recovery of this species, but is not sufficient to conserve populations in the short-term due to the rapid loss of large trees containing cavities suitable for nesting. Large trees cannot be protected against windfall or hillier terrain, which cannot support large trees (Hart 2000, Freed 2001). The use of artificial cavities as a management tool is needed to enable existing populations to hold their own despite loss of nest-site trees. Artificial cavities also have potential to increase the density of nesting pairs within an area or to establish new populations in forests that have suitable foraging substrate but lack large trees with cavities. To complement these efforts, research needs to address factors that affect the growth form of regenerating `ōhi`a. Management of growth form, including removal of ungulates that destroy the apical meristem (growing tip) of seedlings, and possibly providing wind shields or shading, may be essential for long-term regeneration of monopodial `ōhi`a trees that are most likely to develop natural cavities and provide suitable nest sites for `ākepa (Freed 2001).

Disease. Eradication of mosquitoes is not practical with methods currently available, and the birds themselves may be the best way of addressing the threat from disease. Some of the more common native birds have evolved tolerance or resistance to disease (Cann and Douglas 1999, Woodworth *et al*. 2005) and this is associated with larger clutch size and multiple broods per year, which provides greater opportunity to respond to natural selection (Freed 1999). It is crucial to know what is happening at the lower limits of elevation of Hawai`i `ākepa. If individuals are discovered that tolerate disease, then genetic techniques can determine if those genotypes are present outside the range of disease. If those genotypes are not present outside the range, then an appropriate management strategy would be to move birds with pertinent genotypes into populations of birds that are not tolerant.

Predator control. Control of alien predators, especially rats, has been shown to be an effective method of increasing reproduction and survival in other Hawaiian forest birds (VanderWerf and Smith 2002). However, the degree of threat from alien rodents may vary among species and locations, and rodent control programs initially should be conducted in an experimental way to document their effect on `ākepa populations. Ground-based methods of rodent control using snap traps and diphacinone bait stations have been effective on a small scale, but are labor intensive. Effective large-scale rodent control likely will require aerial broadcast methods. Registration of aerial broadcast of diphacinone for rodent control with the U.S. Environmental Protection Agency should be actively pursued and supported.

Captive Propagation. Recovery of the Hawai`i `ākepa may be achieved most effectively through *in situ* management techniques such as habitat management because the current population is relatively large, and captive propagation is not considered essential for recovery at this time. However, captive propagation technology is being developed for the Hawai`i `ākepa in case it is needed to help reestablish wild populations (Zoological Society of San Diego 2004). Techniques developed for Hawai`i `ākepa include protocols for collection of wild eggs, artificial incubation of eggs, hand-rearing of chicks, and maintenance of adults in captivity. Similar techniques developed for other species of honeycreepers have resulted in successful captive breeding, and it is anticipated that the Hawai`i `ākepa will breed in captivity when they reach reproductive age. Progeny from such captive propagation efforts would provide birds for reintroduction in order to establish and enhance wild populations.

17. Maui `Ākepa, *Loxops coccineus ochraceus*

DESCRIPTION AND TAXONOMY

Maui `akepa. © from Rothschild (1893-1900). Courtesy of Smithsonian Institution Libraries.

The Maui `ākepa closely resembles the better known Hawai`i `ākepa (*L. c. coccineus*) in coloration and biometrics (Lepson and Freed 1997; also see Hawai`i `ākepa account). The Maui subspecies differs as follows: (1) adult males vary from dull brownish orange to ochraceus rather than bright orange and (2) females are duller and less yellowish (Amadon 1950). However, no quantitative comparison of the subspecies has been attempted, and females may fall within the range of variability in the Hawai`i subspecies. Plumage sequence and differences between females and young males have not been determined from study skins for Maui `ākepa. Plumage sequence and sexual differences may be the same as for the Hawai`i race. Seasonality and pattern of molt has yet to be described from study skins, and again may be the same as for the Hawai`i race. The Maui `ākepa was described by Finsch (1880), but has been regarded as a subspecies of `ākepa in all modern accounts. The phylogenetic relationship between the Maui and Hawai`i `ākepa has not been investigated by molecular genetics, which in the future may influence their taxonomic placement. The Maui `ākepa is a member of the Hawaiian honeycreeper family (family Fringillidae, subfamily Drepanidinae).

LIFE HISTORY

Almost nothing about the life history of the Maui `ākepa appears in the historical record (Perkins 1903, Rothschild 1893 to 1900, Henshaw 1902, Banko 1984a). Henshaw (1902) found Maui `ākepa in small groups with young in June when the birds were molting. Rothschild (1893 to 1990) claimed they fed on small beetles and other insects, whereas Henshaw (1902) and Perkins (1903) agreed that they fed chiefly on caterpillars and small spiders. Perkins also noted that they drank `ōhi`a (*Metrosideros polymorpha*) nectar.

Perkins (1903) reported watching a pair of Maui `ākepa building a nest in the terminal foliage of a tall `ōhi`a tree. This nest site differs strikingly from the sites in tree cavities chosen by Hawai`i `ākepa. The frequency with which Maui `ākepa nest in tree foliage versus hollows in branches would be important to discover. Refer to the account of Hawai`i `ākepa for comparable information about that subspecies.

HABITAT DESCRIPTION

All specimens of Maui `ākepa were collected in `ōhi`a/koa (*Acacia koa*) rainforest at 1,200 to 1,800 meters (4,000 to 6,000 feet) elevation on the northwest rift of Haleakalā. Rothschild (1893 to 1990) found Maui `ākepa foraging in `ōhi`a. Perkins (1903) noted that the birds were "often seen in koa trees but more often in `ōhi`a." Henshaw (1902) commented that they much preferred koa to `ōhi`a for foraging. Palmer also found `ākepa in mid-elevation `ōhi`a forest, and all likely sightings this century have been in `ōhi`a forest at 1,700 to 2,100 meters (5,500 to 7,000 feet; as described in Rothschild 1893 to 1900). The past distribution of the Hawai`i `ākepa once encompassed a wide range of habitats from 600 meters (2,000 feet) to timberline, and the Maui subspecies may also have once occupied all forests within its range. The current habitat of the Maui `ākepa is mixed shrub montane wet forest (Jacobi 1985) above 1,500 meters (5,000 feet), the same as for other endangered birds on Maui.

HISTORICAL AND CURRENT RANGE AND STATUS

In the absence of early historical surveys, the extent of the geographical range of the Maui `ākepa cannot be reconstructed. This bird occupied at least Maui Island, and one might expect that it also inhabited Moloka`i and Lāna`i Islands like other forest birds in the Maui Nui group, but there are no fossil records of `ākepa from any of these islands (James and Olson 1991). All historical records of the Maui `ākepa were from high elevation forests most accessible to naturalists, near Olinda and Ukulele Camp on the northwest rift of Haleakalā, and from mid-elevation forests in Kīpahulu Valley (see Figure 14 on page 2-94). This range suggests that the birds were missing from forests at lower elevations, perhaps due to the introduction of disease-transmitting mosquitoes to Lahaina in 1826 (Hardy 1960). However, it may be that the Maui `ākepa originally occupied all forests on Maui. Complete destruction of habitat was not extensive during the 20th century, but ecological changes in the forests probably have caused the species to decline to its restricted geographic range. Reports by naturalists at the turn of the century varied in their estimates of abundance of the Maui `ākepa, ranging from rare to locally abundant (Banko 1984a).

From 1970 to 1995, there have been few credible sightings of Maui `ākepa (Banko 1984a, Engilis 1990). Scott *et al.* (1986) estimated a total population of 230 ± 290 birds, in 2 populations on northwestern and eastern Haleakalā. However, this estimate was based on potentially confusing auditory detections, not on visual observations. Songs of the Maui `ākepa were reportedly heard in 1994 and 1995 during the Hawai`i Rare Bird Search, but visual confirmation of the species was not obtained, and it is possible there was some confusion with similar songs or mimicry of the Maui parrotbill (*Pseudonestor xanthophrys*) (Reynolds and Snetsinger 2001). The current population, if any, therefore remains undetected and most likely survives in the vicinity of the northeastern rift of Haleakalā, the location of the last reports. Thorough surveys from 1995 through 1999 turned up no `ākepa in this area (Reynolds and Snetsinger 2001; Hawai`i Department of Land and Natural Resources, unpubl. data), but the conclusion of the Hawai`i Rare Bird Search was that based on the available evidence, it is not possible to either confirm or disprove that the Maui `ākepa is extant (Reynolds and Snetsinger 2001).

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for decline and current threats presumably are the same as for other endangered forest birds on Maui. In addition, we can speculate that rats may have played an especially important role as nest predators of `ākepa. While the only nest of Maui `ākepa ever reported was built in tree foliage, the birds may also have selected tree cavities like the very similar Hawai`i `ākepa. In Maui forests, nest trees are of shorter stature than where `ākepa survive on Hawai`i Island. Suitable cavity sites on Maui are low in the vegetation, some near or at ground level, and thus more accessible to rats. High densities of both black and Polynesian rats (*Rattus rattus* and *R. exulans*) infest `ākepa habitat on Maui (Sugihara 1997).

CONSERVATION EFFORTS

The Maui `ākepa was federally listed as an endangered species on October 13, 1970 (U.S. Fish and Wildlife Service 1970), became protected under the State of Hawai`i endangered species law on March 22, 1982, and was included in the Maui-Moloka`i Forest Birds Recovery Plan (U.S. Fish and Wildlife Service 1984a). No effort has been initiated in the field specifically for Maui `ākepa. However, this species has, or could have, benefited in the long-term from habitat restoration to assist other endangered birds on Maui (see Maui parrotbill and po`ouli accounts).

RECOVERY STRATEGY

See the Rare Bird Discovery Protocol in Section III-D.

18. \`Ākohekohe (Crested Honeycreeper), *Palmeria dolei*

DESCRIPTION AND TAXONOMY

Adult \`ākohekohe. Photo © Eric VanderWerf.

The \`ākohekohe, or crested honeycreeper, is the largest (24 to 29 gram [0.8 to 1.0 ounce]) honeycreeper remaining on Maui Nui (Maui, Moloka\`i, Lāna\`i, and Kaho\`olawe). Primarily a black-plumaged bird, the \`ākohekohe's lanceolate body feathers are strikingly tipped with orange-red, its throat and breast feathers are tipped with gray, silver, or white, and its wing and tail feathers are distinctly white-tipped. A distinctive brush of white feathers curling forward over the bill comprises the crest, giving the species its English name. Brilliant orange feathers surround the eyes and extend to and cover the nape, feathers on the thighs can be orange or yellowish-white, and the feathers of the epaulettes are white with orange tips. The somewhat curved bill, the feet, and the legs are black. Sexes are identical in plumage pattern and coloration, but males are larger and heavier and can be determined with accuracy by measurements (Simon *et al.* 1998). Juvenile plumage is drab and cryptic yellow-brown or brown-gray, the body plumage lacks all orange-scarlet or orange and silver colors on the feathers or tips, and both the gray tail and wing feathers lack white tips. The crest of the juveniles is short and not as pronounced; its color is yellowish-white. The feet, legs, and bill of juveniles are gray to black.

\`Ākohekohe show no geographic variation in plumage, and have no subspecies, although they once were found on the two islands of Maui and Moloka\`i. Fleischer *et al.* (2001) showed that, based on DNA analyses, \`ākohekohe are most closely related to \`apapane (*Himatione sanguinea*) and \`i\`iwi (*Vestiaria coccinea*). The \`ākohekohe is a member of the Hawaiian honeycreeper family (family Fringillidae, subfamily Drepanidinae).

LIFE HISTORY

The \`ākohekohe is primarily nectarivorous, but also feeds on caterpillars, spiders, and dipterans (flies) (Perkins 1903, Carothers 1986, VanGelder and

Smith 2001). Nectar is primarily sought from flowers of `ōhi`a (*Metrosideros polymorpha*), but also from several subcanopy tree and shrub species (Berlin *et al.* 2000, VanGelder and Smith 2001). Insects are taken mostly by gleaning `ōhi`a foliage, buds, and flower clusters (VanGelder 1996). VanGelder (1996) observed the species to spend almost 70 percent of the day in foraging activities.

`Ākohekohe defend relatively discrete feeding and nesting territories throughout the year by chasing and calling (Pratt *et al.* 2001b, VanGelder and Smith 2001). The species appears to be monogamous for more than one breeding season, with pair formation starting in October, nesting occurring mainly between November and May, and some pairs raising two to three successful broods in a season (VanGelder and Smith 2001). `Ākohekohe nests were an average of 14 meters (46 feet) above ground in the terminal ends of branches below the canopy foliage of `ōhi`a trees (Berlin and VanGelder 1999, VanGelder and Smith 2001). The open cup nest is built by the female, who lays one to two eggs. Incubation by the female lasts 17 days, and the chicks fledge after 3 to 4 weeks. Chicks can forage independently after 10 to 14 days, or longer when the chicks are from the last brood of the season (Berlin and VanGelder 1999). Independent juveniles flock in small groups and disperse to the edge of the species' range (Scott *et al.* 1986).

Vocalizations of the `ākohekohe include various guttural clucking gurgles, raspy croaks, buzzing sounds, and clear upslurred whistles; no distinctly ordered sound repertoire or song strophe is produced (Perkins 1903, Berlin and VanGelder 1999, VanGelder and Smith 2001).

HABITAT DESCRIPTION

At present `ākohekohe survive in montane wet and mesic forests dominated by `ōhi`a. The habitat is generally as described for the Maui parrotbill (*Pseudonestor xanthophrys*), except that the lower limit of the `ākohekohe's elevational range is higher, at roughly 1,700 meters (5,576 feet) although some nonbreeding birds may wander further down slope. Fossil bones found in caves at low elevation on the southwestern slopes of Haleakalā suggest that the species once inhabited very different dry forest habitat (James and Olson 1991).

HISTORICAL AND CURRENT RANGE AND STATUS

`Ākohekohe currently are found only in 58 square kilometers (22 square miles) of wet and mesic montane forest dominated by `ōhi`a on the northeastern slope of Haleakalā Volcano in east Maui. Their elevational range has been reported to be from 1,100 to 2,300 meters (3,600 to 7,550 feet), but nearly all birds occur from 1,500 to 2,100 meters (5,000 to 6,600 feet), with some nonbreeding birds found further down slope (Conant 1981b; Scott *et al.* 1986; Hawai`i Division of Forestry and Wildlife, unpubl. data). `Ākohekohe occur from just west of the Waikamoi Drainage in the Ko`olau Forest Reserve east through the Ko`olau and Hāna Forest Reserves and around to Haleakalā National Park lands in Kīpahulu Valley and southeast of Kuiki to Manawainui Valley. The current geographic range is much restricted compared to the known historical range that included native wet forests of the island of Moloka`i (Figure 19; Perkins 1903, Banko 1987). On Moloka`i, the bird was found at 1,200 meters (4,000 feet) on the high forested plateau between Wailau and Pelekunu valleys where the species was not known to have survived later than 1907 (Bryan 1908). On Maui, the species was first collected in the 1890s on the western slopes of Kula in mesic koa (*Acacia koa*)/`ōhi`a forest, but by 1920 it was already absent due to deforestation caused by logging and cattle-ranching (Berger 1981). `Ākohekohe now inhabit only 5 percent of the estimated historical range of 1,015 square kilometers (385 square miles) on Maui and none of the 262 square kilometers (100 square miles) on Moloka`i Island (Scott *et al.* 1986).

James and Olson (1991) have reported subfossil evidence of the species from low, dry forest areas of southeastern and southwestern Maui, indicating the current and historical range of the species is much altered from its original pre-human distribution. No fossils are known from Moloka`i.

The total number of `ākohekohe was estimated to be 3,800 ± 700 (95 percent confidence interval) birds in 1980 by the Hawai`i Forest Bird Survey (Scott *et al.* 1986). Surveys of the same transects in 1992 (Hawai`i Department of Land and Natural Resources, unpubl. data), and limited surveys from 1995 to 1997 by U.S. Geological Survey biologists, indicated approximately the same densities of birds within the same range.

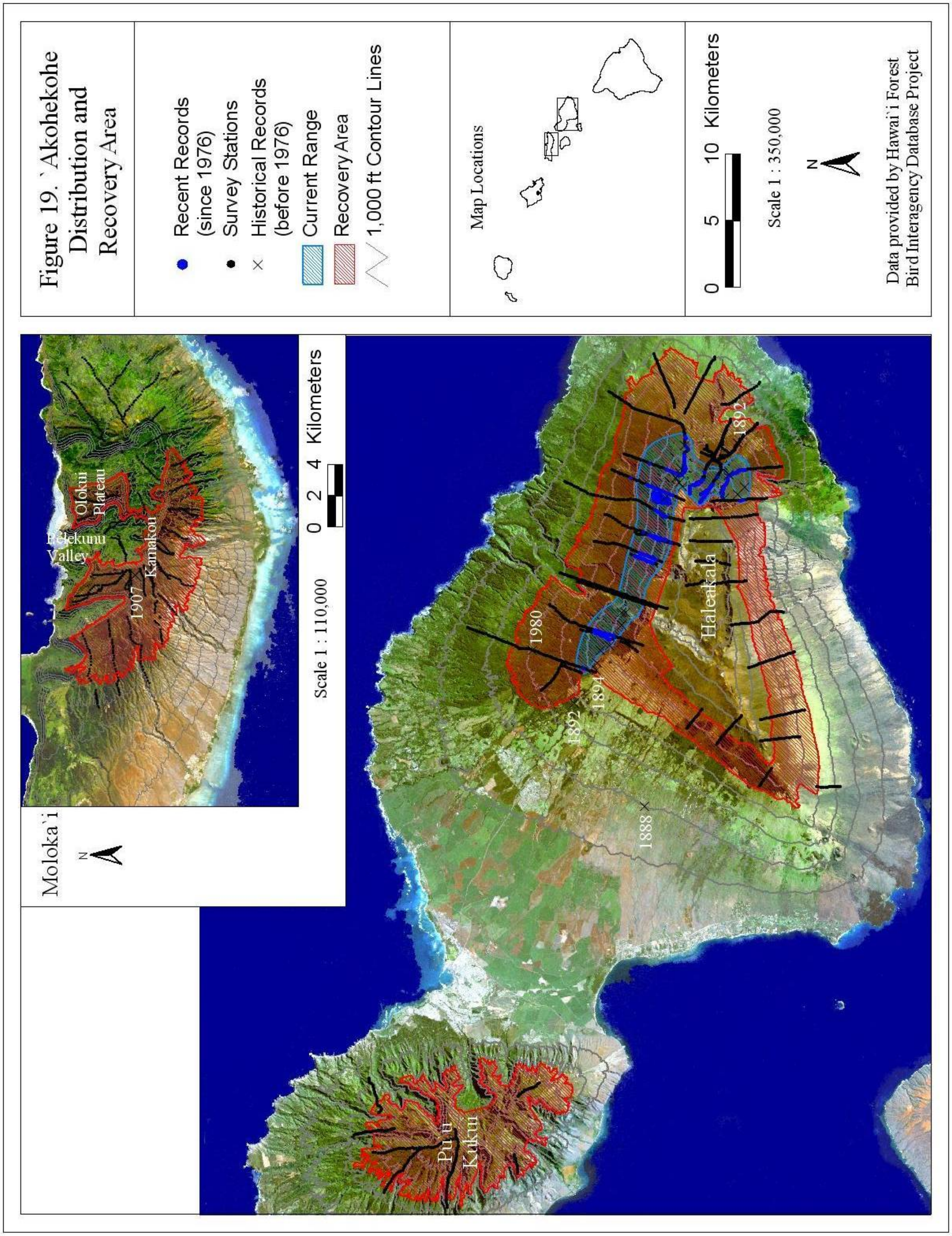


Figure 19. `Akohekohe Distribution and Recovery Area

REASONS FOR DECLINE AND CURRENT THREATS

`Ākohekohe are restricted to higher elevation forests due to the presence of mosquito-borne diseases at lower elevations, and are restricted at upper elevations in some areas by destruction of forest habitat. `Ākohekohe may be particularly vulnerable to mosquito-borne diseases because they migrate altitudinally in response to varying `ōhi`a flowering phenology (Conant 1981a), potentially increasing their exposure to mosquitoes at lower elevations. Avian malaria was recently isolated from an `ākohekohe in Hanawī Natural Area Reserve (Feldman *et al.* 1995). Laboratory challenge experiments have shown that the `i`iwi, which is closely related to the `ākohekohe but more common and has a wider distribution, is extremely vulnerable to avian malaria, with 90 percent of experimental birds dying after being bitten by infected mosquitoes (Atkinson *et al.* 1995). Black and Polynesian rats (*Rattus rattus* and *R. exulans*) are serious predators on adults and nests of Hawaiian forest birds and are abundant in `ākohekohe habitat (Sugihara 1997, Malcolm *et al.* 2002), and Simon *et al.* (2001) found rat predation on an `ākohekohe adult and egg, as evidenced by rat droppings and bird remains in the nest. The remains of an `ākohekohe were found in a barn owl pellet from Hanawī, and feral cat scats also contained remains of other native forest birds (Kowalsky *et al.* 2002). Damage by feral pigs to understory vegetation may deplete nectar resources needed during times of year when `ōhi`a is less available.

CONSERVATION EFFORTS

The `ākohekohe was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967), protected under State of Hawai`i endangered species law on March 22, 1982, and was included in the Maui-Moloka`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1984a).

Conservation efforts for the `ākohekohe have included creation of the 3,035 hectare (7,500 acre) Hanawī Natural Area Reserve to provide additional habitat protection. The upper 800 hectares (2,000 acres) of Hanawī was fenced by 1996, and all ungulates were removed by 1997 (B. Evanson, Maui Department of Fish and Wildlife, pers. comm.). Adjacent forest lands have been protected through acquisition by the National Park Service and formation of the East Maui Watershed Partnership. Ecological and life history research has been conducted since 1992 (Simon *et al.* 1998, 2001; Berlin *et al.* 2001; Pratt *et al.* 2001b; VanGelder and Smith 2001). Research on captive breeding for the `ākohekohe was initiated in 1997, when eggs were removed to the Maui Forest Bird Conservation Center and the Keauhou Bird Conservation Center following the recommendations of Ellis *et al.* (1992). Six individuals hatched in captivity from late-stage wild eggs. Three individuals died before 1 year of age; three are currently surviving. No success at captive production of `ākohekohe has been attained to date due to the aggressive nature of this species and incompatibility of the paired birds.

RECOVERY STRATEGY

The long-term recovery strategy for the `ākohekohe is generally similar to that for the Maui parrotbill because they currently inhabit roughly similar geographic areas and face common threats. Habitat management, such as fencing and control of feral pigs that damage flowering plants, may allow `ākohekohe populations to increase in density. Forest restoration through fencing and removal of feral ungulates in currently degraded areas, particularly on the leeward slopes of Haleakalā, would increase the amount of available habitat and allow range expansion. Control of mosquitoes or their breeding sites may be needed to render existing forest on West Maui and Moloka`i suitable for endangered birds like `ākohekohe. Research to better understand threats and optimize management methods, particularly rat predation and disease, is also important.

The establishment of a second `ākohekohe population in historically occupied habitat on leeward East Maui, West Maui, or Moloka`i is an important component of the recovery strategy in order to reduce the threat from catastrophes such as hurricanes and epizootics of disease that could eliminate a single population. In contrast to the Maui parrotbill, translocation of wild-caught adult birds may be the preferred method of establishing a second `ākohekohe population, because the aggressive nature of this species (Carothers 1986) makes it difficult and expensive to propagate in captivity. However, establishment and maintenance of an effective captive-breeding program for future releases into disease-free recovery areas should remain an option if translocations of wild birds do not succeed in establishing a second population. The suitability of West Maui and Moloka`i as release sites for translocated birds is currently questionable due to the presumed presence of avian diseases in these lower elevation areas.

19. Po`ouli, *Melamprosops phaeosoma*

DESCRIPTION AND TAXONOMY


Adult po`ouli. Photo by Paul Baker.

The po`ouli is a medium-sized, 26 gram (0.9 ounce), stocky Hawaiian honeycreeper (family Fringillidae, subfamily Drepanidinae) easily recognized by its brown plumage and characteristic black mask framed by a gray crown and white cheek patch. Robust birds, they have short wings and tail, stout legs and feet, and a conical finch-like bill. Plumages of the po`ouli are not well known (Engilis *et al.* 1996, Baker 1998), but observations at two nests revealed that adults of both sexes and young differ subtly in coloration. Males have whitish underparts, whereas females (and perhaps young males) have a grayish throat and breast. Fledglings have whitish underparts, a mask smaller than that of the adults, and a pale tip to the mandible. The original species description (Casey and Jacobi 1974) was based on two specimens now believed to be in immature (first basic) plumage, because they look like females but retain a pale tip to the mandible. There is no information on molt.

The po`ouli comprises a monotypic genus and species that, remarkably, was not discovered until 1973 (Casey and Jacobi 1974). Morphological and genetic studies agree that the po`ouli forms a unique lineage within the Hawaiian honeycreepers (Casey and Jacobi 1974, James and Olson 1991, Fleischer *et al.* 2001). Pratt (1992a) suggested that the po`ouli may not be a Hawaiian honeycreeper, but also noted the similarity in tongue morphology with another honeycreeper, the Maui creeper or `alauahio (*Paroreomyza montana*).

LIFE HISTORY

Po`ouli have been observed singly, in pairs, and in family groups with a single young (Pratt *et al.* 1997b). It is unknown whether po`ouli pairs defend territories, but during studies of a nesting pair, territorial behavior, such as singing in vicinity of the nest after eggs were laid or consistent chasing of birds of other species that approached the nest, were not observed (Kepler *et al.* 1996). However, no other po`ouli occurred in the vicinity of the nest.

Our knowledge of po`ouli breeding biology is based on two sequential nestings by the same pair in 1986 (Kepler *et al.* 1996). Egg-laying took place on about March 10 and April 26 and 27 for the first and second nests, respectively. Clutch size was probably two eggs. The second, successful nest fledged only one of the two young, which spent 21 days in the nest. The female alone incubated the eggs and brooded the chicks, but both parents fed the chicks. The male fed the female at or away from the nest throughout the nesting cycle. This provisioning became important in poor weather -- either wind or rain -- when the female spent more time on the nest. Both po`ouli nests were typical of the nests of other honeycreepers: an open cup composed of twigs and mosses and lined with thin fern rootlets (Engilis *et al.* 1996). The nests were 8 meters (26 feet) high in tall `ōhi`a (*Metrosideros polymorpha*) trees and were hidden among leaf-bearing twigs (Kepler *et al.* 1996). Both nests are stored at the Bishop Museum in Honolulu.

Po`ouli forage primarily on tree branches, making extensive use of the subcanopy and understory. They seem to prefer the native hydrangea, kanawao (*Broussaisia arguta*), the native holly, kāwa`u (*Ilex anomala*), and `ōhi`a (Mountainspring *et al.* 1990, Pratt *et al.* 1997b). Po`ouli glean, probe, and excavate moss mats, lichen, and bark for small invertebrate prey. Detailed examination of stomach contents from the two type specimens revealed a diet of tiny native snails, beetles, and proportionately few other arthropods (Baldwin and Casey 1983). Based on foraging observations, Mountainspring *et al.* (1990) believed that po`ouli took proportionately more *Lepidoptera* and *Coleoptera* larvae. The most common food items seen delivered to po`ouli chicks were these larvae and Succineid snails (Hawaiian land snails in the family Succineidae) (Kepler *et al.* 1996).

Po`ouli often associate with mixed species foraging flocks of other insectivorous honeycreepers, especially Maui `alauahio and Maui parrotbill (*Pseudonestor xanthophrys*), gleaning insects from branches and foliage. Observers searching such flocks increase their chances of locating po`ouli.

Po`ouli are unusually quiet, and surveys or variable circular plot counts that depend on vocal detections are not appropriate for this species. Males rarely sing and do so mostly as part of courtship prior to egg-laying. The song is a series of chip notes alternating in pitch. The infrequent chip notes are similar to those of Maui `alauahio, but often characteristically paired or given in rapid succession.  Interestingly, most of the recently observed po`ouli calls have been very similar to those of the Maui parrotbill, with which po`ouli often associate, including an up-slurred "chu-wee" and a soft "whit" contact call (J. Bruch, Hawai`i Department of Land and Natural Resources, pers. comm.).

HABITAT DESCRIPTION

Po`ouli occur in montane wet forests from timberline at 2,100 meters (7,000 feet) elevation down to a lower limit of 1,440 meters (4,750 feet). The terrain is steep and dissected by numerous stream gulches. This area is characterized by high rainfall, delivered mostly by the trade wind weather system, exceeding 5 meters (200 inches) annually in some areas. The vegetation is mixed montane wet forest (Jacobi 1985) with an average canopy height of 13 meters (43 feet) and 60 percent crown cover, dominated by `ōhi`a. Areas of similar habitat remain unoccupied to the southeast and west. The range of the po`ouli coincides with high population densities of other honeycreeper species, a distribution believed to be delimited by disease-bearing mosquitoes prevalent at elevations below 1,500 meters (5,000 feet) (Scott *et al.* 1986).  Po`ouli are associated with low levels of disturbance to soil and vegetation by feral pigs (Mountainspring *et al.* 1990). Po`ouli are believed to require an intact subcanopy and understory for foraging and cover and therefore are intolerant of habitat alteration by feral pigs.

HISTORICAL AND CURRENT RANGE AND STATUS

The po`ouli apparently was unknown to the Hawaiians, and it eluded western naturalists during the discovery period of Hawaiian ornithology at the end of the 19th century.  It was discovered in 1973 by a team of university students (Casey and Jacobi 1974).  Since then, po`ouli have been confined to a 1,300-hectare (3,200-acre) section of forest on the northern and eastern slopes of Haleakalā Volcano, Maui (Figure 20; Mountainspring *et al.* 1990). The type locality was between the eastern and western forks of Hanawī Stream. Fossil evidence shows that the po`ouli once inhabited drier forests at lower elevation on the leeward slope of Haleakalā, indicating it once had a much broader geographic and habitat range (James and Olson 1991).

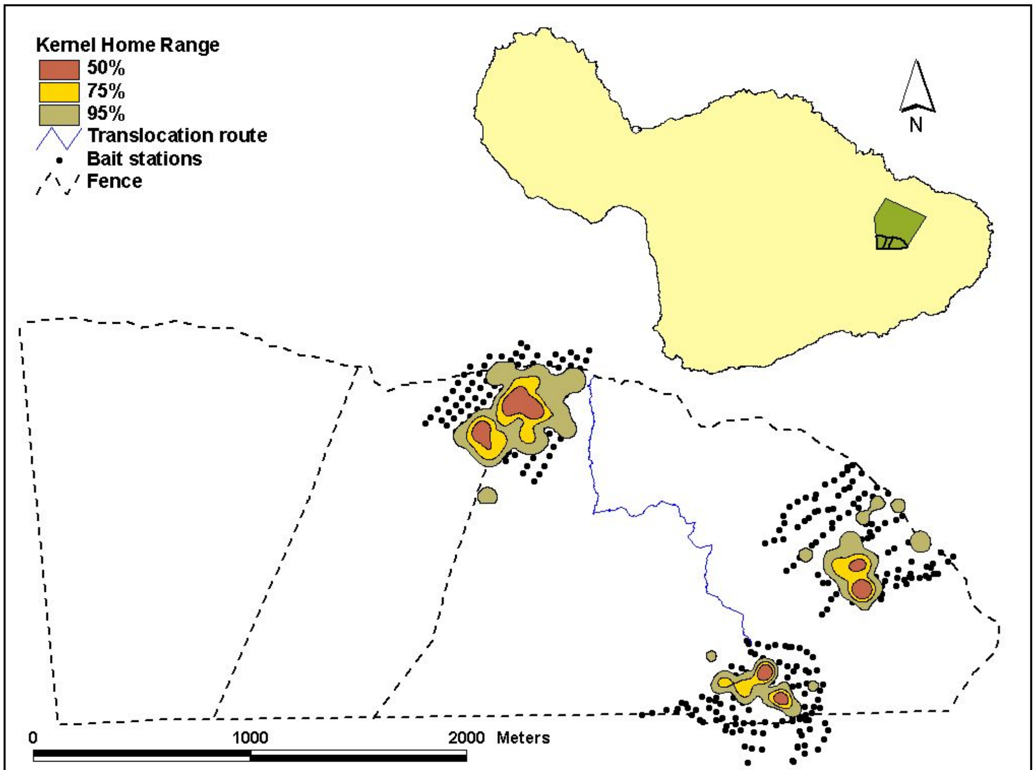


Figure 20. Location of po`ouli home ranges in Hanawī Natural Area Reserve. Map by Bill Sparklin, Maui Forest Bird Recovery Project.

The po`ouli population was estimated at 140 ± 280 birds in the early 1980s (Scott *et al*. 1986), but estimates of population size and density are not accurate and are considered imprecise due to the species' low density and cryptic behavior. Po`ouli numbers and range have since declined to a tiny population over at most a few hundred hectares. Attempts to estimate population size and density have met with frustration because of the bird's poor detectability. Mountainspring *et al.* (1990) reported densities at the type locality of 76 ± 8 (standard error) birds per square kilometer in 1976, 15 ± 7 birds per square kilometer in 1981, and 8 ± 4 birds per square kilometer in 1985 (30.8 ± 3.2 birds per 100 acres in 1976, 6.1 ± 2.8 birds per 100 acres 1981, and 3.2 ± 1.6 birds per 100 acres in 1985). No birds were found in the type locality from 1993 to 1995 (J. Simon, U.S. Geological Survey, unpubl. data). Surveys in 1994 to 1995 found perhaps as many as six po`ouli at four locations, from the west rim of Kūhiwa Valley at 1,880 meters (6,200 feet) east to the upper reaches of Helele`ike`ōhā Stream at 1,570 meters (5,200 feet) (Baker 2001, Reynolds and Snetsinger 2001). Thorough surveys of the historical range in 1997 to 2000 located only three birds, all in Hanawī Natural Area Reserve, and no others have been located since these birds were color-banded in 1996 and 1997 (Hawai`i Department of Land and Natural Resources, unpubl. data). The last three known birds occurred in non-overlapping home ranges separated by 0.75 to 1.7 kilometers (0.5 to 1 mile) (Groombridge *et al*. 2004b). They had never been observed together since they were banded, so there were no known breeding pairs, and the last documented reproduction occurred in 1995 (Reynolds and Snetsinger 2001). Genetic sexing of the three birds produced conflicting results, but the best available information indicated they consisted of one male and two females. Following an attempted translocation in 2002 to form a breeding pair and efforts to capture the remaining po`ouli for captive breeding (details provided in the Recovery Strategy section), one of the three known remaining birds died of natural causes in captivity in 2004, and the other two have not been seen since 2003 and 2004. Currently it is not known whether any po`ouli remain in the wild.

REASONS FOR DECLINE AND CURRENT THREATS

Habitat damage by feral pigs is thought to be an important cause of the decline in po`ouli numbers (Mountainspring *et al.* 1990). Other threats have not been directly linked to the po`ouli, but the species can be assumed vulnerable to the same threats that impact other honeycreepers, particularly mosquito-borne diseases and nest predation by alien rats. Po`ouli and other endangered honeycreepers likely are restricted to cold, high elevation areas by the prevalence of mosquito-borne diseases in the lowlands. Both black and Polynesian rats (*Rattus rattus* and *R. exulans*) are abundant in po`ouli habitat (Sugihara 1997, Malcolm *et al.* 2002). These animals feed largely on invertebrates (Sugihara 1997) and have been blamed for the decline of native land snails, which are an important food for the po`ouli (Hadfield *et al.* 1993). Another predator of the native land snails in po`ouli habitat is the abundant, nonnative garlic snail (*Oxychilus alliarius*).

CONSERVATION EFFORTS

The po`ouli was federally listed as an endangered species on September 25, 1975 (U.S. Fish and Wildlife Service 1975), and was included in the Maui-Moloka`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1984a). Decline of the po`ouli prompted conservation agencies to protect its entire historical range, as it was known at the time, by creation of the 3,035-hectare

(7,500-acre) State Hanawī Natural Area Reserve. The upper 800 hectares (2,000 acres) of Hanawī was fenced by 1996, and all ungulates were removed by 1997 (B. Evanson, Maui Division of Forestry and Wildlife, pers. comm.). These actions have stabilized soil erosion and stimulated vegetation recovery. The National Park Service has fenced and removed feral ungulates from areas adjacent to Hanawī. Formation of the East Maui Watershed Partnership, a consortium of government agencies, nongovernmental agencies, and private landowners, has helped to further protect the forests of east Maui, and this group has fenced large areas of rainforest downhill from Hanawī Natural Area Reserve. Ecological and life-history research was carried out under the direction of the USGS Biological Resources Discipline during 1994 to 1996 (Baker 2001). Ground-based predator control was conducted in the home ranges of the last three known birds (Malcolm *et al*. 2002). The Hawai`i Department of Land and Natural Resources and the U.S. Fish and Wildlife Service jointly fund the Maui Forest Bird Recovery Project. Activities of this project include control of small mammals in an attempt to reduce the threat of predation on adults and nests and competition for invertebrate prey, research on optimizing rodent control methods, and mist-netting, banding, and collecting blood samples to monitor demography and disease prevalence in native bird populations, particularly the po`ouli. The same program attempted to translocate one po`ouli into the home range of another to encourage breeding, and brought one bird into captivity in an attempt to form of a breeding pair (see below).

RECOVERY STRATEGY

Fundamental to the long-term strategy for recovery of the po`ouli is the protection and management of high elevation rainforests on East Maui. While the canopy of this forest remains relatively intact, the understory has been severely degraded by feral pigs in places, and subcanopy trees have died as a result of soil loss and disturbance to roots. The recovery of vegetation should proceed rapidly at first as ferns and native shrubs move into disturbed areas. The regeneration of subcanopy trees will be slower, but within a few decades should return the forest to a restored condition.

Alternative strategies for recovery of the po`ouli were outlined in The Environmental Assessment for Proposed Management Actions to Save the Po`ouli (U.S. Fish and Wildlife Service and Hawai`i Department of Land and

Natural Resources 1999). This document included solicitation for public input on recovery strategies, including continued habitat management only, field translocation with "hard" release to create a breeding pair, field translocation with "soft" release by temporarily holding birds in a field aviary, and bringing all three remaining birds into captivity for propagation. Based on the Environmental Assessment and subsequent public comments, it was decided that the best strategy for recovering the po`ouli was continued habitat management, including predator control, in conjunction with translocation of a female po`ouli into the home range of the last male, in hopes that they would form a breeding pair and nest (U.S. Fish and Wildlife Service and Hawai`i Department of Land and Natural Resources 1999).

Translocation methods were developed by the Maui Forest Bird Recovery Project, using the non-endangered Maui `alauahio or Maui creeper as a surrogate species. Sixteen Maui creepers were translocated between the po`ouli home ranges using different methods of confinement during transport and over varying distances. All trials resulted in zero mortality, and white blood cell counts indicated that stress levels were lower in birds transported with a minimum of restriction on their movement within the transport container (Groombridge *et al*. 2004a). These trials demonstrated that Hawaiian honeycreepers could be safely transported on foot over the steep and rugged terrain separating the po`ouli home ranges, and helped to identify the best methods and protocols for translocating the po`ouli.

Following the surrogate translocation work, a holding-cage was designed to allow brief observation of a captive po`ouli immediately after its translocation and prior to its release. The 30 × 30× 60 centimeter (12 × 12 × 24 inch) holding cage was constructed from soft white cloth walls stretched within a lightweight rigid frame, and was designed to house two birds separately side-by-side. If it became necessary to hold a single po`ouli in field captivity for several days, either as a result of injury or due to weather conditions that precluded helicopter transport, then the holding-cage could separately house a ‘tutor’ individual of an ecologically-compatible species (e.g., Maui parrotbill) to encourage acclimation and feeding behavior. An externally mounted video camera provided continual remote monitoring of the bird’s behavior via a television monitor 20 meters (66 feet) away. Both natural food, such as native Succineid snails (Baldwin and Casey 1983), and supplemental foods routinely used for captive propagation of other insectivores, including waxworms and mealworms, were provided inside the holding cage.

Veterinary facilities were set up in Hanawī to deal with possible injuries to a po`ouli. Requirements focused on delivering a veterinary capacity that could handle critical medical requirements for a period of up to 3 consecutive days, a time frame considered to be a likely delay to any helicopter evacuation of an injured po`ouli due to bad weather. Veterinary equipment consisted of an avian intensive care unit with a controlled environmental temperature and oxygen enriching capacity, general anesthesia and surgical capabilities, equipment and supplies to treat traumatic injuries, antimicrobial drugs, and diagnostic equipment required to perform complete blood counts, cytology, and harvest plasma for chemical analysis. In the event of a death of a po`ouli, various tissues would be collected for cell culture and immediately sent to both the Zoological Society of San Diego's Conservation and Research for Endangered Species center and the Audubon Nature Institute Center for Research of Endangered Species.

A detailed protocol to carry out a po`ouli translocation was cooperatively designed and approved by the U.S. Fish and Wildlife Service, the Hawai`i Department of Land and Natural Resources, and the Zoological Society of San Diego in December 2001. After nearly 2 years of preparation, efforts to capture and translocate po`ouli began in January 2002. On April 4, 2002, a presumed female po`ouli was captured and translocated 2.5 kilometers (1.6 miles) on foot into the home range of the male (Groombridge *et al*. 2004b; see Figure 20). Transit time for the bird was 1 hour and 15 minutes. Upon arrival, the female was examined by an avian veterinarian and determined to be in good health. Following examination, a radio transmitter was attached to the bird, and it was observed for approximately 2 hours in the holding cage. While in captivity, the bird consumed several food items, including nonnative waxworms and native Succineid snails. The female po`ouli was released within the male's home range at dusk that evening. The following morning, radio telemetry signals confirmed that she had roosted within the male's home range overnight and was still present. However, signals throughout the morning indicated that she was steadily moving back toward her own home range, and by that evening she had traveled back to her capture site. The female po`ouli was radio-tracked for 9 days within her home range following her return. It is not known whether the two birds encountered one another, but there was no indication that they did (Groombridge *et al.* 2004b).

Although the translocation was unsuccessful in establishing a wild breeding pair, several important lessons were learned from the effort (Groombridge *et al*. 2004b). First, field biologists demonstrated that individuals of the species could be safely manipulated. Subsequent sightings of the translocated bird indicated that it was not adversely affected by its handling, transport, and temporary captivity. Second, the bird showed signs of potential positive acclimation to captivity, reacting passively to its holding cage and readily consuming foreign food. Third, information gained from observations and radio-telemetry was used to refine estimates of the birds' home ranges.

On June 25, 2002, representatives of the U.S. Fish and Wildlife Service, Hawai`i Department of Land and Natural Resources, Maui Forest Bird Recovery Project, Zoological Society of San Diego, and the Hawaiian Forest Bird Recovery Team convened on Maui to discuss the next step in attempting to recover the po`ouli. Several alternatives from the 1999 Environmental Assessment were discussed, including another translocation attempt, placing the birds in a field aviary in Hanawī, removing the birds from the wild and placing them in captivity, or taking no further action. In addition, a new alternative was introduced which called for the birds to be placed in a field aviary at a more accessible location. It was clear that there were risks associated with all the options and that the chances of success were low no matter what alternative was chosen. Each option appeared to have advantages and disadvantages, and the decision was extremely difficult. No alternative was universally supported. A structured decision-making process was used to help evaluate and compare the alternatives based on the best available information and expertise (VanderWerf *et al*. 2006). Although most participants agreed that the first translocation attempt was worthwhile, a second translocation attempt was rejected because available evidence indicated that adult Hawaiian forest birds have high site fidelity and usually return to their own home range following translocation (Fancy *et al*. 1997, 2001; Groombridge *et al*. 2004a), and there was no reason to suspect a second female po`ouli to behave differently. The two options that were judged to have the highest probability of success were removal to captivity and a field aviary in a more accessible location. Based on the results of the decision process, consensus eventually was reached within the U.S. Fish and Wildlife Service and Hawai`i Department of Land and Natural Resources, the two agencies mandated to recover the species, to capture the three known birds and remove them from the wild for captive breeding. The factors that ultimately were judged to favor removal to captivity over a field aviary were that removal to captivity could be implemented more quickly, which was considered important given the advanced age of the three birds, and that it would be more difficult to provide adequate veterinary care in a field aviary and ensure the safety of the birds from predators, severe weather, and vandals. The Zoological Society of San Diego expressed with reservations that they would undertake the difficult task of attempting to manage and breed the po`ouli in captivity at the Maui Bird Conservation Center. Captive breeding programs for Hawaiian forest birds operated by the Zoological Society of San Diego at the Keauhou Bird Conservation Center and the Maui Bird Conservation Center have been very successful (Kuehler *et al*. 2000, 2001; ZSSD 2004), but establishing a successful program with just a single breeding pair would be the ultimate avicultural challenge.

A detailed protocol for capturing the remaining wild po`ouli and transferring them to captivity was cooperatively designed and approved by the U.S. Fish and Wildlife Service, the Hawai`i Department of Land and Natural Resources, and the Zoological Society of San Diego in January 2003, for the purpose of establishing a captive propagation and reintroduction program. The agencies involved in this effort recognized that there were risks involved in such an attempt to capture wild birds and transport them into captivity. In light of the extreme rarity of the po`ouli, strict operational guidelines were followed throughout the capture effort to ensure that these risks were addressed and mitigated to the fullest extent possible.

Adverse weather and practical constraints hampered capture efforts, but on September 9, 2004 the first of the three po`ouli was captured and removed to captivity at the Maui Bird Conservation Center. Genetic sexing using a blood sample taken from the bird in captivity indicated it was a male. This result conflicted with that of earlier tests and cast some doubt on the sex of the two remaining birds, leading to the possibility that only one sex of po`ouli had remained for the past several years. Even more remarkable, upon capture the bird was found to have only one functioning eye, probably as a result of a previous traumatic injury (K. Swinnerton, Maui Forest Bird Recovery Project, pers. obs.), and it was found to have been infected with avian malaria before it was captured (C. Atkinson, unpubl. data).

Sadly, after being successfully maintained in captivity for 78 days, the captive po`ouli died on 26 November 2004, before a potential mate could be obtained. The death of the captive bird was obviously a severe setback to the recovery of the species. Necropsy results revealed several chronic health problems, indicating the likely cause of death was old age (B. Rideout, Zoological Society of San Diego, pers. comm.). Although the bird had avian malaria, the infection was sub-clinical and was not the primary cause of death. Tissue samples were collected from the bird immediately following its death, and fibroblast cells were successfully grown and cryogenically preserved at the Zoological Society of San Diego's center for Conservation and Research for Endangered Species.

The remaining two birds have not been seen since December 2003 and January 2004 (Maui Forest Bird Recovery Project, unpubl. data.). If they are located, or if new birds are discovered, efforts to facilitate formation of a breeding pair will resume if at all possible. Although much of the suitable habitat on east Maui has been surveyed for po`ouli (Reynolds and Snetsinger 2001; Maui Forest Bird Recovery Project, unpubl. data), there are some areas that have not been thoroughly searched, and due to the rugged terrain and cryptic nature of the species it is not possible to say with certainty that no additional po`ouli exist.

See the Rare Bird Discovery Protocol in Section III-D.

20. \`Akikiki (Kaua\`i Creeper), *Oreomystis bairdi*

DESCRIPTION AND TAXONOMY

The Kaua`i creeper, or `akikiki, is a small honeycreeper, 10.9 to 12.2 centimeters (4.3 to 4.8 inches) in length and 11.5 to 17.0 grams (0.39 to 0.58 ounces) in weight, endemic to the Island of Kaua`i. Its head, back, sides, and flanks are dull gray to olive, the throat, breast, belly, and undertail coverts are white to off-white. The bill is short and slightly downcurved, the tail is short and square-tipped, and the legs, feet, nails, and bill are dull pink. Male and female plumages are identical. Juveniles are similar to adults but are distinguishable by white "spectacles" around the eyes. The song is a short, descending trill. Males and females give a soft "whit" contact call.

Adult `akikiki foraging on `ōhi`a trunk. Photo permission pending.

At the time of European discovery, each of the six main Hawaiian Islands harbored a small, straight-billed, simple-tongued, insectivorous bird. The Kaua`i creeper was first described as *Oreomyza bairdi* by Stejneger in 1887 (the genus was later changed to *Oreomystis* because *Oreomyza* had been used previously, Stejneger 1903). Subsequent nomenclature has been problematic (reviewed in Pratt 1992b, Foster *et al.* 2000), and the species has been variously considered a full species *Oreomystis bairdi* (Perkins 1903), a subspecies of *Paroreomyza bairdi* (Bryan and Greenway 1944), and a subspecies of *Loxops maculata* (Amadon 1950). It is currently classified as *Oreomystis bairdi* (American Ornithologists' Union 1998) following Pratt (1979, 1992b), but its inclusion with the Hawai`i creeper in the genus is a matter of ongoing debate (Johnson *et al.* 1989, Fleischer *et al.* 1998, Pratt 2001). Additional evidence, particularly molecular, may confirm that the Maui `alauahio (*P. montana newtoni*) is the closest living relative of the `akikiki (Foster *et al.* 2000). The `akikiki is in the Hawaiian honeycreeper family (family Fringillidae, subfamily Drepanidinae).

LIFE HISTORY

The life history of the Kaua`i creeper or `akikiki is poorly known. Data below have been summarized from Eddinger (1972) and Foster *et al.* (2000), except where otherwise noted. `Akikiki are usually found in pairs, family groups, and small flocks of 5 to 6 (rarely up to 12) individuals (J. Denny, Hawai`i Department of Land and Natural Resources, pers. comm.; T. Snetsinger, U.S. Geological Survey, pers. comm.). `Akikiki also form mixed-species flocks with `akeke`e (*Loxops caeruleirostris*), `anianiau (*Hemignathus parvus*), Kaua`i `amakihi (*Hemignathus kauaiensis*), and Kaua`i `elepaio (*Chasiempis sandwichensis sclateri*), and historically with `akialoa (*Hemignathus procerus*), and Kaua`i nukupu`u (*Hemignathus lucidus hanapepe*) (Perkins 1903, Munro 1944).

Nest construction has been observed from March to May, and first nests are probably active by mid- to late-March or April. The earliest fledgling was sighted in late April (T. Casey, Kamehameha Schools, pers. comm.), and the breeding season is believed to last into June or July. Only eight nests of the Kaua`i creeper have been found (J. Foster, U.S. Geological Survey, pers. comm.) and only three of these have been reported in the literature (Eddinger 1972, Foster *et al.* 2000). Females and males both participate in nest-building, although the extent of male help is unclear. Three open-cup nests found in the Alaka`i were all 8 to 9 meters (26 to 29 feet) high in the crowns of `ōhi`a (*Metrosideros polymorpha*) trees and were composed primarily of moss, with `ōhi`a bark, plant rootlets, and other fine plant fibers; two others were at 4 and 6 meters (13 and 20 feet) and at least one included `ōlapa (*Cheirodendron trigynum*) bark (J. Denny, pers. comm.). A nest found on 24 May 2006 in the Halepā`ākai area of the Alaka`i contained a single large nestling and was approximately 12 meters (40 feet) high in the crown of a 14 meter (46 foot) tall `ōhi`a tree (E. VanderWerf, unpubl. data). One nest required 14 days from nest completion to first egg (Eddinger 1972). Clutch size is probably two eggs, incubation probably lasts 16 to 18 days, and the nestling period probably lasts 17 to 19 days, based on traits of the closely related Hawai`i creeper (VanderWerf 1998b, Woodworth *et al.* 2001). Family groups of parent(s) and one or two juveniles can be found throughout the year.

No data exist on the survival rate of nests, overall proportion of nests surviving to fledge, or causes of nest failure. One of the two nests found by Eddinger (1972) was abandoned in the egg stage, and one contained two nestlings (fate unknown). The fates of the other five nests that have been found are unknown because nests were not revisited. Pairs can fledge two young, based on observations of a family group with two very young fledglings (J. Foster, pers. comm.). A long parental-dependency period makes double-brooding unlikely, although no data are available.

The Kaua`i creeper generally forages on trunks, branches, and twigs of live and dead `ōhi`a and koa (*Acacia koa*) and occasionally forages in subcanopy shrubs. Creepers feed primarily on insects, insect larvae, and spiders that they glean and probe from the bark, lichens, and moss. In May 2006 an adult Kaua`i creeper was observed excavating the dead twig of a hoawa (*Pittosporum*) tree (E. VanderWerf, unpubl. data), though this may be a rare foraging behavior. Nectarivory and frugivory also have been rarely observed.

No data are available on the annual survival rate of the Kaua`i creeper. The congeneric Hawai`i creeper has a relatively high annual adult survival of about 73 to 88 percent and juvenile survival of about 33 percent (Ralph and Fancy 1994a, Woodworth *et al.* 2001). However, these high survival rates may reflect in part the rarity of avian disease at high elevations (more than 1,500 meters [5,000 feet]) where these data were collected (see below).

HABITAT DESCRIPTION

The habitat description that follows is primarily from Foster *et al.* (2000). Kaua`i creepers occur primarily in mesic and wet forests. In the eastern edge of the species' range, annual rainfall exceeds 13,000 millimeters (512 inches) a year, declining to 1,100 millimeters (43 inches) at the western edge at Kōke`e State Park. This rainfall gradient and varied topography cause great variability in habitat within Kaua`i creeper range. The montane wet forest is dominated by `ōhi`a with a subcanopy of `ōlapa, lapalapa (*Cheirodendron* spp.), and `ōhi`a ha (*Syzygium sandwicensis*). The forest understory is occupied by many species of native shrubs and small trees, typically including `ōhelo (*Vaccinium calycinum*), kanawao (*Broussaisia arguta*), haha`aiakamanu (*Clermontia fauriei)*, kāwa`u (*Ilex anomala*), kōlea (*Myrsine lessertiana*), na`ena`e (*Dubautia* spp.),and pūkiawe (*Styphelia tameiameiae*). The ground cover consists of ferns, mosses, herbs, and lichens. Lowland habitats have been drastically altered by introduced weeds and feral ungulates.

HISTORICAL AND CURRENT RANGE AND STATUS

The Kaua`i creeper is endemic to the island of Kaua`i. It was considered common from high to low elevation in native forests in the late 1800s (Perkins 1903), and was locally abundant on and near the Alaka`i Plateau in the early 1960s (Richardson and Bowles 1964). From 1968 to 1973, John Sincock surveyed 50 points (a total of 866 half-hour counts) throughout the Island of Kaua`i and estimated the population to number 6,832 ± 966 birds in a range encompassing areas from 600 to 1,600 meters (1,968 to 5,248 feet) elevation (Sincock 1982; Figure 21). In 1981, the Hawaii Forest Bird Survey estimated there were approximately 1,650 ± 450 Kaua`i creepers in a 25 square kilometer (9.7 square mile) area of the southeastern Alaka`i, in the vicinity of what is now known as Sincock's Bog (Scott *et al.* 1986). Sincock *et al.* (U.S. Fish and Wildlife Service 1983b) had estimated the population in this same area to be 2,300 ± 700 birds. More recently, surveys in March and April 2000 by Foster *et al.* (2004) showed that in the last 30 years the range has decreased from 88 to 36 square kilometers (from 34 to 14 square miles), the species has disappeared from much of the periphery of its range, and the estimated population has declined from 6,832 ± 966 to 1,472 ± 680 birds (Figure 21).

REASONS FOR DECLINE AND CURRENT THREATS

Modification and loss of habitat, avian disease, predation by introduced mammals, and competition from introduced birds have likely played a part in the decline of the Kaua`i creeper.

Habitat loss and degradation/Invasive species. The habitat of the Kaua`i creeper has been and continues to be negatively affected by invasive alien plant species that displace native plant species used by the creeper for foraging and nesting, and by the action of feral ungulates, particularly feral pigs and goats.

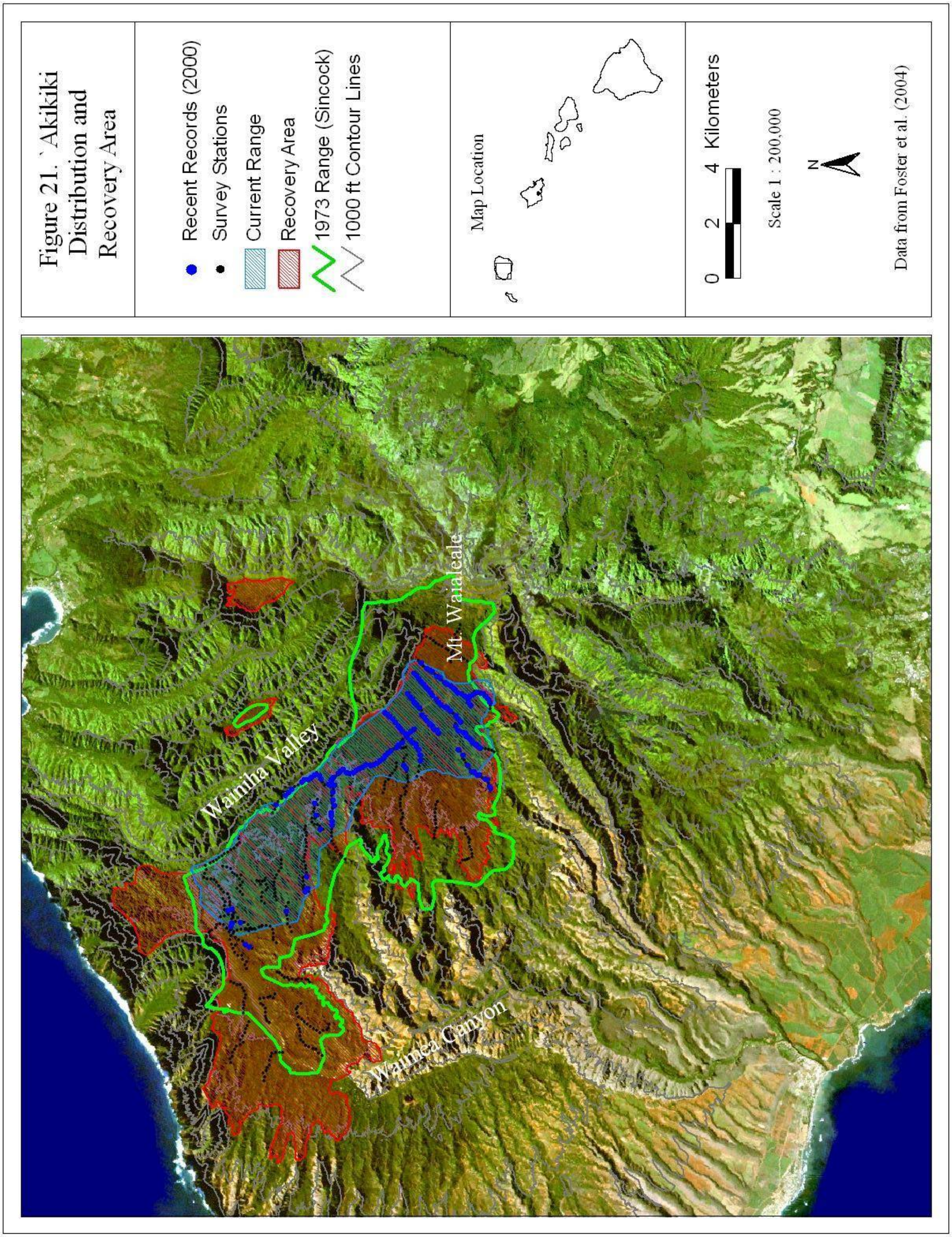


Figure 21. `Akikiki Distribution and Recovery Area

Feral pigs and goats have had a long-term damaging effect upon native pristine forests in the Alaka`i region, opening space for weeds, and transporting weed seeds into the forest. The negative impacts of feral ungulates on forested ecosystems in Hawai`i include direct browsing of native plants, soil erosion, disruption of plant regeneration, spreading of invasive alien weeds, opening of space for invasive alien plants, and creation of mosquito breeding habitat (Cabin *et al.* 2000). Habitat degradation resulting from the invasion of many nonnative weeds has drastically changed the forest structure and integrity. Furthermore, two hurricanes in 1982 and 1992 have severely disrupted portions of native forest and made space for germination and expansion of alien plants.

It has been suggested that the Kaua`i creeper may be negatively impacted by competition from the insectivorous Japanese white-eye (*Zosterops japonicus*; Mountainspring and Scott 1985). Japanese white-eyes are extremely common, numbering over 255,000 during Sincock's surveys from 1968 to 1973 (Sincock 1982). New avian species that have recently become established on Kaua`i, such as the Japanese bush-warbler (*Cettia diphone*), could eventually become competitors for food and space. Perhaps less obvious, but potentially detrimental to the Kaua`i creeper, are additions of new exotic invertebrates to the forest ecosystem. The role of alien invertebrates is unclear; new insects may compete with or prey upon the native insect prey of the creeper, or they could be used as prey by the creeper.

Disease. Avian diseases transmitted by the introduced southern house mosquito (*Culex quinquefasciatus*), including pox (*Poxvirus avium*) and malaria (*Plasmodium relictum*), are thought to play a major role in limiting the distribution of Kaua`i creepers. The Kaua`i creeper is restricted to higher elevation areas where mosquitoes and the diseases they carry are less prevalent (Scott *et al.* 1986), but mosquitoes have been captured as high as Sincock's Bog at 1,330 meters (4,400 feet) elevation and are likely to occur to the highest elevations on Kaua`i (D. LaPointe, U.S. Geological Survey, pers. comm.). Mist-netting of forest birds from 1994 to 1997 in three locations, Pihea-Alaka`i Swamp Trail, Koia`e Camp, and Sincock's Bog, documented 2 to 5 percent of all birds with active malaria infections in these areas, and up to 12 percent with malarial antibodies (C. Atkinson, U.S. Geological Survey, unpubl. data, cited in LaPointe 2000). Malarial infection rates were highest in the west, at Pihea, and lowest in Sincock's Bog. None of the 10 Kaua`i creepers tested for malaria had active infections or evidence of past infection (C. Atkinson, U.S. Geological Survey, unpubl. data, cited in LaPointe 2000), but more data is needed to determine if this low infection rate is caused by a low transmission rate or high mortality of infected birds.

Predation from introduced and native species. The biology of the Kaua`i creeper has been little studied and predation on adults and nests has not been documented, but several introduced mammals known to be serious predators on Hawaiian forest birds are present in the Alaka`i swamp on Kaua`i where `akikiki occur (Tweed *et al.* 2000), including black rats (*Rattus rattus*), Polynesian rats (*R. exulans*), Norway rats (*R. norvegicus*), and feral cats (*Felis catus*). Two species of owls, the native pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*) and introduced barn owl (*Tyto alba*), are known to prey on forest passerines (Snetsinger *et al.* 1994).

Other Factors. Hurricanes struck Kaua`i in 1982 and 1992 and significantly reduced habitat by destroying forests and promoting the spread of alien weeds. Surveys by Foster *et al*. (2000) showed that the Kaua`i creeper declined significantly from 1989 to 1994.

Climate change poses a threat to the Kaua`i creeper and other Hawaiian forest birds by causing an increase in the elevation at which regular transmission of avian malaria occurs (Benning *et al*. 2002). Experimental evidence has shown that the malarial parasite does not develop in birds below 13 degrees Celsius (55 degrees Fahrenheit), and field studies have found that maximum malaria transmission occurs where mean ambient summer temperature is 17 degrees Celsius (63 degrees Fahrenheit; LaPointe 2000). Between 13 and 17 degrees Celsius, malaria transmission is limited and usually associated with warmer periods, such as El Nino events (Feldman *et al*. 1995). There are no forested areas on Kaua`i where mean ambient temperature is below 13 degrees Celsius, meaning all areas are subject to malaria at least periodically. Benning *et al*. (2002) used GIS (Geographic Information System) simulation to show that an increase in temperature of 2 degrees Celsius (3.6 degrees Fahrenheit), which is predicted by some climatic models (Pounds *et al*. 1999, Still *et al*. 1999, IPCC 2001), would raise the 17 degree isotherm by 300 meters (985 feet), resulting in an 85 percent decrease in the land area where malaria transmission currently is only periodic.

SPECIES-SPECIFIC CONSERVATION EFFORTS

Legal protection. The Kaua`i creeper is a candidate for listing under the Endangered Species Act (U.S. Fish and Wildlife Service 2005). If the creeper is listed federally, it will be added automatically to the State of Hawai`i's list of endangered species.

Ecological Studies. In June 1985, the Hawai`i Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service conducted the first systematic survey of forest bird populations throughout the Alaka`i region since John Sincock's 1968 to 1973 surveys. A total of 34 transects were surveyed using standard variable circular plot methodology, including over 77 linear kilometers (48 miles) and 550 point count stations covering approximately 100 square kilometers (38 square miles) of the Alaka`i region (Figure 21). The surveys included the majority of native forest on Kaua`i above about 1,200 meters (4,000 feet). Surveys by Foster *et* al. (2000) have provided more recent estimates of the range and abundance. In combination these surveys have demonstrated serious declines in the abundance and distribution of the species.

Captive propagation and reintroduction. The Zoological Society of San Diego currently is developing techniques for rearing *Oreomystis* creepers from eggs and breeding them in captivity, using the related Hawai`i creeper as a surrogate. To date, nine Hawai`i creepers have been reared from eggs collected from the wild, and two Hawai`i creeper pairs have produced eggs in captivity. In June 2000, the first Hawai`i creeper egg laid in captivity successfully hatched at the Keauhou Bird Conservation Center in Volcano, Hawai`i (The Peregrine Fund 1997, 1998, 1999; The Peregrine Fund and Zoological Society of San Diego 2000).

HABITAT-WIDE CONSERVATION EFFORTS

The habitat that is home to the `akikiki also harbors (or harbored) populations of six other endangered forest birds: the `ō`ū (*Psittirostra psittacea*), Kaua`i `ō`ō (*Moho braccatus*), kāma`o (*Myadestes myadestinus*), Kaua`i nukupu`u (*Hemignathus lucidus hanapepe*), Kaua`i `akialoa (*Hemignathus procerus*), and puaiohi (*Myadestes palmeri*). The area is also important as a watershed, and is popular for recreational hiking, bird watching, and hunting. Thus, there have been ongoing efforts aimed at protecting the Alaka`i region, including legal protection, periodic surveys, control of feral ungulates, education and outreach, and ecological studies.

Legal Protection. The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i. The Act has been strengthened and re-titled "Hawai`i Department of Land and Natural Resources Title 13, Chapter 104 Rules Regulating Activities Within Forest Reserves," and provides protection to native forest habitats from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectare (9,938 acre) Alaka`i Wilderness Preserve in 1964 (Administrative Rule No. 1, Chapter 3), recognizing the pristine forest values of that area, and the need to control potential degrading factors.

Periodic Surveys and Inventories. Regular surveys and inventories of Kaua`i forest bird populations and habitat conditions within the Alaka`i Wilderness Preserve have been conducted on established transects since the late 1960s. John L. Sincock, research biologist with the U.S. Fish and Wildlife Service, Kaua`i Field Station, conducted intensive status and distribution surveys of Kaua`i forest birds between 1968 and 1973 (Sincock 1982). Large-scale multi-agency surveys were conducted on established transects in 1981, 1985, 1989, 1993, 1994, and 2000 (Hawai`i Department of Land and Natural Resources, unpubl. data; U.S. Geological Survey, unpubl. data; Foster *et al*. 2004). The Hawai`i Rare Bird Search and Survey Team made an intensive systematic effort to locate any surviving endangered Kaua`i forest bird populations still in existence on Kaua`i (Reynolds and Snetsinger 2001).

Control of Feral Ungulates. The Hawai`i Department of Land and Natural Resources has maintained liberal public hunting seasons to minimize forest damage caused by feral pigs and goats within the Alaka`i Wilderness Preserve for several decades. Unfortunately, public hunting is effective only in the more accessible areas of the preserve, and ungulate populations in more remote areas remain high. Limited aerial reconnaissance and aerial shooting of feral goats and pigs has been attempted in the most remote regions, but has not proven to be economically effective. Long-term protection of the Alaka`i from feral ungulates will require creativity, commitment, political practical understanding, an extensive public relations campaign, and significant financial support.

Information and Education. Materials featuring Kaua`i's endangered forest birds, as well as those found on other islands, have been published and distributed to schools to assist efforts to inform the public and gain support for funding to preserve endangered species. Privately-funded filmmakers including the British Broadcasting Company and the National Geographic Society have assisted by filming and publicizing the plight of endangered forest birds. Several articles have appeared in popular nature magazines and local newspapers to tell the story of the endangered Hawaiian forest birds, including those on Kaua`i. Most recently, Audubon magazine featured the puaiohi recovery effort in an article in its February 1999 issue.

Ecological Studies. Dr. Carter Atkinson of the Biological Resources Discipline, U.S. Geological Survey, initiated forest bird disease studies on several of the main Hawaiian islands, including Kaua`i, focusing primarily on blood-borne diseases within the range of endangered Hawaiian forest birds. This research is aimed at understanding the significance of disease and confirming the long-held theory that diseases brought to Hawai`i by introduced exotic birds and the establishment of alien vectors of disease such as mosquitoes has had a major role in the decline and extinction of native birds in Hawai`i.

CONSERVATION STRATEGY

The primary strategy for the conservation of the Kaua`i creeper and to preclude the need for listing this species under the Endangered Species Act is protection and management of remaining forest above 1,200 meters (4,000 feet) in the Alaka`i Wilderness Preserve and surrounding State and private lands (Figure 21).

Habitat Protection. Prospects for conservation lie in maintaining and restoring forest habitat by developing, testing, and applying broad-scale habitat restoration measures, including:

- Minimizing populations of feral ungulates through a combination of hunting, fencing, snaring, and possibly development of lethal non-toxicant devices for use in areas inaccessible to hunters, or in areas closed to hunters;

- Controlling the encroachment of noxious weed plants and insects through tested bio-control, and where feasible, mechanical and chemical measures; and
- Continuing enforcement of State and Federal laws that protect against destructive human activities and developments.

Predator Control. Long-term protection of many Hawaiian forest birds, including the Kaua`i creeper, likely will require large-scale control of alien predators, particularly black rats and feral cats. Development of safe and effective toxicants and application methods for control of feral cats and introduced rodents in remote forested habitat is severely needed. Preventing the introduction of additional alien predators, especially the small Indian mongoose (*Herpestes auropunctatus*), which currently is found on other Hawaiian islands, is also important.

Captive Propagation and Reintroduction Programs. Development of captive breeding and release techniques for *Oreomystis* creepers, including the Kaua`i creeper, may be needed and should be pursued if funds are available.

Population Surveys and Monitoring. A primary need is an intensive demographic study of Kaua`i creeper to document key aspects of its life history, especially survival rate, causes of mortality, susceptibility to disease, recruitment rates, and causes of nest failure, in concert with management actions designed to mitigate key limiting factors. Continued monitoring of the status of forest bird populations and their habitats is needed to measure the effectiveness of management actions.

21. Bishop's `Ō`ō, *Moho bishopi*

DESCRIPTION and TAXONOMY

Bishop's `ō`ō. © from Rothschild (1893-1900). Courtesy Smithsonian Institution Libraries.

Bishop's `ō`ō, considered a "species of concern," was a large, 12-inch (31-centimeter) long, vociferous, long-tailed black forest bird with a yellow ear patch, undertail coverts, and axillary (under the wing) tufts. Bishop's `ō`ō was known with certainty only from Moloka`i, and was a member of the honeyeater family (*Meliphagidae*), originating in Australia and the South Pacific and not related to the Hawaiian honeycreepers. The genus *Moho* was endemic to the Hawaiian Islands. The Bishop's `ō`ō was last seen in 1904 (Munro 1944), though there were unconfirmed reports into the 1980s (Sabo 1982). Detailed descriptions of this species and its calls were provided by Perkins (1903) and Munro (1944).

LIFE HISTORY

Information on the life history of the Bishop's `ō`ō is very fragmentary and known only from the writings of early naturalists (Perkins 1903, Munro 1944). Apparently this species was primarily nectarivorous, preferring lobelia (*Lobelia* spp.) flowers, but it also fed on insects. Nothing is known of its nesting biology.

HABITAT DESCRIPTION

Munro (1944) reported Bishop's `ō`ō from forested areas with `ōhi`a (*Metrosideros polymorpha*) and lobeliads in the upper elevations of Moloka`i. Possible detections of `ō`ō on Maui were from montane rainforest of northeastern East Maui (Sabo 1982).

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, this species was recorded only from Moloka`i (see Figure 8 on page 2-29). Subfossil remains of *Moho* from Maui may be this species (James and Olson 1991). Black birds reported to be `ō`ō, and perhaps most likely this species, have been reported historically from `ōhi`a forests on Maui according to Banko (1980 to 1984) and most recently Sabo (1982), but these reports were never confirmed. The 1980 Hawaiian Forest Bird Survey failed to detect this species on Moloka`i or Maui (Scott *et al.* 1986), nor have subsequent searches and other field work turned up any (Reynolds and Snetsinger 2001). This species should most likely be considered extinct.

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for the early decline and loss of Bishop's `ō`ō are unknown, but presumably are the same as for other endangered forest birds on Moloka`i and Maui. Additionally, this species was hunted by early Hawaiians for its yellow plumes, and it is possible that unregulated feather collecting in the 1800s, when guns became available, contributed to the bird's demise.

CONSERVATION EFFORTS

No specific efforts to conserve this species have been initiated because no individuals are known to exist and the species is almost certainly extinct.

CONSERVATION STRATEGY

It is very unlikely that this species survives on either Moloka`i or Maui. However, the Rare Bird Discovery Protocol in Section III-D is provided in the event that the species should possibly persist.

III. RECOVERY

A. Recovery Goal and Objectives

The ultimate goal of this plan is to achieve the successful conservation and recovery of the 19 Hawaiian forest birds listed as endangered. Once recovery is achieved, the protections of the Endangered Species Act (Act) are no longer necessary and these species may be removed from the Federal List of Endangered and Threatened Wildlife and Plants (delisted). For the candidate species and species of concern, the goal is to address the threats to the species and arrest or reverse the declines in their populations such that the protections of the Act are not required and the need to list the species is precluded.

In order to reach these recovery goals, the primary objective of this plan is to specify how to restore and maintain each species to self-sustaining populations, while at the same time promoting natural demographic and evolutionary processes. Small populations are especially susceptible to extinction by chance demographic events, and species with a limited distribution are more susceptible to extinction due to catastrophes (e.g., hurricanes, fires, disease) and environmental stochasticity (e.g., periodic absence of an important food item).

For each taxon, the recovery objectives are to:

(1) Restore populations to levels that allow the taxon to persist despite demographic and environmental stochasticity and that are large enough to allow natural demographic and evolutionary processes to occur;
(2) Protect enough habitat to support these populations; and
(3) Identify and remove the threats responsible for its decline.

In addition, stabilization of the current population(s) is considered an interim recovery objective. Once stabilization has been accomplished, the focus should shift to the recovery of viable, self-sustaining populations. For species that are extremely rare (no individuals can be located), an implicit interim objective is to locate any remaining individuals and implement the Rare Bird Discovery Protocol (Section III-D).

B. Recovery Criteria

Recovery criteria common to all taxa covered by this recovery plan are listed below. More specific criteria have been developed for well-studied taxa based on their life histories, and for taxa with specific recovery needs. These recovery criteria are based on the threats that have caused the decline of Hawaiian forest birds, as discussed in the Introduction, and they include population stability and growth rates, habitat protection, and threat management. For those taxa for which sufficient information was available (O`ahu `elepaio, puaiohi, palila, Maui parrotbill, `akiapōlā`au, Hawai`i creeper, Hawai`i `ākepa, `ākohekohe, po`ouli, and `akikiki), we have developed species-specific recovery criteria, listed in Table 6. For species that have not been detected in 10 or more years, the general recovery criteria provided still pertain in the long-term; however, the immediate recovery need is to continue searching for them, following the Rare Bird Discovery Protocol (Section III-D), and to find nesting pairs if possible. These species include the kāma`o, `oloma`o, Kaua`i `ō`ō, `ō`ū , Kaua`i `akialoa, Kaua`i nukupu`u, Maui nukupu`u, O`ahu `alauahio, kākāwahie, and Maui `ākepa. Bishop's `ō`ō also falls into this category, although as the species is not yet listed, the recovery criteria do not technically apply. More specific recovery criteria will be developed for these taxa should the species be relocated and sufficient information becomes available to do so.

Forest bird surveys are conducted on only one of the main Hawaiian islands each year, because there are limited numbers of personnel trained to survey Hawaiian forest birds, and the time frame in which surveys can be conducted is limited to only a few months each year during the forest bird breeding season. The surveys rotate among Hawai`i, Maui, Moloka`i, O`ahu, and Kaua`i, but Hawai`i is divided in halves because of its larger size and thus takes 2 years to survey. Systematic surveys have been conducted only once on O`ahu, in 1991, though targeted surveys for the O`ahu `elepaio are conducted each year in portions of the island (VanderWerf *et al*. 2001). After 15 years, this survey schedule will thus produce four data points on each island, which is the minimum required to conduct a meaningful population trend analysis. We feel this amount of information will be adequate to determine if a species can be downlisted under recovery criterion 2, in conjunction with other downlisting criteria identified below. However, a greater number of data points are needed (seven data points, or censuses every 5 years over a 30-year period) to be able to determine population trends with the improved confidence necessary for delisting, in conjunction with other delisting criteria. Because populations may fluctuate in response to good or poor breeding years and environmental factors, we feel it is important to survey over a long enough time so that results are representative of long-term trends.

A taxon may be downlisted from endangered to threatened when all four of the following criteria are met, as well as any species-specific downlisting criteria listed in Table 6:

1. The species occurs in two or more viable populations or a viable metapopulation* (as described in Table 6; viable as defined in criterion 2) that represent the ecological, morphological, behavioral, and genetic diversity of the species.

2. Viability of the populations is demonstrated through either a) quantitative surveys that show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or b) demographic monitoring that shows each population or the metapopulation has an average growth rate (lambda, λ) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.

3. Sufficient habitat in recovery areas (described in Section III-C) is protected and managed to achieve Criteria 1 and 2 above.

4. The threats that were responsible for the decline of the species have been identified and controlled.

The 21 taxa of Hawaiian forest birds covered in this plan all face the same set of threats, including habitat loss and degradation, disease, predation, and natural stochastic events. However, the severity of these threats varies among species depending on their life history and current distribution. Moreover, these

* A metapopulation, as used here, is defined as a group of partially isolated populations belonging to the same species among which at least occasional exchange of individuals occurs.

factors interact in complex and dynamic ways that are only partly understood, and the degree to which each threat must be managed in order to recover each species is difficult to ascertain. For example, transmission and prevalence of avian diseases and abundance of alien predators vary from year to year and from site to site, causing fluctuations in the amount of management that would be needed to ameliorate these threats. If bird populations are stable in the long-term, despite periodic episodes of increased disease, predation, and other threats, then the species can be considered safe from extinction. Setting a recovery criterion of demographic persistence highlights the need for effective monitoring, and helps ensure that all threats have been adequately managed and any population increases are not transient.

A taxon may be delisted due to recovery when the downlisting criteria described above, as well as any species-specific criteria listed in Table 6 for species downlisting and delisting, have been satisfied for at least 30 consecutive years. To delist because of extinction will require additional information gathering, including sufficient survey effort in areas where the species was detected most recently and in other areas of the species' historical range, as described in individual species accounts. An analysis of historical information, search effort, and survey results will be conducted to determine the probability of the species' extinction, and based on this analysis the species could be considered for delisting because of extinction (see Section D, Rare Bird Search Protocol below for discussion on designation of species as "potentially extinct").

We set recovery criteria to serve as objective, measurable guidelines to assist us in determining when a listed species has recovered to the point that the protections of the Act are no longer necessary. However, the actual change in status (downlisting or delisting) requires a separate rulemaking process based upon an analysis of the same five factors considered in the listing of a species (see page 5-2). 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 a taxon is warranted as the outcome of a formal five factor analysis in a subsequent regulatory rulemaking. Achieving the prescribed criteria is an indication that the taxon no longer meets the definition of threatened or endangered under the Act, but this must be confirmed by a thorough analysis of the five factors.

Table 6. Additional species-specific recovery criteria for some of the Hawaiian forest birds, as discussed in Section III-B, Recovery Criteria. See individual species accounts for discussion of the recovery strategy and justification of recovery criteria.

Table 6. Additional Species-specific Recovery Criteria		
Listed Species	Downlisting Criteria	Delisting Criteria
O`ahu `elepaio	Existing core populations in Waikāne/Kahana, southern Ko`olau, central Ko`olau, southern Wai`anae, Schofield Barracks West Range, and Mākaha/Wai`anae Kai are viable, or function as viable metapopulations on both the windward and leeward sides of the Ko`olau and Wai`anae Mountains, and criteria 2 and 3 apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
Puaiohi	Total population of 1,000 adults in at least 5 subpopulations (Mōhihi, Kawaikōī, Koai`e, Halehaha/Halepā`ākai, and Halekua drainages) that constitute a single metapopulation, and criteria 2 and 3 apply over a 15-year period.	Same as downlisting, but with total population of 2,000 adults, and criteria 2 and 3 apply over a 30-year period.
Palila	Viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualālai or Mauna Loa, and criteria 2 and 3 apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
Maui parrotbill	Viable populations exist on Haleakalā and either West Maui or Moloka`i, and criteria 2 and 3 apply over a 15-year period.	Same for downlisting, and criteria 2 and 3 apply over a 30-year period.
`Akiapōlā`au	Viable populations or metapopulations exist in Hāmākua, Kūlani/Kīlauea/Keauhou, Ka`ū, south Kona, and māmane forest on Mauna Kea, and criteria 2 and 3 above apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.

Table 6. Additional Species-specific Recovery Criteria		
Listed Species	Downlisting Criteria	Delisting Criteria
Hawai`i creeper	Viable populations or metapopulations exist in Hāmākua, Kūlani/Kīlauea/Keauhou, Ka`ū, south Kona, and Pu`u Wa`awa`a/Hualālai, and criteria 2 and 3 above apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
Hawai`i `ākepa	Viable populations or metapopulations exist in Hāmākua, Kūlani/Kīlauea/Keauhou, Ka`ū, south Kona, and Pu`u Wa`awa`a/Hualālai, and criteria 2 and 3 above apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
`Ākohekohe	Viable populations exist on Haleakalā and either West Maui or Moloka`i, and criteria 2 and 3 apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
Po`ouli	Viable populations exist on Haleakalā and West Maui, and criteria 2 and 3 apply over a 15-year period.	Same as downlisting, and criteria 2 and 3 apply over a 30-year period.
Candidate Species	Guidelines to preclude listing; short-term goal	Long-term goal
`Akikiki	Total population of 6,000 birds throughout 75 percent of the area occupied from 1968 to 1973 (Sincock surveys, Sincock 1982), and criteria 2 and 3 apply over a 15-year period.	Total population of 10,000 birds throughout the entire area occupied from 1968 to 1973 (Sincock surveys, Sincock 1982), and criteria 2 and 3 apply over a 30-year period.

C. Recovery Areas

1. Guidelines for Establishing Recovery Area Boundaries

To better address the recovery needs of endangered Hawaiian forest birds, we established "recovery area" boundaries to emphasize where recovery efforts should be focused. We define "recovery area" as those areas of habitat that will allow for the long-term survival and recovery of endangered Hawaiian forest birds. The identification of recovery areas is based on a biological evaluation of habitat potentially important for the recovery of Hawaiian forest birds only, and conveys no legal obligation on the part of private landowners to manage their lands for forest bird recovery. The delineation of recovery areas should not be confused with "critical habitat," a formal designation that requires analysis of both biological and economic factors. Listing of most of the species in this plan, except the O`ahu `elepaio (listed in 2000) and Hawai`i creeper and po`ouli (listed in 1975), preceded the legal requirements of the Endangered Species Act of 1973 to consider the designation of critical habitat at time of listing, therefore critical habitat was not a consideration for these species. Of the birds in this plan, critical habitat has been designated for the O`ahu `elepaio (U.S. Fish and Wildlife Service 2001) and palila (U.S. Fish and Wildlife Service 1977). Implementation of the recovery actions identified in the Recovery Actions Narrative (Section IV) within the recovery areas identified on each island will address the threats to each species and allow for its stabilization, recovery, and ultimately, delisting.

The biological determination of recovery area boundaries was based on each species' ecology, conservation needs, current and former distribution, and the recovery criteria of protecting and establishing viable populations and metapopulations. Historical and subfossil records indicate that the distribution of many species was originally much larger than the area identified as recovery area for each species in this plan. The overall purpose of recovery areas is to guide efforts to stabilize and recover listed species. Recovery areas include lands that currently provide habitat for existing populations, lands that are currently unoccupied but contain suitable habitat to provide for expansion of existing populations and establishment of new populations, and, in cases where sufficient suitable habitat currently is not available for recovery, lands where habitat could be restored. In addition, recovery areas also include intervening areas that will facilitate dispersal of birds and gene flow among high elevation populations that are currently isolated, thereby increasing the effective population size and possibly creating a metapopulation. Lands within recovery area currently differ in suitability for forest bird recovery; some areas already contain high quality habitat and support core populations of endangered forest birds, whereas others may need intensive management and restoration before they can be considered suitable.

The foremost concern in determining recovery areas for the great majority of endangered Hawaiian forest birds is to provide areas that are free of introduced mosquitoes and disease. This habitat occurs primarily at upper elevations because the cooler temperatures at these elevations are less suitable for both the introduced mosquito vector and the malarial parasite (van Riper *et al.* 1986, LaPointe 2000). In addition, there is generally less habitat degradation and urbanization at these higher elevations. Recovery areas therefore focus on existing habitat and restorable habitat at high elevations, up to treeline on the higher islands (Maui and Hawai`i) and to the mountain summits on lower islands (Kaua`i, O`ahu, and Moloka`i). The lower elevational boundaries in most cases were chosen to include areas that provide a buffer from transmission of avian disease by mosquitoes, which can travel up to 3 kilometers (1.9 miles) and possibly farther depending on environmental conditions (D. LaPointe, U.S. Geological Survey, unpubl. data).

For species on some islands (Maui, Moloka`i, O`ahu), recovery areas occur in blocks that are separated by large gaps of unsuitable developed land, while on other islands (Hawai`i, Kaua`i) there is one contiguous block that contains a mosaic of different habitat types that vary in degree of suitability. Within this mosaic some areas may support permanent breeding populations, while others may be used only temporarily as dispersal corridors. On all main islands except Kaua`i, which has only a single mountain, it should be possible, in principle, to establish two or more disjunct viable populations. The establishment of more than one population will help incorporate existing variation, provide the opportunity for local adaptation to evolve, and spread the risk associated with catastrophes such as hurricanes and fires. In the event that the amount of recovery area possible on an isolated mountain does not support a viable population, translocation of individuals from a viable population, or other management techniques, can be used to create a managed metapopulation among different isolated mountains or blocks of habitat.

Within the identified recovery areas, every attempt should be made to manage for continuous habitat that matches the historical distribution and environmental conditions in which the life history characteristics of each species evolved, such as dispersal. High philopatry of juveniles is characteristic of all the endangered Hawaiian forest birds studied thus far, and these birds are not expected to cross wide habitat gaps. The maintenance or development of continuous habitat within recovery areas will facilitate dispersal and connectivity. Contiguous recovery area is also important for providing heterogeneity in forest structure that can shape local adaptation and genetic variability, and for permitting movements in response to seasonal variation in food resource availability. The density of birds is not expected to be uniform throughout the recovery area; source-sink dynamics, metapopulation dynamics, and seasonal movements in response to geographic variation in resources should be included where they naturally would exist.

The immediate recovery action needed for species that have not been detected in 10 or more years is to continue searching for them, following the Rare Bird Discovery Protocol (Section III-D), and to find nesting pairs if possible. These species include the kāma`o, `oloma`o, Kaua`i `ō`ō, `ō`ū , Kaua`i `akialoa, Kaua`i nukupu`u, Maui nukupu`u, O`ahu `alauahio, kākāwahie, Maui `ākepa, and Bishop's `ō`ō. With the exception of the `ō`ū on the island of Hawai`i, we have not identified separate recovery areas for species that have not been seen recently because areas that should be searched are included in the recovery area for other species. We have identified recovery area for the `ō`ū because it is most likely to occur in different parts of Hawai`i than other species on the Island. Maps of recovery areas and historical and current ranges for all 21 species covered by this plan are presented with the species accounts (Figures 6 – 11 and 13 – 21).

2. Hawai`i Recovery Areas

`Akiapōlā`au

- Recovery areas encompass all portions of the current and historical ranges that lie above the mosquito zone and within elevations that can be expected to support suitable forest habitat, including areas that currently contain forest and areas where forest could be restored (Figure 15, page 2-101). `Akiapōlā`au inhabit both koa/`ōhi`a (*Acacia koa*/*Metrosideros polymorpha*) forest and māmane (*Sophora chrysophylla*) forest. More than half of the recovery area is currently in a heavily degraded state and will need restoration. Recent observations of `akiapōlā`au using relatively young koa plantations on Kamehameha Schools land at Keauhou Ranch and at Hakalau Forest National Wildlife Refuge indicate that both old growth and second growth forest are suitable.

- Avian diseases transmitted by mosquitoes limit `akiapōlā`au distribution at low elevations in all forest areas. Because of differences in topography, wind patterns, and temperature, mosquitoes have differing elevational limits on different mountain slopes. Therefore, the lower limit of suitable habitat occurs at 910 meters (3,000 feet) on the eastern slope of Mauna Kea, 910 meters (3,000 feet) on the eastern and southeastern slopes of Mauna Loa, 1,210 meters (4,000 feet) on the western slopes of Mauna Loa, and 1,150 meters (3,800 feet) on the northern slope of Hualālai.

- The upper limit of recovery area is delineated by the highest elevation edge of the historical koa and māmane vegetation zones on all volcanoes.

<u>Hawai`i Creeper and Hawai`i `Ākepa</u>

- Recovery areas encompass all portions of the current and historical ranges of these species that lie above the mosquito zone and within elevations that can be expected to support suitable forest habitat, including areas that currently contain forest and areas where forest could be restored (Figure 16, page 2-112 and Figure 18, page 2-129). Both species are found in koa-`ōhi`a forest, but unlike the `akiapōlā`au they do not regularly inhabit māmane forest, such as that found at higher elevations on Mauna Kea. Hawai`i `ākepa are currently restricted to only a portion of their recovery area due to the limited availability of large diameter trees for nesting as well as other limiting factors.

- The lower limit of recovery area is determined by the distribution of mosquitoes, the same as for the `akiapōlā`au.

- The upper limit of recovery area is delineated by the highest elevation edge of koa and `ōhi`a vegetation zones on all volcanoes.

Palila

- The palila is an extreme food specialist, preferring unhardened māmane (*Sophora chrysophylla*) seeds in green pods or in pods that are just beginning to turn brown. Palila are dependent on māmane and māmane/naio (*Myoporum sandwicense*) forest for all their needs.

- The elevational range of māmane forest is the most important variable of response of palila to available habitat. A wide belt of māmane forest results in more consistent availability of seeds within the range of daily movements typically made by palila, especially during the breeding season. Remaining large areas of māmane and māmane-naio forest that meet the biological requirements of palila or that are restorable occur at elevations above 1,360 meters (4,500 feet) on Mauna Kea and the western slope of Mauna Loa.

- The current population of palila is concentrated on the southwestern slope of Mauna Kea. Additional habitat is needed to reestablish populations or a metapopulation in portions of the historical range on the northern, eastern, or southern slope of Mauna Kea, and on Mauna Loa, as described in the recovery criteria. Management and restoration of māmane forest may be necessary at some sites before they are suitable for palila establishment.

- The upper limit of recovery area is delineated by the highest elevation edge of the historical māmane and māmane-naio forest on Mauna Kea and the upper limit of historical māmane and māmane-naio forest on the western slope of Mauna Loa.

3. Maui Nui Recovery Areas

Maui Parrotbill and `Ākohekohe

- Currently there is only one population each of Maui parrotbill and `ākohekohe, both on the windward side of Haleakalā volcano on east Maui (Figure 13, page 2-80 and Figure 19, page 2-141). Suitable habitat is needed in other areas to achieve at least two populations or a metapopulation of each species on Maui Nui (Maui, Moloka`i, Lāna`i, and Kaho`olawe). Parrotbills and `ākohekohe are known to have occurred on Moloka`i, but not on Lāna`i or

Kaho`olawe.  West Maui and Moloka`i currently contain intact native forest that appears suitable for both species, except for the presence of mosquitoes and avian diseases. Forest habitat on Lāna`i and Kaho`olawe is much more degraded, occurs at lower elevations, and would require a great deal more restoration than forest on West Maui or Moloka`i.  It is possible that Lāna`i and Kaho`olawe may again provide suitable habitat for forest birds, possibly including parrotbills and `ākohekohe, but no recovery areas for these species have been identified on those islands because other areas currently provide more cost effective recovery potential.

- Haleakalā population: Haleakalā currently supports a population of approximately 3,800 `ākohekohe that occupy about 58 square kilometers (22 square miles) from 1,100 to 2,300 meters (3,600 to 7,550 feet) elevation, and a population of approximately 500 Maui parrotbills that occupy about 50 square kilometers (19 square miles) from 1,200 to 2,350 meters (4,000 to 7,700 feet) elevation. For each species these areas represent less than 5 percent of the estimated historical ranges on Maui (Scott *et al*. 1986). Both species appear to occupy almost all habitat that is currently suitable, given disease constraints at lower elevations and boundaries of native vegetation. Population increases could be achieved by increasing the amount of suitable habitat or possibly by enhancing habitat quality and increasing carrying capacity. The potential for increasing carrying capacity is poorly known, however, and to ensure the potential for population increase, additional suitable habitat must be restored from 1,210 to 2,120 meters (4,000 to 7,000 feet) on the leeward slopes and from 1,515 to 2,120 meters (5,000 to 7,000 feet) on the western slopes. A lower elevational limit of 750 meters (2,500 feet) on windward Haleakalā encompasses nonbreeding habitat for some birds following seasonal flowering downslope.

- West Maui population: The recovery area indicated in Figure 13, from 750 meters (2,500 feet) to the summit of Pu`u Kukui at 1,765 meters (5,788 feet), encompasses all remaining forest habitat on West Maui currently suitable for forest bird habitation.  Most of this area is already managed for conservation, and vegetation condition in some areas is virtually pristine.  Populations of parrotbill and `ākohekohe situated here would provide second geographically disjunct populations for each of these species. Only a small area is high enough to provide disease- and vector-free habitat, but management actions such as strategic fencing to exclude feral pigs might reduce mosquito breeding habitat and disease transmission.

- Moloka`i population: The recovery area indicated in Figure 19, from 750 meters (2,500 feet) to the summits of Oluku`i at 1,403 meters (4,602 feet) and Kamakou at 1,515 meters (4,970 feet), encompasses all remaining forest habitat on Moloka`i currently suitable for forest bird habitation. The upper elevations are managed for conservation, and habitat conditions and disease implications are similar to West Maui.

<u>Po`ouli</u>

- No po`ouli are currently known to exist in the wild. As the habitat requirements for the po`ouli are poorly understood, it must be assumed that habitat needs of this species are similar to those of the Maui parrotbill, with which it is sympatric and often associates, and that recovery needs of the po`ouli will be met by the recovery area identified for Maui parrotbill (Figure 13, page 2-80). Fossil evidence suggests the original range of the po`ouli probably encompassed the full range of forest habitats on the windward, leeward, and western slopes of East Maui. To allow for recovery of a population on Haleakalā, additional habitat must be restored on the leeward slopes from 1,210 to 2,120 meters (4,000 to 7,000 feet) and from 1,515 to 2,120 meters (5,000 to 7,000 feet) on the western slopes.

- To accomplish the goal of a second population it will be necessary to establish po`ouli in some part of Maui Nui other than Haleakalā. West Maui is the most appropriate area because po`ouli are not known to have inhabited Moloka`i or Lāna`i (Olson and James 1991). If it is not possible to establish a population on West Maui, then Moloka`i could be considered as an alternative, but at this time West Maui is given higher priority because it is within the known range of the species. The indicated area on West Maui in Figure 13, from 750 meters (2,500 feet) to the summit of Pu`u Kukui at 1,765 meters (5,788 feet), encompasses all remaining forest habitat sufficient for forest bird habitation on West Maui. This area is already managed for conservation, and vegetation condition in some areas is virtually pristine. Only a small area is high enough to provide disease- and vector-free habitat, but management actions such as strategic fencing to exclude feral pigs might reduce mosquito breeding habitat and disease transmission.

4. Lāna`i and Kaho`olawe

Currently there is no forest bird recovery area identified on Lāna`i or Kaho`olawe. These islands once supported a variety of forest birds, including a now-extinct endemic species in the case of Lāna`i, the Lāna`i hookbill (*Dysmorodrepanis munroi*; James *et al.* 1989), but they are now highly disturbed, contain little (Lāna`i) or no (Kaho`olawe) forest, and are too low in elevation to provide disease free habitat. Efforts are underway to restore native ecosystems on both islands (Kaho`olawe Island Reserve Commission 2004), and it is possible that they may be suitable for reintroduction of forest birds at some point in the future. Their status should be reassessed in future revisions of this plan.

5. O`ahu Recovery Areas

O`ahu `Elepaio

- Recovery areas include all areas that are currently occupied by the O`ahu `elepaio, excluding one very small, isolated area near Hau`ula that contains only a single male (Figure 6, page 2-7).

- Currently unoccupied lands were added to provide for range expansion, dispersal corridors, and recovery of viable populations or metapopulations. Lands were considered to have greater recovery value and were included first if they: (a) provided forest types more preferred by `elepaio, (b) were more recently occupied, or (c) were contiguous, formed large blocks of suitable habitat, and helped link existing populations.

- Boundaries of recovery areas were determined by the extent of suitable forest, which in many areas coincided with the boundaries of State Forest Reserves, Natural Area Reserves, and other conservation lands. Urban and agricultural lands generally were not included because they did not contain suitable forest, but lower Wailupe Valley, which is zoned for urban use but has not been developed yet, was included because it contains suitable forest and is currently occupied by O`ahu `elepaio.

- Although disease is a serious threat to the O`ahu `elepaio, it was not considered in delineating recovery areas because no parts of the island are high enough to provide refuge from mosquitoes and all areas are subject to disease (VanderWerf *et al*. 2006).

6. Kaua`i Recovery Areas

Puaiohi

- Puaiohi currently have a more restricted distribution than the `akikiki because they are found only in areas with deeply eroded, rocky stream beds that provide nest sites on cliff ledges that are relatively safe from alien predators. Puaiohi currently exist at a density of about 16 birds per square kilometer (42 birds per square mile) in the core of their range that contains the best remaining habitat (Snetsinger *et al.* in prep.). However, it may be possible to increase the distribution and abundance of puaiohi by improving habitat quality through the use of predator-resistant artificial nesting structures. Surrounding lowland areas are too degraded to consider as possible habitat and would require development of methods for dealing with avian disease. The small amount of forest habitat at high elevations outside the Alaka`i/Koke`e region may make it difficult to establish a second population that is functionally isolated. Recovery area for the puaiohi (Figure 9, page 2-36) includes:

    - All the high elevation montane wet forest remaining in the Alaka`i/Kōke`e region above 900 to 1,060 meters (3,000 to 3,500 feet), that contains suitable stream beds with suitable nest sites;

    - Montane wet and mesic forest and scrub on Lā`au Ridge and Nāmolokama Peak, based on historical distribution of the species in these areas documented by John Sincock (Sincock 1982). However, Lā`au and Nāmolokama are isolated habitat areas that may be too small to sustain viable populations separate from the main population in the Alaka`i; and

- All of the Alaka`i Wilderness Preserve, portions of Kōke`e State Park, and private lands to the south deemed recoverable.

`Akikiki

- `Akikiki recovery will require protecting and managing as much of the remaining forest habitat on Kaua`i as possible, as well as restoring forest habitat in additional areas to allow range expansion. It may also be possible to increase population density in some areas by improving habitat quality, though there is limited information available about habitat needs in this species. As with the puaiohi, the small amount of forest habitat at high elevations outside the Alaka`i/Koke`e region may make it difficult to establish a second population that is functionally isolated. Recovery areas for the `akikiki (Figure 21, page 2-159) include:

    - All the high elevation montane wet forest remaining in the Alaka`i/Kōke`e region above 900 to 1,060 meters (3,000 to 3,500 feet), except steep unforested cliffs;

    - Montane wet and mesic forest and scrub on Lā`au Ridge and Nāmolokama Peak, based on historical distribution of the species in these areas documented by John Sincock (Sincock 1982). However, Lā`au and Nāmolokama are isolated habitat areas that may be too small to sustain viable populations separate from the main population in the Alaka`i; and

    - All of the Alaka`i Wilderness Preserve, portions of Kōke`e State Park, and private lands to the south and northeast deemed to be recoverable.

Other Endangered Kaua`i Forest Birds

There have been no confirmed sightings of the Kaua`i `akialoa, Kaua`i nukupu`u, Kaua`i `ō`ō, kāma`o, and `ō`ū for several years, but it is possible that some of these species still exist. All recent observations of these species occurred within the boundaries of the recovery area identified for the puaiohi, so for the purposes of this recovery plan, their recovery areas are included within that of the puaiohi. However, historical data suggest that some of these species (e.g., nukupu`u) were originally more widespread than puaiohi, existing in lower-elevation koa (*Acacia koa*) forests. Presumably the Alaka`i was a last refuge from disease for these species, but it may not necessarily provide the preferred or optimal habitat.

D. Rare Bird Discovery Protocol

1. Background and Justification

While numerous surveys of forest birds have taken place since 1976, the majority of these surveys have focused on determining the relative abundance of species and have not targeted individual species or populations. With the status and life history characteristics of many critically endangered species unknown, there is an urgent need to collect information before management strategies can be developed and implemented. Moreover, given the magnitude of the threats to Hawaiian forest birds, immediate management measures should be undertaken whenever possible. In October 1993, personnel of the U.S. Fish and Wildlife Service formed a field team (the Hawai`i Rare Bird Search Team), to determine the status of rare forest birds in the Hawaiian Islands. The objectives of this project (excerpted from Draft Memorandum, U.S. Fish and Wildlife Service, October 17, 1993) were to: (1) systematically search areas of forest habitat on all of the main Hawaiian Islands in an attempt to locate critically endangered forest bird species; (2) assist with field surveys and more detailed ecological surveys in areas where any of the extremely rare birds might be found; (3) coordinate, via the project leader, annual systematic Statewide surveys of Hawaiian forest bird populations; and (4) investigate sightings of rare bird species by other observers, and conduct follow-up surveys if deemed necessary.

These objectives helped to guide the activities of the Hawaiian Rare Bird Search Team through 1996. The purpose in developing the following protocol is to add additional objectives and establish guidelines in the event of a future rediscovery of a species that is extremely rare or possibly extinct. These additional objectives are to: (5) maximize data collection efforts; (6) facilitate communication and decisions between collaborating individuals, agencies, and species working groups; and (7) provide the information necessary to formulate the most effective and successful conservation management strategies for the target species.

2. Target Species

The species for which these protocols may pertain, generally those numbering fewer than 50 individuals and/or that have not been seen for 10 years or longer, include:

kāma`o (large Kaua`i thrush)	*Myadestes myadestinus*
oloma`o (Moloka`i thrush)	*Myadestes lanaiensis rutha*
Kaua`i `ō`ō	*Moho braccatus*
Bishop's `ō`ō	*Moho bishopi*
`ō`ū	*Psittirostra psittacea*
Kaua`i `akialoa	*Hemignathus procerus*
Kaua`i nukupu`u	*Hemignathus lucidus hanapepe*
Maui nukupu`u	*Hemignathus lucidus affinis*
O`ahu `alauahio (O`ahu creeper)	*Paroreomyza maculata*
kākāwahie (Moloka`i creeper)	*Paroreomyza flammea*
Maui `ākepa	*Loxops coccineus ochraceus*
po`ouli	*Melamprosops phaeosoma*

3. Protocol

The following outline shows the steps, the order to be followed, and the agencies, teams, working groups, and cooperators responsible for each step.

i. Identify and prioritize target species (Hawaiian Forest Bird Recovery Team, Captive Propagation Working Group).

   Determination of species priority and status, including categorization as "possibly extinct" or "extinct," should be made only after thorough analysis of the number of years since the species was last observed, the rate and causes of decline, condition of preferred habitat, accessibility of habitat, natural history characteristics, frequency and thoroughness of previous searches, and the joint recommendations of the participating biologists of the U.S. Fish and Wildlife Service, Hawai`i Division of Forestry and

Wildlife, U.S. Geological Survey, National Park Service, and Hawaiian Forest Bird Recovery Team.

ii. Search, find, and study target species (U.S. Fish and Wildlife Service, Hawai`i Division of Forestry and Wildlife, U.S. Geological Survey, private birdwatchers*).

Once a target species is located, an intensive search of the surrounding vicinity should be made to study the target species and determine:

a) Number of individuals, and, if possible, sex and age of each.

b) Immediate threat(s) to the population (e.g., predators, disease, human disturbance, habitat loss, hurricane and other weather-related risks, avian competitors, pesticides, etc.).

c) Reproductive status (e.g., observations/descriptions of nests, photos of nests when possible, copulation, courtship, carrying of nesting material or insects, vocalizations, etc.).

d) Foraging activities (e.g., identification and quantification of food, and collection of samples for nutrient analyses).

e) Inter- and intra-specific behavioral interactions.

iii. Evaluate all possible management strategies (Hawaiian Forest Bird Recovery Team, Captive Propagation Working Group, U.S. Fish and Wildlife Service, Hawai`i Division of Forestry and Wildlife, U.S. Geological Survey, and National Park Service).

After the target species has been initially observed and its situation documented, the U.S. Fish and Wildlife Service and/or Hawai`i

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* Private citizens who sight any of these rare birds are requested to report their observations immediately to either the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service, or to the Hawai`i Division of Forestry and Wildlife.

Division of Forestry and Wildlife, in consultation with the Hawaiian Forest Bird Recovery Team and Captive Propagation Working Group, will consider some or all of the following procedures and management actions:

a) Mist-netting and banding of individuals with U.S. Fish and Wildlife Service metal bands and unique combination of color bands to facilitate monitoring.

b) Collecting feather and/or blood samples for genetics, sexing, and veterinary evaluation.

c) Attachment of transmitters on some or all individuals to allow tracking of movements.

d) Implementation of control measures for potential threats (e.g., fencing, trapping, poisoning, shooting, public education, etc.).

e) Implementation of measures that may enhance reproductive success in the wild (e.g., providing supplementary food stations, artificial nests and nesting material, and field aviaries).

f) Translocation, in situations where birds of the opposite sex exist but are not paired.

g) Removal from the wild of individuals and nestlings and/or eggs for transfer to one of the captive propagation facilities for propagation and/or hand-rearing for release. These actions will be coordinated with the managers of the captive propagation facilities. Timely and practical issues such as cage space, available labor, and transfer logistics, will require discussion before each proposed action. Avicultural options including egg/nest manipulation, and captive propagation will be evaluated based on current levels of expertise. Subsequent release options will be dependent on available habitat, levels of habitat management (i.e., continuous funding and implementation), and current levels of expertise.

h) Cryopreservation. If removal from the wild of individuals is attempted, and mortality occurs during capture, transport, or later when the animal is in captivity, appropriate techniques should be used to cryopreserve gonads and ovaries for possible transplantation in hosts and to cryopreserve other body tissues for cloning and post-mortem methods to propagate the species.

iv. Initiate intervention if necessary (U.S. Fish and Wildlife Service, Hawai`i Division of Forestry and Wildlife, Captive Propagation Working Group, U.S. Geological Survey, National Park Service).

Each management strategy selected will require participation by various combinations of agencies, personnel and/or facilities managers. Each step will require population specific protocols, which should be developed by all entities involved prior to the time of need.

If invasive procedures are undertaken, their effectiveness will be evaluated and a summary report will be written and circulated by the responsible participants. This report will critically evaluate each procedure and its relative impact on the species in question. At that time a preliminary long-range plan with specific goals and objectives should be developed for species restoration.

If it is determined that a technique is not effective, or is potentially too hazardous to the survival of the individual or population in relation to the recovery of the species in question, it will be suspended. If an approach is determined to be beneficial or cannot yet be evaluated, it may be continued after consultation.

IV. RECOVERY ACTIONS

The recovery program for the Hawaiian forest birds is organized into six broad categories of recovery actions:

1) **Protect Ecosystems for Recovery of Endangered Forest Birds**, which includes recommendations for new partnerships, private and Federal conservation agreements on private lands, and land use and management goals;

2) **Manage Forest Ecosystems for the Benefit and Recovery of Endangered Forest Birds**, which includes recommendations for reforestation of recovery areas, reducing or eliminating the detrimental effects of alien plants, feral ungulates, and introduced predators, and ways to decrease the threat of avian disease;

3) **Develop Captive Propagation and Related Recovery Strategies**, which describes techniques and priorities for the captive propagation and release of Hawaiian forest birds into the wild;

4) **Conduct Research as Needed**, which describes general categories of research needed to better evaluate threats to Hawaiian forest birds and to develop and evaluate management strategies to address those threats;

5) **Monitor Changes in the Distribution and Abundance of Forest Birds**, which describes systematic surveys to monitor changes in the distribution and abundance of forest birds, to help evaluate the effects of management actions, and to provide necessary information for developing measures of population stability for future listing actions; and

6) **Public Awareness and Information**, which describes important outreach and information activities.

The general recovery action categories above are not assigned priority numbers for implementation, but each specific recovery action was assigned an implementation priority number (see below; also Table 19, Implementation Schedule). Tables in the recovery action narrative are organized by island and land parcel, and show priority numbers to help landowners identify management needs for their lands and the relative importance of each action for recovery of forest birds. The detailed Recovery Action Narrative below is preceded by a Step-down Outline, showing only the most general recovery action categories.

Definition of Recovery Action Priorities:

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

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

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

A. Step-down Outline of Recovery Actions

1. Protect Ecosystems for Recovery of Endangered Forest Birds.

    1.1 Describe and delineate recovery areas.

    1.2 Continue existing partnerships and develop new partnerships.

    1.3 Secure recovery areas through conservation easements, partnership agreements, safe harbor agreements, changes in land use designation, leases, or purchase from willing sellers.

    1.4 Provide private landowners with financial and regulatory incentives to restore and manage suitable habitat for native forest birds.

2. Manage Forest Ecosystems for the Benefit and Recovery of Endangered Forest Birds.

2.1 Reforest recovery areas that no longer contain the necessary constituent elements for species recovery.

2.2 Reduce or eliminate the detrimental effects of ungulates on vegetation within forest ecosystems.

2.3 Reduce or eliminate the detrimental effects of alien plants within forest ecosystems, through mechanical, chemical, or biological means, as appropriate.

2.4 Reduce or eliminate the detrimental effects of alien mammalian predators (rats, mice, feral cats, mongooses) on forest birds.

2.5 Decrease the threat of avian disease.

2.5.1 Prevent introduction of new diseases and disease vectors into Hawai`i.

2.5.2 Prevent movement of diseases and disease vectors between islands.

2.5.3 Control the mosquito vector (*Culex quinquefasciatus*) of avian pox and malaria.

2.5.4 Foster ability of native birds to tolerate or develop resistance to avian pox and malaria.

2.5.5 Monitor long-term changes in the prevalence and transmission of avian diseases in recovery forest bird habitats.

2.6 Reduce or eliminate effects of other alien species.

2.6.1 Prevent introductions of new detrimental species.

2.6.2 Eradicate all incipient populations of new nonnative vertebrate species.

2.6.3 Reduce or eliminate the detrimental effects of *vespulid* wasps (yellow jackets) on forest birds within forest ecosystems.

3. Develop Captive Propagation and Related Recovery Strategies.

3.1 Periodically evaluate and identify the target species that will require captive propagation for recovery and the appropriate strategy to be used.

3.2 Develop captive propagation programs for target species, including both endangered and surrogate species.

3.3 Develop methods of evaluating, selecting, and preparing sites for releases and/or translocation of endangered birds to ensure long-term persistence of reintroduced populations.

3.4 Acquire funding to build additional facilities to maintain, propagate, incubate, and rear endangered species and, if necessary, surrogate species.

3.5 Identify wild populations and/or individuals with potential natural disease resistance on a species-by-species basis.

3.6 Develop and refine techniques for the release of captive-reared birds into managed habitat.

3.7 For each of the species identified as candidates for captive propagation, establish demographic goals for captive propagation programs, e.g., how many birds to produce using which demographic strategy over what period of time and released into how many sites.

3.8 Develop species-specific reintroduction guidelines based on risk assessments that consider the behavioral, disease, demographic and genetic needs of the species, with the ultimate goal being the re-establishment of wild populations.

3.9 Provide biological samples from captive-held birds to an approved holding location or locations determined on a species-by-species basis for use in genetic and/or veterinary examination.

3.10 If egg collections fail, develop methods of bringing nestling birds, juveniles, and/or adults into captivity with concomitant quarantine procedures.

3.11 Establish a cryogenic cell culture of germplasm of the endangered Hawaiian avifauna at two partner institutions willing to hold the cell line in perpetuity.

3.12 Evaluate the outplacement of endangered species currently at the Keauhou Bird Conservation Center and Maui Conservation Center to the Honolulu Zoo or other qualified institutions.

4. Conduct Research as Needed.

4.1 Identify the threats that cause geographical variation in density and that maintain populations at or below carrying capacity within particular locations.

4.2 Study the magnitude of threats and, if appropriate, develop and evaluate effective methods for control.

4.3 Evaluate the effectiveness of threat management actions.

4.4 Determine safety of threat management to non-target species.

4.5 Investigate role of natural selection in dealing with threats.

4.6 Conduct research that may lead to new tools for managing forest birds or their habitat, or to identification of emerging or unrecognized threats.

4.7 Special research considerations for translocations and reintroduction programs.

4.7.1 Evaluate effectiveness of translocations of both disease survivors and disease resistant forest birds for restoration of populations in areas with active disease transmission.

4.7.2 Determine optimal parameters for translocation and reintroduction efforts.

4.7.3 Evaluate the relative costs of habitat suitability analysis versus experimental translocation or reintroduction.

4.8 Special research considerations for disease and parasitism.

4.8.1 Determine the effects of land use changes on disease transmission.

4.8.2 Determine the effects of long-term climate change on disease transmission.

4.8.3 Conduct research on the feasibility of vaccines for avian pox and malaria, methods for their delivery, and possible effects on host-parasite coevolutionary adaptations.

4.8.4 Conduct research on genetic variability, virulence, and interactions between avian pox virus and malarial parasites and how these variants interact with susceptible and resistant host genotypes.

4.8.5 Determine dispersal distances of adult mosquitoes from point sources outside of recovery area.

4.8.6 Determine the feasibility of decreasing malarial transmission through genetic manipulation of vector populations.

4.8.7 Determine the role that ectoparasites such as ticks and lice play in transmission of avian pox, particularly during the nesting cycle when adults may pass infections to offspring.

4.8.8 Determine the role that endoparasites such as *Coccidea* play in demography of birds.

4.8.9 Monitor long-term changes in the prevalence and transmission of avian diseases in forest bird recovery areas.

4.9 Special research considerations for monitoring.

4.10 Research needs and priorities by species.

5. Monitor Changes in the Distribution and Abundance of Forest Birds.

5.1 Systematically survey all forest bird habitat on Kaua`i, O`ahu, Moloka`i, Lāna`i, Maui, and Hawai`i at least once every 5 years to determine changes in distribution and population size of all native and nonnative forest birds.

5.2 Conduct systematic annual surveys of selected forest areas to more carefully monitor changes in distribution and population size and efficacy of management actions.

5.3 Establish and support an interagency Forest Bird Monitoring Coordinator position to coordinate monitoring and provide regular reports on the status and trend of forest bird populations.

6. Public Awareness and Information.

6.1 Build alliances with the public through outdoor experience with native forest birds and their forest habitats.

6.1.1 Promote and support public native species awareness and environmental education through increased visitor access on trails with interpretive and educational displays.

6.1.2 Promote increased access and interpretation programs on Federal, State, County, and private refuges, parks, preserves, and other lands where native species are found.

6.1.3 Expand visitor awareness with development of visitor centers, displays, facilities, and public interpretive programs.

6.1.4 Promote the opening of State Forest Reserve trails to the general public for nature walks and birding on all islands.

6.1.5 Support the Nā Ala Hele Trail System.

6.2 Fund, support, and promote programs that inform teachers and educate children, lawmakers, the local public, and visitors.

6.2.1 Fund and support teacher education programs that promote native species issues.

6.2.2 Support and fund programs that educate children about Hawai`i's natural environments and that inform the public through non-traditional partnerships.

6.2.3 Create a clearinghouse, such as a website or "hotline," for information and educational materials about Hawai`i's native species.

6.2.4 Provide information and promote awareness of the harmful effects of some alien species to public health, native species, and native ecosystems.

6.3 Use a professional marketing agency and business marketing techniques (television, radio, internet, newspapers, advertising, and magazines) to promote awareness of the uniqueness of Hawai`i's native species and gain local support for endangered species and related conservation issues.

6.3.1 Conduct market research on the public's knowledge of native species and attitudes towards conservation in order to provide information on the most direct ways to inform the public and gain support for native species.

6.3.2 Promote and fund the development of public service announcements for television and radio about native species and their habitat.

6.3.3 Promote private business use of native species likenesses, images, and names on old and new products and use them in advertising and logos.

6.3.4 Promote fundraisers and solicit corporate funding and promotion to expand the economic base for public awareness and information campaigns.

6.4 Promote the creation of and support "Friends" groups, partnerships, environmental outreach programs, and other groups to provide support for parks, refuges, reserves, and natural areas to cultivate understanding and conservation of Hawai`i's natural and cultural resources.

6.4.1. Recruit, train, and support volunteer community leaders to organize native species outreach and awareness programs at the community level.

6.4.2. Develop and support partnership and outreach programs with other conservation agencies, native Hawaiian groups, hunter groups, and private landowners.

B. Recovery Actions Narrative

1. Protect Ecosystems for Recovery of Endangered Forest Birds.

1.1 Describe and delineate recovery areas. (Priority 1)
Recovery area maps have been created for each island and for species with known current distributions (Figures 6, 9, 11, 13, 15, 16, 18, 19, and 21; see also Section III-C, Recovery Areas).

1.2 Continue existing partnerships and develop new partnerships. (Priority 2)
Partnerships among local community groups, private individuals, non-governmental organizations, and State and Federal agencies contribute substantially to conservation efforts and community education. Existing partnerships should be continued, and expanded if appropriate, and new partnerships should be developed on islands where they currently do not exist. The goals and mission of each partnership are described below:

1.2.1 \`Ōla\`a/Kīlauea Partnership. The \`Ōla\`a/Kīlauea Partnership is a cooperative land management effort for approximately 24,240 hectares (60,000 acres) on the island of Hawai\`i. This joint management program offers an exceptional opportunity to preserve a large, functioning native ecosystem and the endangered species that depend on it for survival. It can also serve as a model for future biological resource conservation efforts.

1.2.2 Kahikinui Forest Partnership Working Group, Maui. The Working Group's mission/purpose is to revive Hawaiian Home Lands beneficiary involvement in management of the 3,030 hectare (7,500 acre) Kahikinui Forest Reserve, to protect the Kahikinui Forest Reserve from further deterioration, to begin the process of restoration of its native flora and fauna, and to integrate forest management with the Department of Hawaiian Home

Lands and the beneficiary community initiative to resettle the ahupua`a* of Kahikinui.

1.2.3 **The East Maui Watershed Partnership** is a voluntary effort between six public and private landowners and the County of Maui to jointly protect the 40,400-hectare (100,000-acre) core of critical watershed against ungulates, destructive weeds, insect pests, and other threats. The long-range goal is to stop ungulate damage in native forests and other upland areas and to limit ungulate damage in lowland forests to levels that prevent loss of forest cover, utilizing increased public hunting, and fencing in the strategy.

1.2.4 **The Leeward Haleakalā Watershed Restoration Partnership** began in June 2003 as a voluntary effort among 11 private and public landowners and managers to restore healthy and sustainable koa (*Acacia koa*) forests on the leeward side of Haleakalā from `Ulupalakua to Kaupō above 1,067 meters (3,500 feet) elevation, encompassing 17,473 hectares (43,175 acres). This area once supported some of the tallest and most extensive koa forests in the islands, but today only about 5 percent remain. Restoration of these forests will greatly enhance the watershed potential, provide for the long-term survival of many native plants and animals, and present possibilities for the renewable use of koa for canoes and woodworking.

1.2.5 **The West Maui Mountains Watershed Partnership** is a voluntary cooperative effort between eight public and private landowners of Kahalawai with a shared commitment to the long-term protection and preservation of the West Maui Mountains Watershed. The partners recognize that cooperation is the key to a timely and successful watershed management program to protect this

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* A section of land that extends from the mountain top to the ocean.

region from alien pest animals, weeds, inappropriate human activities, and other threats.

1.2.6 **The East Moloka`i Watershed Partnership** is a coalition of conservation interests, landowners, and County, State, and Federal government agencies bringing together economic and conservation interests to save, protect, and enhance water resources and native forest species and ecosystems. The East Moloka`i Watershed Partnership is based on community-wide planning and economic revitalization efforts under the U.S. Department of Agriculture Empowerment Zone Initiative, with a focus on watershed protection, sustainability, and Moloka`i's culture and traditions.

1.2.7 **Ko`olau Mountains Watershed Partnership, O`ahu.** The memorandum of understanding made among landowners in this partnership provides for accretive, cooperative management "to maintain a healthy forested watershed." The partners also agreed to jointly develop a management plan, but it is still in draft form. The overall goals of the partnership are generally consistent with and favorable toward the recovery of forest birds, but the degree of current management varies substantially among landowners. Certain parcels of land that support important core populations of O`ahu `elepaio have been identified for additional, more specific measures to protect and manage forest habitat.

1.3 **Secure recovery areas through conservation easements, partnership agreements, safe harbor agreements, changes in land use designation, leases, or purchase from willing sellers.** Table 7 lists, by island, recovery areas requiring protection. Habitat management plans should be written for all protected areas, and protection could be implemented through conservation easements, partnerships, changes in land use designation, or, if necessary, land exchanges or purchase from willing sellers. Public

(Federal, State, and County) lands should be managed or restored to provide suitable habitat for native forest birds. Private lands should be managed through easements, partnerships, and safe harbor agreements whenever possible. Further incentives such as tax breaks and partnership financial rewards could be used to secure recovery areas and for reforestation programs (see Recovery Action 1.4) and reducing or eliminating the detrimental effects of ungulates on vegetation within forest ecosystems (see Recovery Action 2.2), in addition to planting assistance programs. Several watershed partnerships are in effect across the State, and the overall goals of these partnerships are generally consistent with and favorable to the recovery of forest birds, but the degree of current management varies substantially among landowners. Most land parcels contained in these partnerships are not included in Table 7, but a few parcels have been identified as possibly requiring additional protection because they support particularly important populations of forest birds or because there are concerns about the extent of current management. In Table 7, under Landowner/Comments, the most appropriate approach(es) to achieving land protection are listed. While private lands in many cases are best managed through partnerships or easements, parcels may be considered for purchase by private and public conservation organizations when owners are interested in selling and an organization is prepared to take on ownership and management. Because the course of such acquisitions varies greatly with each situation, this recovery plan can only prioritize parcels for their potential contribution to recovery area and state that, when the opportunity arises, purchase in each case should be weighed as an option for forest bird conservation.

Table 7. Parcels in recovery areas in need of protection or that should remain protected for forest bird recovery. The "Landowner/Comments" column includes suggested means of protection. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. Species Codes: AKEP = Hawai`i `ākepa; AKIP = `akiapōlā`au; AKOH = `ākohekohe; HCRE = Hawai`i creeper; KAAK = Kaua`i `akialoa; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nukupu`u; MAPA = Maui parrotbill; OAEL = O`ahu `elepaio; OO = Kaua`i `ō`ō; OU = `ō`ū; PALI = palila; POOU = po`ouli; PUAI = puaiohi. Refer to the Implementation Schedule, Key to Acronyms on page 5-7 for landowner and partnership abbreviations.

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.1	H	Northeastern Slopes of Mauna Kea, Portions of 344014002 344014003 343010002 343010008	AKIP PALI	Hawai`i DLNR. Currently leased for cattle grazing. By lease, conservation easement, change of jurisdiction, or change in land use designation to protective subzone of conservation.	2
1.3.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i DHHL. Provides vital link between mesic koa forest and dry māmane forest. By conservation easement, lease, or partnership. Remove grazing and enhance natural communities.	1
1.3.3	H	Hilo Forest Reserve, Laupāhoehoe Section, 337001004	AKIP HCRE AKEP OU	Hawai`i DOFAW. Currently the Laupāhoehoe Section of Hilo Forest Reserve Area. By change in land use designation to conservation protective subzone. Mid-elevation forest with native tree canopy vulnerable to destruction by continued sustained yield pig hunting.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.4	H	Hilo Forest Reserve, Pīhā Section, 333001004	AKIP HCRE AKEP OU	Hawai`i DOFAW. Important wet and mesic forest remnants. Currently the Pīhā Section of Hilo Forest Reserve, bounded on both sides by Hakalau Forest National Wildlife Refuge. By conservation easement or change in land use designation to protective subzone of conservation. Mid-elevation forest with intact native tree canopy vulnerable to destruction by sustained yield pig hunting.	2
1.3.5	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i DHHL, leased by DOFAW and currently under annual lease. A long-term lease should be negotiated.	2
1.3.6	H	Humu`ula, 338001002	AKIP HCRE AKEP PALI	Hawai`i DHHL. Restorable. A vital link between wet and dry forest communities. Former lease for cattle grazing recently terminated. By lease, conservation easement, cooperative agreement, or partnership.	1
1.3.7	H	Humu`ula, Portions of 338001007	AKEP AKIP HCRE PALI	Hawai`i DHHL. Leased to Parker Ranch for grazing. Restorable. A vital link between wet and dry forest communities. By lease, conservation easement, cooperative agreement, or partnership.	2
1.3.8	H	Luma`ia Section, 326018002	AKIP HCRE AKEP	Hawai`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Highest mesic forest remnant on the eastern slope of Mauna Kea. By lease, conservation easement, cooperative agreement, or partnership.	1

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.9	H	TMK 326018001	AKIP HCRE AKEP	Hawai`i DLNR, Land Division. Leased for cattle grazing. Important mesic and wet koa/`ōhi`a forest remnants, link between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.	1
1.3.10	H	Ka`ohe Lease, 344015002	AKIP PALI	Hawai`i DLNR, Land Division, currently leased for cattle grazing. A link could be restored between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.	1
1.3.11	H	Keauhou Ranch, 399001004	AKIP HCRE AKEP	Kamehameha Schools. Remnant mesic koa and `ōhi`a forest. By lease or conservation easement. Currently a member of the Ōla`a-Kīlauea Partnership.	2
1.3.12	H	Kapāpala Ranch, Portions of 398001010	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, Kapāpala Ranch. Currently leased for cattle grazing. Restorable. A link between forest to the east and west. By lease, conservation easement, or change in land use designation to conservation.	2
1.3.13	H	Ka`ū Forest Reserve, 397001007	AKIP HCRE AKEP	The Nature Conservancy of Hawaii. Protect wet forest habitat from development.	2
1.3.14	H	Ka`ū Forest Reserve, Portions of 397001006 397001005	AKIP HCRE AKEP	Kamehameha Schools. Protect wet forest habitat from development. By lease, conservation easement, partnership agreement, or purchase from willing seller.	2
1.3.15	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Recently purchased by Hawai`i Volcanoes National Park. Valuable wet and mesic forest habitat that links Ka`ū Forest and South Kona Forest. Restorable.	1

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.16	H	Honomalino, 389006004 389006029	AKIP HCRE AKEP	Scott C. Rolles Trust. Links Ka`ū Forest and South Kona Forest. By lease, conservation easement, partnership, change in land use designation, or purchase from willing seller.	2
1.3.17	H	Pāpā, 388001001	AKIP HCRE AKEP	The Nature Conservancy, Kona Hema Preserve. Recently sold by Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest.	2
1.3.18	H	Yee Hop Ranch, Portions of 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011 387001004	AKIP HCRE AKEP	Yee Hop Ranch Ltd. Provides links between state owned land parcels and protects contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	2
1.3.19	H	`Alae Ranch, Portions of 387001014	AKIP HCRE AKEP	Hawai`i DLNR, Land Division. Currently leased for cattle grazing. By conservation easement, lease, change of jurisdiction, or change in land use designation to conservation protective subzone.	3
1.3.20	H	McCandless Ranch, Portions of 392001003 386001001	AKIP HCRE AKEP	McCandless Ranch. Protect contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.21	H	Waiea Tract, 386001003	AKIP HCRE AKEP	Hawai`i DLNR. Land Division. Protect contiguous forest habitat in South Kona from continued degradation. Currently leased for cattle grazing. By conservation easement, lease, change of jurisdiction, or change in land use designation to conservation protective subzone.	2
1.3.22	H	Keālia Ranch, 385001001	AKIP HCRE AKEP	Kamehameha Schools. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	2
1.3.23	H	Hōnaunau Forest, 384001001 384001002 383001001 383001002	AKIP HCRE AKEP PALI	Kamehameha Schools. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	2
1.3.24	H	Keālia Ranch, Portions of 385001002	AKIP HCRE AKEP	Elizabeth Stack *et al.* Protect contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	2
1.3.25	H	Kealakekua Development Corp., Portions of 382001001	AKIP PALI	Protect contiguous forest habitat in South Kona from development, and provide habitat for a second palila population. Restorable. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	3

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.26	H	Pu`u Lehua, Portions of 378001003 378001007 372002001 378001001	AKIP PALI HCRE	Kamehameha Schools. Provides habitat for a second palila population. Restorable. By lease, conservation easement, partnership agreement, change in land use designation to conservation, or purchase from willing seller.	2
1.3.27	MA	Ko`olau Forest Reserve, 224016003 224016004 228008001 228008007	AKOH MAPA POOU	Alexander and Baldwin, East Maui Irrigation. Additional measures may be needed to ensure forest bird recovery. By partnership, safe harbor agreement, easement, change of land use designation to protective subzone of conservation, or purchase from willing seller.	1
1.3.28	MA	Kīpahulu Forest Reserve, Kukui`ula, 216001007	AKOH, MAPA, POOU	J. Haili. Small parcel at lower edge of recovery area. By partnership with LHWRP.	3
1.3.29	MA	Kīpahulu Forest Reserve, Kukui`ula, 216001006	AKOH MAPA POOU	Cleveland Kalalau. Small parcel at lower edge of recovery area. By partnership with LHWRP.	3
1.3.30	MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006 218001007	AKOH MAPA POOU	Hawai`i DOFAW. Isolated; secure access for management needed. By continuing partnership with LHWRP.	1
1.3.31	MA	Kīpahulu Forest Reserve, 217001032	AKOH MAPA POOU	A. Kaapana *et al.* Small parcel at lower edge of recovery area. By partnership with LHWRP.	3
1.3.32	MA	Kīpahulu Forest Reserve, 217001024	AKOH MAPA POOU	Kaupō Ranch Ltd. Small parcel at lower edge of recovery area. By partnership with LHWRP.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.33	MA	Nu`u, 218001001	AKOH MAPA POOU	Kaupō Ranch Ltd. Degraded former forest land in need of active management. By continuing partnership with LHWRP, safe harbor agreement, conservation easement, change of land use designation, or purchase from willing seller. Acquisition being negotiated by NPS.	3
1.3.34	MA	Nu`u, 218001002	AKOH MAPA POOU	James Campbell Est. Degraded former forest land in need of active management. By continuing partnership with LHWRP, safe harbor agreement, conservation easement, change of land use designation, or purchase from willing seller. Acquisition being negotiated by NPS.	3
1.3.35	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i DOFAW. Isolated; secure better access for management. Degraded former forest land in need of active management. By continuing partnership with LHWRP.	1
1.3.36	MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	AKOH MAPA POOU	Hawai`i DHHL. Degraded former forest land in active forest stewardship program with FWS. By continuing partnership with LHWRP.	1
1.3.37	MA	Upper Auwahi, 219001006 221009001 222001001 222001034	AKOH MAPA POOU	`Ulupalakua Ranch Inc. Pasture with ongoing restoration at selected sites in partnership with DOI and NHPS. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.38	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i DOFAW. By continuing partnership with LHWRP. Degraded forest dominated by alien species. Resolve conflicting management as game management area.	2
1.3.39	MA	Kēōkea, 222004033	AKOH MAPA POOU	James Campbell Est. Degraded former forest in need of active management. By partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.	2
1.3.40	MA	Waiohuli, 222005052	AKOH MAPA POOU	James Campbell Est. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.	2
1.3.41	MA	Ka`ono`ulu, 222007002 222006009 222006032 222007010	AKOH MAPA POOU	Ka`ono`ulu Ranch Co. Ltd. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, or purchase from willing seller.	2
1.3.42	MA	Waiakoa, 222008001	AKOH MAPA POOU	Lucky Shoji USA Inc. *et al.* Degraded former forest in need of active management. By partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.43	MA	Kamehame Nui/Kealahou, 223005002	AKOH MAPA POOU	John Zwaanstra. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.	2
1.3.44	MA	Haleakalā Ranch (Pūlehu Nui/ Kalialinui), 223005003	AKOH MAPA POOU	Haleakalā Ranch Co. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.	1
1.3.45	MA	Waikamoi Preserve, 223005004	AKOH MAPA POOU	Haleakalā Ranch Co. Under active management by The Nature Conservancy of Hawai`i through conservation easement. In EMWP and NAPS. Support continued management by TNCH, or by purchase from willing seller.	1
1.3.46	MA	West Maui Forest Reserve, Wailuku, 233003003 235003001 236003001	AKOH MAPA POOU	Wailuku Agriculture. In West Maui Watershed Partnership (WMWP). By conservation easement or purchase from willing seller.	2
1.3.47	MA	West Maui Forest Reserve, Launiupoko, 247001002	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.	2
1.3.48	MA	West Maui Forest Reserve, Kaua`ula, 246025001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.49	MA	West Maui Forest Reserve, Kahoma, 245022001	AKOH MAPA POOU	Kamehameha Schools. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.	2
1.3.50	MA	West Maui Forest Reserve, Pu`u Kī/Haakea, 245022002 245022004	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.	2
1.3.51	MA	Kapunakea Preserve, 244007001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Currently managed by TNCH through conservation easement. In WMWP and NAPS. By purchase from willing seller.	2
1.3.52	MA	West Maui Forest Reserve, Kapāloa, 244007007	AKOH MAPA POOU	Unknown. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.	2
1.3.53	MA	Pu`u Kukui Watershed Management Area, 242001001 241001017	AKOH MAPA POOU	Maui Land and Pineapple. In WMWP and NAPS. Support continued conservation management by Maui Land and Pine, or by purchase from willing seller.	2
1.3.54	MO	Moloka`i Forest Reserve, Kahanui, 252014001	AKOH MAPA POOU	R. W. Myer Ltd., *et al.* By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.55	MO	Moloka`i Forest Reserve, Pelekunu Valley, 259006011	AKOH MAPA POOU	The Nature Conservancy of Hawai`i. Support continued Management by TNCH.	2
1.3.56	MO	Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, 259008017	AKOH MAPA POOU	Wm. Hitchcock *et al.* By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.57	MO	Moloka`i Forest Reserve, Pelekunu Valley, 254003032	AKOH MAPA POOU	The Nature Conservancy of Hawai`i. Support continued Management by TNCH.	2
1.3.58	MO	Moloka`i Forest Reserve, Wailau Valley and Oloku`i, 259006004	AKOH MAPA POOU	G. Brown III *et al.* By easement, safe harbor agreement, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.59	MO	Moloka`i Forest Reserve, Laeokapuna, 257005027	AKOH MAPA POOU	P. Hodgins. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.60	MO	Moloka`i Forest Reserve, Keanakoholua, 257005001	AKOH MAPA POOU	M. Hustice Trust. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.61	MO	Moloka`i Forest Reserve, Manawai, 256006013	AKOH MAPA POOU	P. Petro Trust. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.62	MO	Moloka`i Forest Reserve, West `Ōhi`a Gulch, 256006010	AKOH MAPA POOU	E. Wond Trust. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.63	MO	Moloka`i Forest Reserve, Keawa Nui, 256006007	AKOH MAPA POOU	Kamehameha Schools. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.64	MO	Moloka`i Forest Reserve, Pua`ahala, 256006002	AKOH MAPA POOU	K&H Horizons Hawai`i. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.65	MO	Moloka`i Forest Reserve, Kumu`eli, 256006001	AKOH MAPA POOU	D. Fairbanks III Trust. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.66	MO	Moloka`i Forest Reserve, Kamalō, 255001016 255001006 255001017	AKOH, MAPA, POOU	Kamehameha Schools. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.67	MO	Moloka`i Forest Reserve, Mākolelau, 255001015	AKOH MAPA POOU	Ashton Pitts Jr. Trust. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.68	MO	Kamakou Preserve, Kawela, 2540003026	AKOH MAPA POOU	Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.69	MO	Moloka`i Forest Reserve, Kawela, 254003001 254003028	AKOH MAPA POOU	Kawela Plantation Homes Association. By easement or purchase from willing seller. In EMOWP.	2
1.3.70	MO	Moloka`i Forest Reserve, Kaunakakai, 253003005	AKOH MAPA POOU	Moloka`i Ranch Ltd. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.71	O	Pia Valley, 37003073 37003033	OAEL	Benjamin Cassiday, James Pflueger. Upper valley in KMWP, but additional measures may be needed to ensure protection of large `elepaio population. Lower valley zoned conservation, but no other protection. By enrollment in KMWP, easement, or purchase from willing seller.	1
1.3.72	O	Lower Wailupe Valley, 36004001	OAEL	City and County of Honolulu. Contains lower edge of large `elepaio population. Currently zoned urban. By enrollment in KMWP, easement, change in land use designation, or purchase from willing seller.	1
1.3.73	O	Kūpaua Valley, 37004001 37004002	OAEL	Hawai`i Humane Society. Upper valley in KMWP, but additional measures needed to ensure protection of large `elepaio population. By easement, safe harbor agreement, enrollment in KMWP, or purchase from willing seller.	1
1.3.74	O	Kuli`ou`ou Valley, 38013001	OAEL	Joseph Paiko Trust. Contains western half of small `elepaio population. By easement, safe harbor agreement, enrollment in KMWP, or purchase from willing seller.	1
1.3.75	O	Ka`alākei Valley, 39009001	OAEL	Hawai`i Kai Development Co. Contains small `elepaio population. By easement, safe harbor agreement, enrollment in KMWP, or purchase from willing seller.	2

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.76	O	Kapālama, 14015009	OAEL	Julius Chung Trust. Small parcel. By partnership in KMWP.	3
1.3.77	O	Moanalua Valley, 11013001	OAEL	Damon Estate. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, safe harbor agreement or purchase from willing seller.	1
1.3.78	O	South Hālawa Valley, Tripler Ridge, 99011001	OAEL	Queen's Medical Center. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, safe harbor agreement, or purchase from willing seller.	1
1.3.79	O	Waikāne Valley, 48014005	OAEL	SMF Enterprises. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, safe harbor agreement, or purchase from willing seller.	1
1.3.80	O	Waianu Valley, 48014003 48013014	OAEL	Waiāhole Irrigation Co. Ltd. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, safe harbor agreement, or purchase from willing seller.	2
1.3.81	K	Southern Alaka`i Plateau, Portions of 417001001	PUAI KACR KAMO KAAK OO OU KANU	Robinson Family Partners. Develop cooperative management agreement or purchase from willing seller.	1

Table 7. Parcels in recovery areas in need of protection					
Recovery Action #	**Island**	**Land Parcel, Tax Map Key (TMK)**	**Species Targeted**	**Landowner/Comments**	**Priority**
1.3.82	K	Upper Wainiha Pali, Portions of 458001001	PUAI KACR KAMO KAAK OO OU KANU	Alexander and Baldwin Hawai`i Inc. Currently under surrender agreement to DLNR. Area under management of DLNR. Land is remote, no public access. Adequately protected at present and for foreseeable future. Any change in this status should be reassessed.	2

1.4 Provide private landowners with financial and regulatory incentives to restore and manage suitable habitat for native forest birds. Approximately one-half of lands in the State conservation district are privately owned. Many private landowners are interested in taking conservation measures but may be concerned they will face additional regulation as a result of their voluntary stewardship. Other landowners are willing to implement conservation actions but lack the resources to do so.

1.4.1 Continue and expand private landowner incentive programs that support restoration and management of private lands, including the U.S. Department of Interior's Landowner Incentive Program (LIP) and Private Stewardship Grants Program (PSGP), the State of Hawai`i's Natural Areas Partnership Program (NAPP) and Forest Stewardship Program (FSP), and the U.S. Department of Agriculture's Healthy Forest Reserve Program, Wildlife Habitat Incentives Program (WHIP), and other "farm bill" programs (those authorized through the Food Security Act of 1985).

1.4.2 Continue to provide regulatory incentives and assurances to private landowners, such as safe harbor agreements, and encourage making these a permanent provision of Hawai`i State law.

1.4.3 **Provide dedicated State and Federal staffing** to administer and provide technical support for private landowner programs.

1.4.4 **Develop local, State, and Federal tax incentives** for landowners who convert lands to native forest, provide greater conservation management of forested lands, or agree to protect native forest through term or permanent easements.

2. Manage Forest Ecosystems for the Benefit and Recovery of Native Forest Birds.

2.1 **Reforest recovery areas that no longer contain the necessary constituent elements for species recovery.** (Priority 1-3) Recovery of most forest bird species included in this plan will require reforestation of degraded habitats. Parcels in need of restoration efforts and bird species expected to benefit from these efforts are listed in Table 8.

Table 8. Parcels in recovery areas needing reforestation. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. Species Codes: AKEP = Hawai`i `ākepa; AKIP = `akiapōlā`au; AKOH = `ākohekohe; HCRE = Hawai`i creeper; KAAK = Kaua`i `akialoa; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nukupu`u; MAPA = Maui parrotbill; OAEL = O`ahu `elepaio; OO = Kaua`i `ō`ō; OU = `ō`ū; PALI = palila; POOU = po`ouli; PUAI = puaiohi. Refer to the Implementation Schedule, Key to Acronyms (page 5-7) for landowner and partnership abbreviations.

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.1	H	Northeastern Slope of Mauna Kea, Portions of 344014002 344014003 343010002 343010008	AKIP PALI	Hawai`i DLNR, Land Division. Reforest and restore pasturelands to dry māmane and mesic koa forest.	2
2.1.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i DHHL. Provides a vital link between mesic koa forest and dry māmane forest. Restore upper pasturelands.	1
2.1.3	H	Hilo Forest Reserve, Laupāhoehoe Section, 337001004	AKIP HCRE AKEP OU	Hawai`i DOFAW. Remove alien trees, restore transition forest from wet `ōhi`a to mesic koa.	3
2.1.4	H	Hilo Forest Reserve, Pīhā Section, 333001004	AKIP HCRE AKEP OU	Hawai`i DOFAW. Remove alien trees. Restore transition forest from wet `ōhi`a to mesic koa. Facilitate understory regeneration.	3
2.1.5	H	Hakalau Forest NWR, 337001010 329005005 333001007 329005003	AKIP HCRE AKEP	USFWS. Remove alien trees and continue successful forest restoration program.	1
2.1.6	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i DHHL, leased by DOFAW. Facilitate canopy tree and understory regeneration.	3

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.7	H	Humu`ula, 338001002	AKIP HCRE AKEP PALI	Hawai`i DHHL. Restorable. A vital link between wet and dry forest. Reforest pasturelands to transition forest from mesic koa to dry māmane.	2
2.1.8	H	Humu`ula, Portions of 338001007	AKEP AKIP HCRE PALI	Hawai`i DHHL, leased to Parker Ranch. Reforest pasturelands to native montane dryland habitat.	2
2.1.9	H	Luma`ia Section, 326018002	AKIP HCRE AKEP	Hawai`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Vital link between montane mesic forest and montane dry forest. Protect existing forest and reforest pasturelands.	2
2.1.10	H	Pu`u `Ō`ō Ranch, 326018001	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, leased to Pu`u `Ō`ō Ranch. Important mesic and wet koa/`ōhi`a forest remnants, and vital link between wet and dry forest communities. Protect and reforest.	2
2.1.11	H	Ka`ohe, 344015002	AKIP PALI	Hawai`i DLNR, Land Division. Protect and reforest.	2
2.1.12	H	Mauna Kea Forest Reserve, 344015001	AKIP PALI	Hawai`i DLNR. Restore montane dry māmane/naio forest.	1
2.1.13	H	Keauhou Ranch, 399001004	AKIP HCRE AKEP	Kamehameha Schools. Reforest transition wet `ōhi`a, mesic koa and dry māmane/sandalwood.	3
2.1.14	H	Hawai`i Volcanoes National Park, 399001002	AKIP HCRE AKEP	Hawai`i Volcanoes National Park. Continue dryland forest restoration.	3
2.1.15	H	Kapāpala Ranch, 398001004	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, Kapāpala Ranch. A link between forest communities to the east and west. Remove alien trees, restore montane dry koa, `ōhi`a and māmane forest.	2
2.1.16	H	Ka`ū Forest Reserve, 397001007	AKIP HCRE AKEP	Mauna Kea Agribusiness. Protect and facilitate natural regeneration.	3

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.17	H	Ka`ū Forest Reserve, Portions of 397001006 397001005	AKIP HCRE AKEP	Kamehameha Schools. Protect and facilitate natural regeneration.	2
2.1.18	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Samuel M. Damon Trust. Valuable wet and mesic forest habitat needs restoring. A link between Ka`ū Forest and the South Kona Forest.	2
2.1.19	H	Honomalino, 389006004 389006029	AKIP HCRE AKEP	Scott C. Rolles Trust. A link between Ka`ū Forest and South Kona Forest. Protect and restore montane mesic koa forest.	3
2.1.20	H	Pāpā, 388001001	AKIP HCRE AKEP	The Nature Conservancy, Kona Hema Preserve. Recently sold by Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. Restore montane mesic koa forest.	3
2.1.21	H	TNCH, Honomalino, 389001001	AKIP HCRE AKEP	The Nature Conservancy of Hawai`i. Continue forest restoration program.	3
2.1.22	H	Honomalino Forest Reserve, 389001002	AKIP HCRE AKEP	Hawai`i DOFAW. Restore montane mesic koa and `ōhi`a forest.	2
2.1.23	H	Yee Hop Ranch, Portions of 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011 387001004	AKIP HCRE AKEP	Yee Hop Ranch Ltd. Provides links between State land parcels and protects contiguous forest habitat in South Kona from development. Protect and restore wet `ōhi`a, mesic koa and dry māmane/naio forest.	2
2.1.24	H	Kona Forest NWR, 386001001	AKIP HCRE AKEP	USFWS. Restore montane mesic koa and `ōhi`a forest.	1

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.25	H	\`Alae Ranch, Portions of 387001014	AKIP HCRE AKEP	Hawai\`i DLNR, Land Division, leased to \`Alae Ranch. Protect and restore wet \`ōhi\`a forest.	3
2.1.26	H	McCandless Ranch and E. Stack *et al.*, Portions of 392001003 386001001 385001002	AKIP HCRE AKEP	Protects contiguous forest habitat in South Kona from development. Restore pasture to mesic koa and dry māmane/naio forest.	2
2.1.27	H	Waiea Tract, 386001003	AKIP HCRE AKEP	Hawai\`i DLNR, Land Division. Protects contiguous mesic koa forest habitat in South Kona.	2
2.1.28	H	Keālia Ranch 385001001 and Portions of 384001001 383001001	AKIP HCRE AKEP	Kamehameha Schools. Restore mesic koa forest and dry māmane/naio forest.	2
2.1.29	H	Kealakekua Development Corp., Portions of 382012001	AKIP PALI	Kealakekua Development Corp. Protect contiguous forest habitat in South Kona, provide habitat for a second palila population. Restore wet \`ōhi\`a, mesic koa and dry montane māmane forest.	3
2.1.30	H	Pu\`u Lehua, Portions of 378001003 378001007 378001002 378001001	AKIP PALI	Kamehameha Schools. Protects contiguous forest habitat in South Kona from development, and provide habitat for a second palila population. Restore mesic koa and dry montane māmane forest.	2
2.1.31	H	Pu\`u Wa\`awa\`a, 371001001 371001006	HCRE AKEP	Hawai\`i DOFAW, Pu\`u Wa\`awa\`a Forest Bird Sanctuary. Restore montane mesic koa and māmane/naio forest habitat.	2
2.1.32	H	Haulālai Ranch, 372002001	HCRE AKEP	Kamehameha Schools. Restore mesic and dry montane forest.	2
2.1.33	MA	Haleakalā National Park, 218001007	AKOH MAPA POOU	NPS. Restore montane mesic forest in Kaupō Gap.	1

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.34	MA	Kīpahulu Forest Reserve, 217004006	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane mesic forest along cliffs and head of Manawainui Valley.	2
2.1.35	MA	Nu`u, 218001001	AKOH MAPA POOU	Kaupō Ranch Ltd. Restore montane mesic forest and shrubland.	3
2.1.36	MA	Nu`u, 218001002	AKOH MAPA POOU	James Campbell Est. Restore montane mesic forest and shrubland.	3
2.1.37	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane mesic forest and shrubland.	1
2.1.38	MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	AKOH MAPA POOU	Hawai`i DHHL. Support ongoing restoration of montane mesic forest and shrubland.	1
2.1.39	MA	Upper Auwahi, 219001006 221009001 222001001 222001034	AKOH MAPA POOU	`Ulupalakua Ranch Inc. Support ongoing restoration of montane mesic forest and shrubland.	2
2.1.40	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.41	MA	Kēōkea, 222004033	AKOH MAPA POOU	James Campbell Est. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.42	MA	Waiohuli, 222005052	AKOH MAPA POOU	James Campbell Est. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.43	MA	Ka`ono`ulu, 222007002 222006009 222007010 222006032	AKOH MAPA POOU	Ka`ono`ulu Ranch Co. Ltd. Restore montane mesic forest and shrubland. Replace nonnative trees.	3

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.44	MA	Waiakoa, 222008001	AKOH MAPA POOU	Lucky Shoji USA Inc. *et al.* Restore montane mesic forest and shrubland. Replace nonnative trees.	3
2.1.45	MA	Kamehame Nui/Kealahou, 223005002	AKOH MAPA POOU	John Zwaanstra. Restore montane mesic forest and shrubland.	3
2.1.46	MA	Haleakalā Ranch (Pūlehu Nui/Kalialinui), 223005003	AKOH MAPA POOU	Haleakalā Ranch Co. Restore montane mesic forest and shrubland.	1
2.1.47	MA	Waikamoi Preserve, 223005004	AKOH MAPA POOU	Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Restore montane mesic forest and shrubland at high elevation. Replace nonnative trees.	1
2.1.48	MA	Makawao Forest Reserve, 224016001 224016002	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.49	MA	West Maui NAR, Kahakuloa, 231006001	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane wet forest and shrubland.	2
2.1.50	MA	West Maui Forest Reserve, Kaheawa, 248001001	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.	2
2.1.51	MA	West Maui Forest Reserve, Ukumehame/Olowalu, West Maui NAR, Līhau, 248001002	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane wet forest and shrubland.	2
2.1.52	MA	Pu`u Kukui Watershed Management Area, 241001017	AKOH MAPA POOU	Maui Land and Pineapple. Restore montane wet forest and shrubland. Replace nonnative trees.	2
2.1.53	MO	Moloka`i Forest Reserve, Kalamāula, 252014003	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.	2
2.1.54	MO	Moloka`i Forest Reserve, Kahanui, 252014001	AKOH MAPA POOU	R. W. Myer Ltd., *et al.* Restore montane wet forest and shrubland. Replace nonnative trees.	2

Table 8. Parcels in recovery area needing reforestation					
Recovery Action #	Island	Land Parcel, Tax Map Keys	Species Targeted	Landowner/Comments	Priority
2.1.55	MO	Moloka`i Forest Reserve, Kahanui, 261001004	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.	2
2.1.56	MO	Moloka`i Forest Reserve, Kamalō, 255001016 255001006 255001017	AKOH MAPA POOU	Kamehameha Schools. Restore montane mesic forest and shrubland.	2
2.1.57	MO	Moloka`i Forest Reserve, Mākolelau, 255001015	AKOH MAPA POOU	Ashton Pitts Jr. Trust. Restore montane mesic forest and shrubland.	3
2.1.58	MO	Kamakou Preserve, Kawela, 2540003026	AKOH MAPA POOU	Moloka`i Ranch Ltd, The Nature Conservancy of Hawai`i. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.59	MO	Moloka`i Forest Reserve, Kawela, 254003001	AKOH MAPA POOU	Kawela Plantation Homes Association. Restore montane mesic forest and shrubland.	3
2.1.60	MO	Moloka`i Forest Reserve, Kamiloloa/ Makakupaīa, 254003025	AKOH MAPA POOU	Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.	2
2.1.61	MO	Moloka`i Forest Reserve, Kaunakakai, 253003005	AKOH MAPA POOU	Moloka`i Ranch Ltd. Restore montane mesic forest and shrubland. Replace nonnative trees.	3
2.1.62	O	Mākua Military Reservation	OAEL	U.S. Army. Portions of upper valley recently burned, need reforestation.	3
2.1.63	K	Kōke`e State Park, 414001013 459001016 414001020 414001014 414001002 and numerous small parcels	KACR	Hawai`i DLNR, Division of State Parks. Additional protection may be needed to secure remaining forested habitat.	3

2.2 **Reduce or eliminate the detrimental effects of ungulates on vegetation within forest ecosystems.**

The detrimental effects of introduced feral ungulates including pigs, cattle, goats, sheep, mouflon, axis deer, and other species on forest ecosystems is well documented (Loope and Scowcroft 1985, Stone 1985, Stone *et al.* 1992, Loh and Tunison 1999). These alien species damage forest bird habitat and negatively affect forest bird populations by removing native understory vegetation, suppressing regeneration of native canopy species, and dispersing seeds of invasive alien plant species in their fur, hooves, and droppings. Effective control or elimination of introduced ungulates requires fencing in most cases. The most cost-effective approach in the long term to restore habitat damaged by feral ungulates is to fence areas and remove all ungulates using drives, hunting, snaring, and other measures as appropriate. Parcels where fencing and/or ungulate control are needed for recovery of species included in this plan are listed in Table 9.

Table 9. Parcels in recovery areas needing fencing and ungulate control. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. Species Codes: AKEP = Hawai`i `ākepa; AKIP = `akiapōlā`au; AKOH = `ākohekohe; HCRE = Hawai`i creeper; KAAK = Kaua`i `akialoa; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nukupu`u; MAPA = Maui parrotbill; OAEL = O`ahu `elepaio; OO = Kaua`i `ō`ō; OU = `ō`ū; PALI = palila; POOU = po`ouli; PUAI = puaiohi. Refer to the Implementation Schedule, Key to Acronyms (page 5-7) for landowner and partnership abbreviations.

Table 9. Parcels in recovery areas needing fencing and ungulate control

Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.1	H	Northeastern slopes of Mauna Kea, portions of 344014002 344014003 343010002 343010008	AKIP PALI	Hawai`i DLNR, Land Division.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i DHHL. Provides vital link between mesic koa forest and dry māmane forest. Currently under lease for cattle grazing.	1
2.2.3	H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001004 333001004	AKIP HCRE AKEP	Hawai`i DOFAW. Currently managed for game hunting.	2
2.2.4	H	Hakalau Forest NWR, 337001010 333001007 329005005 329005003	AKIP HCRE AKEP	USFWS. Ungulate control under way. Construct additional fences and control ungulates in unmanaged areas.	1
2.2.5	H	Luma`ia Section 326018002	AKIP HCRE AKEP	Hawai`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Encourage fencing and ungulate removal.	2
2.2.6	H	Pu`u `Ō`ō Ranch, 326018001	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, Pu`u `Ō`ō Ranch lease. Encourage fencing and ungulate removal.	2
2.2.7	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i DHHL. Encourage fencing and ungulate removal.	2
2.2.8	H	Ka`ohe, 344015002	AKIP PALI	Hawai`i DLNR, Land Division. Suspend lease. Fence and remove ungulates.	2
2.2.9	H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	AKIP PALI	Hawai`i DLNR. Palila critical habitat. Continue to remove ungulates.	1
2.2.10	H	Waiākea Forest Reserve, Upper Portion, 324008001	AKIP AKEP HCRE	Hawai`i DOFAW. Fence and remove ungulates.	1

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.11	H	Waiākea Forest Reserve, Lower Portion, 324008001	OU	Hawai`i DOFAW. Fence and remove ungulates.	1
2.2.12	H	`Ōla`a/Kīlauea Partnership, 324008009 399001007 399001004 324008025 319001001 319001007	AKIP HCRE AKEP	Kamehameha Schools, Keauhou Ranch. Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP.	1
2.2.13	H	Kapāpala Forest Reserve, Portions of 398001004	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, Kapāpala Forest Reserve. Fence and remove ungulates.	2
2.2.14	H	Ka`ū Forest Reserve, 397001001	AKIP HCRE AKEP OU	Hawai`i, DOFAW, Ka`ū Forest Reserve. Fence and remove ungulates.	1
2.2.15	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Recently purchased by NPS. Fence and remove ungulates, particularly mouflon sheep.	1
2.2.16	H	Manukā NAR, Upper portions of 391001002	AKIP HCRE AKEP	Hawai`i, DOFAW. Fence and remove ungulates.	2
2.2.17	H	TNCH, Honomalino, 389001001	AKIP HCRE AKEP	The Nature Conservancy of Hawai`i. Fence and remove ungulates.	3
2.2.18	H	Yee Hop Ranch, 392001005	AKIP HCRE AKEP	Yee Hop Ranch Ltd. Fence and remove ungulates.	3
2.2.19	H	Kona Forest NWR, 386001001	AKIP HCRE AKEP	USFWS. Fence and remove ungulates.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.20	H	McCandless Ranch and E. Stack *et al.*, 392001003 386001001 385001002	AKIP HCRE AKEP	McCandless Ranch and E. Stack *et al.* Fence and remove ungulates.	2
2.2.21	H	Waiea Tract, 386001003	AKIP HCRE AKEP	Hawai`i DLNR, Land Division. Fence and remove ungulates.	2
2.2.22	H	Hōnaunau Forest, 384001001 384001002 383001001 383001002	AKIP HCRE AKEP	Kamehameha Schools. Fence and remove ungulates.	2
2.2.23	H	Pu`u Lehua, Portion of 378001003	PALI	Kamehameha Schools. Fence and remove ungulates.	2
2.2.24	MA	Ko`olau Forest Reserve, 224016003 224016004 228008001 228008007	AKOH MAPA POOU	Alexander and Baldwin, East Maui Irrigation. EMWP fence protects lower boundary in east; TNCH protects upper boundary. Remove ungulates from protected areas. Additional ungulate removal needed from unprotected areas.	1
2.2.25	MA	Ko`olau Forest Reserve, 211002002 212004005 229014001 211001050 211001044	AKOH MAPA POOU	Hawai`i DOFAW. EMWP fencing underway to protect forest above about 3,600 ft. Remove ungulates above fence. Additional ungulate control needed from unprotected areas below fence. Proposed additions to Hanawī NAR would support forest bird recovery.	1
2.2.26	MA	Hanawī NAR and Ko`olau Forest Reserve, 212004007	AKOH MAPA POOU	Hawai`i DLNR. NAR fencing protects 1,734 acres, ungulate-free, above 5,400 ft. Fence and remove ungulates from remain portions of NAR (above 2,500 ft. for bird management).	1

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.27	MA	Hāna Forest Reserve, 210001001 214001001 215001001	AKOH MAPA POOU	Hawai`i DLNR. Fencing and ungulate control urgently needed. Proposed additions to Hanawī NAR would support forest bird recovery.	1
2.2.28	MA	Haleakalā National Park, 213001003 216001002 216001001 216001003 217004016 216010001	AKOH MAPA POOU	NPS. Mostly protected by fencing, ungulate removal needs to be completed in some areas. Fence and remove ungulates from remaining areas, e.g., Ka`āpahu.	1
2.2.29	MA	Kīpahulu Forest Reserve, Kukui`ula, 216001007	AKOH MAPA POOU	J. Haili. Encourage ungulate control and fencing.	3
2.2.30	MA	Kīpahulu Forest Reserve, Kukui`ula, 216001006	AKOH MAPA POOU	C. Kalalau. Encourage ungulate control and fencing.	3
2.2.31	MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006	AKOH MAPA POOU	Hawai`i DLNR. Fence and remove ungulates.	1
2.2.32	MA	Kīpahulu Forest Reserve, 217001032	AKOH MAPA POOU	A. Ka`apana *et al.* Encourage ungulate control and fencing.	3
2.2.33	MA	Kīpahulu Forest Reserve, 217001024	AKOH MAPA POOU	Kaupō Ranch Ltd. Encourage ungulate control and fencing.	2
2.2.34	MA	Nu`u, 218001001	AKOH MAPA POOU	Kaupō Ranch Ltd. Encourage ungulate control and fencing.	3
2.2.35	MA	Nu`u, 218001002	AKOH MAPA POOU	James Campbell Est. Encourage ungulate control and fencing.	3

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.36	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i DOFAW. Fencing of portion underway. Complete fencing and ungulate removal from Forest Reserve above 4,000 ft.	1
2.2.37	MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	AKOH MAPA POOU	Hawai`i DHHL. Fencing of portions underway. Continue fencing through partnership programs. Ungulate removal above 4,000 ft.	1
2.2.38	MA	Upper Auwahi, 219001006 221009001 222001001 222001034	AKOH MAPA POOU	`Ulupalakua Ranch Inc. Some exclosures for plant protection in place or underway. Encourage fencing and ungulate removal above 4,000 ft.	1
2.2.39	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i DOFAW. Currently a sustained yield game management area. For portions within forest bird recovery area, fence and remove ungulates to allow regeneration of native forest.	2
2.2.40	MA	Kēōkea, 222004033	AKOH MAPA POOU	James Campbell Est. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.	2
2.2.41	MA	Waiohuli, 222005052	AKOH MAPA POOU	James Campbell Est. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.	2
2.2.42	MA	Ka`ono`ulu, 222007002 222006009 222007010 222006032	AKOH MAPA POOU	Ka`ono`ulu Ranch Co. Ltd. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.43	MA	Waiakoa, 222008001	AKOH MAPA POOU	Lucky Shoji USA Inc. *et al.* Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.	2
2.2.44	MA	Kamehame Nui/Kealahou, 223005002	AKOH MAPA POOU	John Zwaanstra. Fence and remove ungulates within forest bird recovery area.	2
2.2.45	MA	Haleakalā Ranch (Pūlehu Nui/ Kalialinui), 223005003	AKOH MAPA POOU	Haleakalā Ranch Co. The ranch is formulating a conservation reforestation plan. Fence and remove ungulates within forest bird recovery area.	2
2.2.46	MA	Waikamoi Preserve, 223005004	AKOH MAPA POOU	Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Strategic fencing and ungulate control protects the Preserve. Additional protection, especially from deer, may be warranted.	1
2.2.47	MA	Makawao Forest Reserve, 224016001 224016002	AKOH MAPA POOU	Hawai`i DOFAW. Public hunting currently permitted. Fence and remove ungulates within forest bird recovery area.	1
2.2.48	MA	West Maui NAR, Kahakuloa, 231006001	AKOH MAPA POOU	Hawai`i DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery area.	2
2.2.49	MA	West Maui Forest Reserve, Waihe`e, 232014001	AKOH MAPA POOU	Maui Board of Water Supply. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.50	MA	West Maui Forest Reserve, Kou, 232014002	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.51	MA	West Maui Forest Reserve, Wailuku, 233003003 235003001 236003001	AKOH MAPA POOU	Wailuku Agriculture. Strategic fencing and ungulate removal within forest bird recovery area.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.52	MA	West Maui Forest Reserve, `Īao, 233003004,	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.53	MA	West Maui Forest Reserve, Kealaloloa, 236001014	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.54	MA	West Maui Forest Reserve, Manawainui Plant Reserve, 236001052 248001010	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.55	MA	West Maui Forest Reserve, Kaheawa, 248001001	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.56	MA	West Maui Forest Reserve, Ukumehame/ Olowalu, West Maui NAR, Līhau, 248001002	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.57	MA	West Maui Forest Reserve, Launiupoko, 247001002	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.58	MA	West Maui Forest Reserve, Pūehuehu, 247001004	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.59	MA	West Maui Forest Reserve, Kaua`ula, 246025001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.60	MA	West Maui Forest Reserve, Pana`ewa, 246025002	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.61	MA	West Maui Forest Reserve, Kahoma, 245022001	AKOH MAPA POOU	Kamehameha Schools. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.62	MA	West Maui Forest Reserve, Kahoma, 245022005	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.63	MA	West Maui Forest Reserve, Pu`u Kī/Haakea, 245022002 245022004	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.64	MA	West Maui Forest Reserve, Wahikuli, 245022003	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.65	MA	Kapunakea Preserve, Amfac/JMB, TNCH, 244007001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co., TNCH. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.66	MA	West Maui Forest Reserve, Kapāloa, 244007007	AKOH MAPA, POOU	Unknown. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.67	MA	West Maui NAR, Honokōwai, 244007004	AKOH MAPA POOU	Hawai`i DLNR. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.68	MA	Pu`u Kukui Watershed Management Area, 242001001, 241001017	AKOH MAPA POOU	Maui Land and Pineapple. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.69	MO	Moloka`i Forest Reserve, Kalama`ula, 252014003	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.70	MO	Moloka`i Forest Reserve, Kahanui, 252014001	AKOH MAPA POOU	R. W. Myer Ltd., *et al.* Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.71	MO	Moloka`i Forest Reserve, Kahanui, 261001004	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.72	MO	Moloka`i Forest Reserve, Waikolu, 261001002	AKOH MAPA POOU	Hawai`i DOFAW. Ungulate control currently ongoing at Pu`u Ali`i NAR. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.73	MO	Moloka`i Forest Reserve, Pelekunu Valley, 259006011	AKOH MAPA POOU	The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.74	MO	Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, 259008017	AKOH MAPA POOU	Wm. Hitchcock, *et al*. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.75	MO	Moloka`i Forest Reserve, Pelekunu Valley, 254003032	AKOH MAPA POOU	The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.76	MO	Oloku`i NAR, Moloka`i Forest Reserve, Wailau Valley, 259006002	AKOH MAPA POOU	Hawai`i DOFAW. Naturally isolated but vulnerable to incursion. Ungulate control ongoing. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.77	MO	Moloka`i Forest Reserve, Wailau Valley and Oloku`i, 259006004	AKOH MAPA POOU	G. Brown III, *et al*. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.78	MO	Moloka`i Forest Reserve, Laeokapuna, 257005027	AKOH MAPA POOU	P. Hodgins. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.79	MO	Moloka`i Forest Reserve, Keanakoholua, 257005001	AKOH MAPA POOU	M. Hustice Trust. Strategic fencing and ungulate removal within forest bird recovery area.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.80	MO	Moloka`i Forest Reserve, `Uala`pue, 256006026	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.81	MO	Moloka`i Forest Reserve, Kahananui, 256006014	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.82	MO	Moloka`i Forest Reserve, Manawai, 256006013	AKOH MAPA POOU	P. Petro Trust. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.83	MO	Moloka`i Forest Reserve, eastern `Ōhi`a Gulch, 256006011	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.84	MO	Moloka`i Forest Reserve, West `Ōhi`a Gulch, 256006010	AKOH MAPA POOU	E. Wond Trust. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.85	MO	Moloka`i Forest Reserve, Keawa Nui, 256006007	AKOH MAPA POOU	Kamehameha Schools. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.86	MO	Moloka`i Forest Reserve, Pua`ahala, 256006002	AKOH MAPA POOU	K&H Horizons Hawai`i. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.87	MO	Moloka`i Forest Reserve, Kumu`eli, 256006001	AKOH MAPA POOU	D. Fairbanks III Trust, (Austin Estate?). In EMOWP; currently fencing portions and removing ungulates. Continue strategic fencing and remove ungulates within forest bird recovery area.	2
2.2.88	MO	Moloka`i Forest Reserve, Kamalō, 255001016 255001006 255001017	AKOH MAPA POOU	Kamehameha Schools. In EMOWP; currently fencing portions and removing ungulates. Strategic fencing and ungulate removal within forest bird recovery area.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.89	MO	Moloka`i Forest Reserve, Mākolelau, 255001015	AKOH MAPA POOU	Ashton Pitts Jr. Trust. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.90	MO	Kamakou Preserve, Kawela, 2540003026	AKOH MAPA POOU	Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. In EMOWP. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.91	MO	Moloka`i Forest Reserve, Kawela, 254003001	AKOH MAPA POOU	Kawela Plantation Homes Association. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.92	MO	Moloka`i Forest Reserve, Kamiloloa/ Makakupa`ia, 254003025	AKOH MAPA POOU	Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.93	MO	Moloka`i Forest Reserve, Kaunakakai, 253003005	AKOH MAPA POOU	Moloka`i Ranch Ltd. Strategic fencing and ungulate removal within forest bird recovery area.	2
2.2.94	O	Honouliuli Preserve, 92005013	OAEL	James Campbell Estate, managed by The Nature Conservancy of Hawai`i. One 40-acre exclosure completed, a second is planned. More, larger fences needed to exclude ungulates from as much of the preserve as possible.	1
2.2.95	O	Lualualei Naval Magazine, 88001001	OAEL	U.S. Navy. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Not open to public hunting.	2

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.96	O	Schofield Barracks West Range, 77001001	OAEL	U.S. Army. Ungulate control to protect forest and reduce mosquito breeding habitat. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Not open to public hunting.	1
2.2.97	O	Pahole NAR, 68001002	OAEL	Hawai`i State. Fencing and ungulate eradication to protect forest, reduce mosquito breeding habitat. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Currently few `elepaio, but high potential for augmentation.	2
2.2.98	O	Kahanahāiki Valley, 81001012	OAEL	U.S. Army. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.	2
2.2.99	O	O`ahu Forest NWR, 95004001 76001001	OAEL	U.S. Fish and Wildlife Service. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Currently no `elepaio, but high potential for reintroduction.	3
2.2.100	O	Lower Ka`ala NAR, 67003025	OAEL	Hawai`i State. Currently few `elepaio, but high potential for augmentation/ reintroduction. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.	3

Table 9. Parcels in recovery areas needing fencing and ungulate control					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.101	K	Halehaha, Halepā`ākai and Koai`e drainages, Alaka`i Wilderness Preserve, Portions of 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Fencing of at least a 4 km square area in the Halepā`ākai and Koai`e Stream drainage and eradication of pigs is needed to protect key habitat. Fencing and ungulate control and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.	1
2.2.102	K	Upper Mōhihi and Waiakoali drainages, Alaka`i Wilderness Preserve, Portions of 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Fencing as much of the core puaiohi population as possible. Fencing and ungulate control and/or time/area closure to hunting in preparation for aerial broadcast of rodenticide.	2
2.2.103	K	Alaka`i Wilderness Preserve 4414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Strategic fencing to exclude ungulates from as much of the preserve as practical.	2
2.2.104	K	Southern Alaka`i Plateau, Portions of 417001001	PUAI AKIK	Gay and Robinson Partnership with DLNR/ DOFAW. Fencing and ungulate control may be needed in preparation for aerial broadcast of rodenticides.	2

2.3 Reduce or eliminate the detrimental effects of alien plants within forest ecosystems, through mechanical, chemical, or biological means, as appropriate. (Priority 1-3)

Habitat degradation resulting from the invasion of nonnative weeds is a long-term, pervasive threat in many recovery areas. Alien plants can drastically alter forest structure and function and impact forest birds by choking out native vegetation, altering food availability and phenology, and altering roost- and nest-site availability. Priority control efforts should be aimed at eradicating incipient populations of known forest invasives, and controlling established populations of species that highly impact forest structure or function. For species that have become established and are beyond the means of mechanical or chemical control, research into biological control agents is imperative. Table 10 lists species, genera, and families of plants that pose serious threats to habitat needed for forest bird recovery on all islands.

Table 10. Alien plant taxa known or suspected to pose a significant threat to forest bird recovery areas on the main Hawaiian Islands. At the species level, 39 taxa of alien grasses, shrubs, vines, or trees pose a significant threat to forest bird recovery areas. At higher taxonomic levels, all known naturalized taxa from five genera and four families pose significant threats to forest bird recovery areas. Urgency of the need for management of each taxon is represented by a code: 1 = high; 2 = moderate; 3 = low.

Table 10. Threatening alien plant taxa.

Scientific Name	Common Name	Hawai`i	Maui Nui	O`ahu	Kaua`i
Acacia mearnsii	black wattle	3	1		3
Acacia melanoxylon	Australian blackwood		1		3
Cinchona pubescens	quinine		1	3	
Cinnamomum burmannii	padang cassia		2		
Cinnamomum camphora	camphor tree		1		
Cortaderia jubata	Andean pampas grass	2	2		
Cortaderia selloana		2	2		
Delairea odorata	German ivy	2			
Ehrharta stipoides	meadow ricegrass	2			
Erigeron karvinskianus	daisy fleabane		3		1

Table 10. Threatening alien plant taxa.

Scientific Name	Common Name	Hawai`i	Maui Nui	O`ahu	Kaua`i
Heliocarpus popayanensis	white moho	3	3	1	
Holcus lanatus	velvetgrass, Yorkshire fog	3	3		
Ilex aquifolium	English or European holly	1	2		
Juncus effuses	Japanese mat rush	1	3		2
Juncus planifolius	rush	3	3		
Lantana camara	lantana, lakana	3	3	1	
Leptospermum scoparium	New Zealand tea tree			2	
Lonicera japonica	Japanese honeysuckle	3	3		2
Melinis minutiflora	molasses grass	3	3		3
Myrica faya	firetree	1	2		1
Oplismenus hirtellus	basketgrass, honohono			3	
Panicum maximum	Guinea grass	3	2		
Paspalum conjugatum	Hilo grass, mau`u-hilo	3	3		3
Paspalum urvillei	Vasey grass	3	3		2
Pennisetum clandestinum	kikuyu grass	1			
Pennisetum setaceum	fountain grass	1			
Pyracantha angustifolia	firethorn, pyracantha	3	3		3
Rubus argutus	blackberry	1	1	1	1
Rubus discolor		3	2		
Rubus ellipticus var. *obcordatus*	yellow Himalayan raspberry	1	2		
Rubus niveus	hill or mysore raspberry	3	2		
Rubus rosifolius	thimbleberry	3	3	2	2
Schinus terebinthifolius	Christmas berry	2	2	1	
Schizachyrium condensatum	beardgrass	3	3		2
Setaria palmifolia	palmgrass	2	2	2	
Sphaeropteris cooperi	Australian tree fern	2	2	2	2
Toona ciliata	Australian red cedar		3	1	
Ulex europaeus	gorse	2	2		

Genera					
Eucalyptus spp. (90+ spp)	gum trees	2	1	1	3
Ficus (microcarpa, nota, platyphyllum, rubigenosa)	figs	2	2	1	
Fraxinus (uhdei, griffithi)	ashes	1	1	3	
Hedychium (coronarium, flavescens, gardnerianum)	gingers	1	1	3	1
Psidium (cattleianum, guajava)	guavas	1	1	1	1
Families					
Melastomataceae	Melastome family	1	1	1	3
Passifloraceae	Passion fruit family	1	2	2	2
Pinaceae	Pine family	2	2		
Proteaceae	Protea family	2	3	2	

2.4 Reduce or eliminate the detrimental effects of alien mammalian predators (rats, mice, feral cats, mongooses) on forest birds.

Hawaiian birds evolved in the absence of mammalian predators and are extremely vulnerable to the novel selection pressure exerted by these introduced species, particularly rats (*Rattus* spp.) and feral cats (*Felis catus*). The black rat (*R. rattus*) is thought to have been a major cause of the declines in native bird populations in the early 1900s (Atkinson 1977), and it continues to limit recovery of listed forest birds through predation on eggs, nestlings, and adults (Amarasekare 1993, VanderWerf 2001, VanderWerf and Smith 2002). Feral cats have a widespread distribution throughout forest bird habitat on all of the main Hawaiian Islands, and have been described as "the most dangerous predator ever introduced by man" because of their devastating effect on island bird populations (Ebenhard 1988). The small Indian mongoose (*Herpestes auropunctatus*) has had a major negative effect on the nēnē, seabirds, and waterbirds (U.S. Fish and Wildlife Service 1999, Hodges and Nagata 2001, Hu *et al.* 2001), but its limited climbing ability suggests it is a lesser threat to forest birds than rats and feral cats. Nonetheless, field observations and necropsies by

National Park Service personnel indicate the impact of mongooses should not be underestimated (D. Reeser, National Park Service, pers. comm.). Recovery of most Hawaiian forest bird species will require active predator control efforts, as well as increased research into the development of effective means for controlling predators over large areas of forest. Attempts at reintroducing birds by translocation or captive releases to areas where they have been extirpated should be accompanied by predator control.

2.4.1 Control alien mammalian predators in core forest bird habitat by trapping, poisoning, and other means (see Table 11).

Table 11. Parcels in recovery areas where predator control is needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. Species Codes: AKEP = Hawai`i `ākepa; AKIP = `akiapōlā`au; AKOH = `ākohekohe; HCRE = Hawai`i creeper; KAAK = Kaua`i `akialoa; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nukupu`u; MAPA = Maui parrotbill; OAEL = O`ahu `elepaio; OO = Kaua`i `ō`ō; OU = `ō`ū; PALI = palila; POOU = po`ouli; PUAI = puaiohi. Refer to the Implementation Schedule, Key to Acronyms (page 5-7) for landowner and partnership abbreviations.

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.1	H	Northeastern slopes of Mauna Kea, portions of 344014002 344014003 343010002 343010008	AKIP PALI	Hawai`i DLNR, State Land Division.	2
2.4.1.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i DHHL. Predator control needed in conjunction with reforestation to allow range expansion by forest birds.	2
2.4.1.3	H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001002 333001004	AKIP HCRE AKEP	Hawai`i, DOFAW. Currently managed for game hunting.	2
2.4.1.4	H	Hakalau Forest NWR, 337001010 333001007 329005005 329005003	AKIP HCRE AKEP	USFWS. Currently managed forest bird habitat. Predator control needed to protect core populations of three listed species.	1
2.4.1.5	H	326018002	AKIP HCRE AKEP	Hawai`i DHHL. Adjacent to Hakalau Forest National Wildlife Refuge.	2
2.4.1.6	H	Pu`u `Ō`ō Ranch, 326018001	AKIP HCRE AKEP	Hawai`i DLNR, State Land Division, Pu`u `Ō`ō Ranch lease.	2

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.7	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i DHHL.	2
2.4.1.8	H	Ka`ohe, 344015002	AKIP PALI	Hawai`i DLNR, State Land Division. Suspend lease.	2
2.4.1.9	H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	AKIP PALI	Hawai`i DOFAW. Palila critical habitat. Feral cats known to be predators in this area.	1
2.4.1.10	H	Waiākea Forest Reserve, Upper portion, 324008001	AKIP AKEP HCRE	Hawai`i, DOFAW.	2
2.4.1.11	H	Waiākea Forest Reserve, lower portion, 324008001	OU	Hawai`i, DOFAW.	2
2.4.1.12	H	`Ōla`a/Kīlauea Partnership, 324008009 399001007 399001004 324008025 319001001 319001007	AKIP HCRE AKEP	Kamehameha Schools, Keauhou Ranch. Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP.	1
2.4.1.13	H	Kapāpala Forest Reserve, Portions of 398001004	AKIP HCRE AKEP	Hawai`i DLNR, Land Division, Kapāpala Forest Reserve. Needs predator control.	2
2.4.1.14	H	Ka`ū Forest Reserve, 397001001	AKIP HCRE AKEP OU	Hawai`i DOFAW. Predator control needed to protect large populations of three listed species.	1
2.4.1.15	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Samuel M. Damon Trust. Purchase by NPS.	2
2.4.1.16	H	Manukā NAR, Upper portions of 391001002	AKIP HCRE AKEP	Hawai`i, DOFAW.	2

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.17	H	TNCH, Honomalino, 389001001	AKIP HCRE AKEP	The Nature Conservancy of Hawai`i.	2
2.4.1.18	H	Yee Hop Ranch, 392001005	AKIP HCRE AKEP	Yee Hop Ranch Ltd.	2
2.4.1.19	H	Kona Forest NWR, 386001001	AKIP HCRE AKEP	USFWS. Predator control needed to protect last wild `alalā and other listed species.	1
2.4.1.20	H	McCandless Ranch and E. Stack *et al.*, 392001003 386001001 385001002	AKIP HCRE AKEP	Elizabeth Stack *et al.*, McCandless Ranch.	2
2.4.1.21	H	Waiea Tract, 386001003	AKIP HCRE AKEP	Hawai`i State, DLNR, State Land Division.	2
2.4.1.22	H	Hōnaunau Forest, 384001001 384001002 383001001 383001002	AKIP HCRE AKEP	Kamehameha Schools.	2
2.4.1.23	H	Pu`u Lehua, Portion of 378001003	PALI	Kamehameha Schools.	2
2.4.1.24	H	Pu`u Wa`awa`a Forest Bird Sanctuary, 371001001 371001006	AKIP HCRE AKEP	Hawai`i State, DLNR, DOFAW.	2
2.4.1.25	MA	Ko`olau Forest Reserve, 224016003 224016004 228008001 228008007	AKOH MAPA POOU	Alexander and Baldwin, East Maui Irrigation. Portions providing habitat for endangered species; remaining portions are priority 2.	1

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.26	MA	Ko`olau Forest Reserve, 211002002 212004005 229014001 211001050 211001044	AKOH MAPA POOU	Hawai`i State. Portions providing habitat for endangered species; remaining portions are priority 2.	1
2.4.1.27	MA	Hanawī NAR and Ko`olau Forest Reserve, 212004007	AKOH MAPA POOU	Hawai`i State. Portions providing habitat for endangered species; remaining portions are priority 2.	1
2.4.1.28	MA	Hāna Forest Reserve, 210001001 214001001 215001001	AKOH MAPA POOU	Hawai`i State. Portions providing habitat for endangered species; remaining portions are priority 2.	1
2.4.1.29	MA	Haleakalā National Park, 213001003 216001002 216001001 216001003 217004016 216010001 218001007	AKOH MAPA POOU	National Park Service. Portions providing habitat for endangered species; remaining portions are priority 2.	1
2.4.1.30	MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006	AKOH MAPA POOU	Hawai`i State. Adjacent to known populations of AKOH and MAPA. Potential for range expansion.	2
2.4.1.31	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i State. Potential long-term site for reintroduction.	2
2.4.1.32	MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	AKOH MAPA POOU	Hawai`i State, DHHL. Potential long-term site for reintroduction.	2

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.33	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i State. Potential long-term site for reintroduction.	3
2.4.1.34	MA	Haleakalā Ranch (Pūlehu Nui/ Kalialinui), 223005003	AKOH, MAPA, POOU	Haleakalā Ranch Co. Adjacent to current populations. Likely site of near-term range expansion for AKOH and MAPA.	3
2.4.1.35	MA	Waikamoi Preserve, 223005004	AKOH MAPA POOU	Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Portions providing habitat for endangered species, priority #1; remaining portions, priority #2.	1
2.4.1.36	MA	Makawao Forest Reserve, 224016001 224016002	AKOH MAPA POOU	Hawai`i State. Likely site of near-term range expansion for AKOH and MAPA.	2
2.4.1.37	MA	West Maui NAR, Kahakuloa, 231006001	AKOH MAPA POOU	Hawai`i State. Primary site for reintroduction.	2
2.4.1.38	MA	West Maui NAR, Līhau, 248001002	AKOH MAPA POOU	Hawai`i State. Potential long-term site for reintroduction.	3
2.4.1.39	MA	West Maui Forest Reserve, Pana`ewa, 246025002	AKOH MAPA POOU	Hawai`i State. Potential long-term site for reintroduction.	3
2.4.1.40	MA	Kapunakea Preserve Amfac/JMB, TNCH, 244007001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co., TNCH. Primary site for reintroduction.	2
2.4.1.41	MA	West Maui NAR, Honokōwai, 244007004	AKOH MAPA POOU	Hawai`i State. Primary site for reintroduction.	2
2.4.1.42	MA	Pu`u Kukui Watershed Management Area, 242001001 241001017	AKOH MAPA POOU	Maui Land and Pineapple. Primary site for reintroduction.	2
2.4.1.43	MO	Moloka`i Forest Reserve, Pu`u Ali`i NAR and Waikolu, 261001002	AKOH MAPA POOU	Hawai`i State. Primary site for reintroduction.	2

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.44	MO	Moloka`i Forest Reserve and Oloku`i NAR, Wailau Valley, 259006002	AKOH MAPA POOU	Hawai`i State. Primary site for reintroduction.	2
2.4.1.45	MO	Kamakou Preserve, Kawela, 2540003026	AKOH MAPA POOU	Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. Primary site for reintroduction.	2
2.4.1.46	O	Honouliuli Preserve, 92005013	OAEL	James Campbell Est. The Nature Conservancy of Hawai`i has controlled rodents since 2000 with snap traps and bait stations. Control should be continued and expanded, using aerial broadcast if possible.	1
2.4.1.47	O	Lualualei Naval Magazine, 88001001	OAEL	U.S. Navy. Rodent control initiated in 2002 using diphacinone bait stations and snap traps, should be continued and expanded, using aerial broadcast if possible.	2
2.4.1.48	O	Schofield Barracks West Range, 77001001	OAEL	U.S. Army. Environmental Division has controlled rodents on a small-scale using snap traps and bait stations, but insufficient access to be effective. Aerial broadcast of rodenticide would increase scale, less access needed.	1
2.4.1.49	O	Honolulu Watershed Forest Reserve (Wailupe), 36004004	OAEL	Hawai`i DOFAW. Rodent control begun in 1997 using snap traps and bait stations, should be continued and expanded, using aerial broadcast if possible.	1
2.4.1.50	O	North Hālawa Valley, 99011002	OAEL	Kamehameha Schools. Rodent control needed to protect core `elepaio population.	1
2.4.1.51	O	Moanalua Valley, 11013001 11013002	OAEL	Damon Estate. Rodent control needed to protect core `elepaio population.	1

Table 11. Parcels in recovery areas where predator control is needed

Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.52	O	Waikāne Valley, 48014005	OAEL	SMF Enterprises. Rodent control needed to protect core `elepaio population.	1
2.4.1.53	O	Kahana Valley State Park, 52001001 52002001	OAEL	Hawai`i DLNR, State Parks. Rodent control needed to protect core `elepaio population.	1
2.4.1.54	O	Mākaha Valley, 84002014 84002001	OAEL	City and County of Honolulu. Rodent control needed to protect core `elepaio population.	1
2.4.1.55	O	Pahole NAR, 68001002	OAEL	Hawai`i DLNR, NARS.  Rodent control conducted in 1999 using bait stations.  Currently few `elepaio, but aerial broadcast would help prepare site for reintroduction.	2
2.4.1.56	O	Kahanahāiki Valley, 81001012	OAEL	U.S. Army. Rodent and mongoose control begun in 1998 using snap traps, bait stations, and live traps. Currently few `elepaio, aerial broadcast would help prepare site for reintroduction.	2
2.4.1.57	O	O`ahu Forest NWR, 95004001 76001001	OAEL	USFWS. Currently no `elepaio, rodent control would help prepare site for reintroduction.	2
2.4.1.58	O	Lower Ka`ala NAR, 67003025	OAEL	Hawai`i DLNR, NARS. Currently few `elepaio, predator control would help prepare site for reintroduction.	3
2.4.1.59	K	Halehaha, Halepā`ākai, and Koai`e drainages, Alaka`i Wilderness Preserve, 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Recommend aerial broadcast of rodenticide in Halehaha and Halepā`ākai drainages, and a tributary of Koai`e Stream.	1

Table 11. Parcels in recovery areas where predator control is needed					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.4.1.60	K	Upper Mōhihi and upper Waiakoali drainages, Alaka`i Wilderness Preserve, 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Pending study of threat posed by rats to core puaiohi population, aerial broadcast of rodenticides in upper Mōhihi and Waiakoali drainages. Ground-based protection of active nests.	2
2.4.1.61	K	Upper Kawaikōī, Alaka`i Wilderness Preserve, 459001001	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i DOFAW. Ground-based bait station rodent control in association with puaiohi release, and ground-based feral cat control.	2
2.4.1.62	K	Southern Alaka`i Plateau, 417001001 (in part)	PUAI AKIK KAMO KAAK OO OU NUKU	Robinson Family Partners, aerial broadcast of rodenticide in conjunction with release program for puaiohi.	2

2.4.2 Continue the public information campaign explaining the need and low relative risks of using aerial broadcast of diphacinone for conservation purposes. (Priority 1)

2.4.3 Examine feasibility/appropriateness of time/area closure of public use areas when using broadcast application of diphacinone. (Priority 1)

2.5 Decrease the threat of avian disease.

Introduced avian disease and disease vectors have had a devastating effect on Hawai`i's endemic forest birds. The introduction of the southern house mosquito (*Culex quinquefasciatus*) to the islands in 1826, introduction of avian pox virus (*Poxvirus avium*) in the 1800s, and the introduction of avian malaria (*Plasmodium relictum*) in the early 1900s each played significant roles in the wave of extinctions of lowland native birds that occurred in the late 19th and early 20th centuries (Warner 1968, van Riper *et al*. 1986). Both diseases continue to limit the geographic range, recruitment, and survivorship of native forest bird populations, with the most significant impacts on Hawaiian honeycreepers (subfamily Drepanidinae) at elevations below 1,200 meters (4,000 feet) (Atkinson *et al*. 1995, 2000; VanderWerf 2001). Differences between the current and historical ranges of most species can, in large part, be explained by high susceptibility to introduced diseases. With the exception of the O`ahu `elepaio, all populations of endangered Hawaiian forest birds occur at elevations higher than 1,200 meters (4,000 feet), where thermal constraints limit development of the malarial parasite in the mosquito vector (LaPointe 2000) and where abundance of mosquito vectors is low (van Riper *et al*. 1986, LaPointe 2000). Given the high susceptibility of isolated island populations to disease introductions and the significant impacts of established diseases, high priority should be given to efforts to prevent introductions of new vectors and pathogens and efforts to control or mitigate the effects of those that are already established in the Hawaiian Islands.

2.5.1 Prevent introduction of new diseases and disease vectors into Hawai`i.

Hawai`i has become a textbook example of what can happen to a highly susceptible wildlife population after introduction of a novel pathogen. Preventing the introduction of new diseases and disease vectors to Hawai`i must receive high priority because of potential impacts on wildlife populations, domestic animals, and human health. An Avian Disease Working Group involving representatives of the U.S. Fish and Wildlife Service, National Park Service, Department of Defense, U.S. Geological Survey, State Division of Forestry and Wildlife, State Department of Agriculture, State Department of Health, the Animal and Plant Health Inspection Service, the U.S. Postal Service, and key private landowners should be convened to identify loopholes and propose legislation for regulating movement of live animals and potentially infectious biological material both into the State and between islands.

2.5.1.1 Enforce existing quarantine laws for importation of pet birds. (Priority 1)

The pet bird trade rather than domestic poultry or the poultry industry poses the greatest threat to endemic forest birds because of the large number of species involved, their ability to establish breeding populations in remote native forest habitats, and lack of regulation and enforcement. Efforts should be made to encourage local production of pet birds in disease-free facilities to minimize numbers of new hosts entering the State. A public outreach program is needed to educate pet bird owners about the threats pet birds pose to the endemic avifauna. Existing quarantine and importation laws should be enforced and made more restrictive. The Avian Disease Working Group should meet to determine whether a centralized quarantine facility similar to the facility for rabies quarantine for dogs and cats should be established for imported birds.

2.5.1.2 Work with the Postal Service and the State Department of Agriculture to ban shipments of poultry and game birds to Hawai`i via first class mail. (Priority 1)

Importation of day-old poultry and game birds from flocks that are not tested or certified to be free of avian pathogens can be an important unregulated route for entry of new pathogens into the State. The Avian Disease Working Group should meet to propose legislation that will close loopholes in laws regulating movement of domestic and wild birds to Hawai`i. An outreach program is needed to educate the public about the potential dangers of unregulated shipments of live birds to public health, domestic poultry, pet birds, and wildlife.

2.5.1.3 Establish a monitoring program for new diseases and diagnose causes of avian disease outbreaks. Rapid response to new introductions of both diseases and disease vectors is essential for containing their spread. The Avian Disease Working Group should meet to discuss strategies for monitoring for disease outbreaks and to discuss creation of a rapid response plan for containing and eradicating new outbreaks that threaten endemic wildlife. This plan should identify responsible parties, lines of authority, and funding sources for actual control operations.

2.5.1.3.1 Develop a list of priority diseases to be screened in all imported cage birds and poultry. (Priority 1)

Some pathogens, such as West Nile virus (Bernard *et al*. 2000), pose an inherently greater risk to wildlife than others, particularly those with a broad host range and those that affect species with close phylogenetic relationships to Hawaiian avifauna. The Avian Disease Working Group should identify a list of “hot” pathogens that may pose a high risk for the endemic avifauna. Mandatory testing for these pathogens should be required for imported birds that may serve as potential carriers.

2.5.1.3.2 Respond to and determine causes of avian disease outbreaks in forest bird recovery areas and in other areas. (Priority 1)

Because of their close proximity to human habitation, areas outside forest bird recovery areas may be where a new pathogen or vector is detected. Long-term funding and expansion of diagnostic and research capabilities at the Honolulu Field Station of the U.S. Geological Survey - National Wildlife Health Center and veterinary expertise at the Hawai`i Division of Forestry and Wildlife should be supported. All State and Federal wildlife biologists and technical support personnel should receive training in how to collect wildlife carcasses and recognize potential wildlife disease outbreaks so that Federal and State wildlife disease experts can be notified immediately about potential outbreaks. Agencies responsible for this training should be identified by the Avian Disease Working Group. The Avian Disease Working Group should prepare detailed protocols, lines of responsibility and designate funding sources to eradicate new disease introductions into the state and to control the spread of existing pathogens into new areas.

2.5.1.4 Work to stop global climate change. (Priority 1) Global warming and local climate change are a serious threat to listed species in Hawai`i primarily because of the potential for movement of disease carrying mosquitoes into higher elevation avian refugia currently free of mosquito breeding sites. This work will require cooperation by appropriate agencies and entities to develop agreements and technologies needed to slow greenhouse gas emissions, a significant factor contributing to global climate change.

2.5.2 Prevent movement of diseases and disease vectors between islands.

Detailed knowledge about potential routes of introduction and spread of diseases and disease vectors between islands is essential for preventing spread of introduced pathogens and vectors. Research that identifies these routes and assesses their relative importance should be supported. Once obtained, this information should be used to assess the magnitude of the problem, institute new procedures for preventing transport of vectors on vessels and aircraft, and introduce new legislation to make inter-island movement of live birds subject to stricter regulation and enforcement.

2.5.2.1 Initiate inspection programs for all inter-island vessels, including ships, airplanes, and barges and their cargos to intercept and kill mosquito larvae and adults. (Priority 1)

Commercial shipping is the most likely route by which mosquitoes first reached the Hawaiian Islands. It is not known whether ocean traffic still plays a role in the spread of mosquitoes from island to island or whether aircraft are now the primary vehicles. Research should assess these risks, attempt to measure the magnitude of the problem, and identify measures that can be taken to decontaminate these vessels. High risk cargos, e.g., bromeliads for the commercial nursery industry, old tires, and containers that may hold water, should be targeted for inspection to insure that mosquito larvae are not transported between islands.

2.5.2.2 Enforce and toughen existing laws that require health certificates for inter-island movement of pet birds and poultry. (Priority 1)

Existing regulations require a health certificate for inter-island movement of domestic poultry and pet birds, but this does not require that birds undergo quarantine or be tested for specific pathogens. Research that assesses the magnitude of inter-island movement of live birds and the effectiveness of existing regulations in preventing spread of pathogens should be conducted in order to justify legislation that will toughen existing laws.

2.5.2.3 Establish disease monitoring protocols for captive native birds to assess presence of avian disease in captive held populations and risk of

transfer of disease strains between avian captive holding facilities. (Priority 2)
The inter-island transport and release of birds that are reared in captive propagation facilities can be a route for movement of disease organisms between isolated populations and facilities if these birds are not reared under mosquito netting or in isolation from wild and domestic birds. Adequate quarantine and isolation protocols must be maintained at all times and periodic disease screening should be conducted to assess efficacy of those protocols.

2.5.2.3.1 Develop a list of diseases of concern for which captive birds should be routinely tested before they can be transferred between avian captive holding facilities. (Priority 2)

2.5.3 Control the mosquito vector (*Culex quinquefasciatus*) of avian pox and malaria.
Source reduction by eliminating larval habitats for mosquito vectors is still the most effective way to manage mosquito populations, although emerging technologies that use cytoplasmic incompatibility to control adult populations or genetic manipulation of vectors to reduce their capacity to transmit infections may be feasible in the future.

2.5.3.1 Determine primary source areas of mosquitoes through surveys of potential larval habitats.
Culex quinquefasciatus is a mosquito that has become established in native and nonnative habitats in the Hawaiian Islands at elevations below 1,800 meters (5,900 feet), although a few records exist from sites as high as 2,100 meters (6,900 feet) (Goff and van Riper 1980). The

preferred larval habitat is standing water with a high organic content, although larvae of this mosquito can develop in clear, clean aquatic habitats if other sites are not available. Primary sources for *Culex* mosquitoes in Hawai`i are man-made bodies of water (cattle troughs, buckets, cans, and small ponds) in residential and agricultural areas that are contaminated with animal or human waste and feral animal-damaged tree ferns that catch and hold rain water in forest habitats. Other sites that contribute to mosquito productivity are temporary ground pools, pig wallows, tree holes, and stream margins, but their relative role in contributing to epidemic outbreaks or pox and malaria are not known (D. LaPointe and C. Atkinson, U.S. Geological Survey, unpubl. data). Effective control depends on identifying and either eliminating or treating these sites over areas large enough to exceed the flight range of adult mosquitoes. The ability of adult *Culex* to travel up to 3 kilometers (1.9 miles) through closed-canopy forest (D. LaPointe, U.S. Geological Survey, unpubl. data) and potentially much farther along natural and man-made corridors such as fence lines, roads, and lava flows makes it important to create a suitable buffer around recovery areas where management actions can be taken to reduce numbers of mosquitoes.

2.5.3.1.1 Survey recovery areas for mosquito breeding sites and adjacent lands for mosquito breeding sites that may serve as sources of wind-dispersed adult mosquitoes (see Table 12).

Table 12. Areas where mosquito surveys are needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. For key to landowner and partnership acronyms, refer to the Implementation Schedule (page 5-7).

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.1	H	Portions of parcels between the 2,000 and 5,000 foot contour lines on Mauna Loa and Kīlauea Volcanoes that include recovery area	Results of surveys for larval mosquitoes conducted by U.S. Geological Survey-BRD in the Upper Waiākea Forest Reserve, Hawai`i Volcanoes National Park, and Kona Unit of Hakalau Forest National Wildlife Refuge indicate that primary larval habitats are feral pig damaged tree ferns, cattle troughs and stock ponds, and infrastructure associated with human dwellings. Extensive work already conducted in these areas lowers priority ranking.	3
2.5.3.1.1.2	H	Portions of parcels between the 3,400 and 5,000 foot contour lines on Mauna Kea Volcano that include recovery area	Preliminary surveys by U.S. Geological Survey-BRD conducted at Hakalau Forest National Wildlife Refuge found abundant larval habitat in feral pig damaged tree ferns, but few mosquitoes. Larvae were rarely found in stagnant pools along stream margins. Additional work is needed in these areas to document seasonal trends and distribution of mosquito vectors.	1
2.5.3.1.1.3	H	Portions of parcels 371001001,372002001, 374002008,374001003, 374002007, 374001002 between the 3,400 and 5,000 foot contour lines on Hualālai Volcano that include recovery area	Surveys for adult and larval mosquitoes have not been conducted in these areas and have high priority. Preliminary disease surveys by State of Hawai`i, Hawai`i Department of Land and Natural Resources have shown that pox and malaria are present, but nothing is known about the dynamics of their transmission.	1

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.4	H	Portions of windward Hāmākua parcels between the 3,400 and 2,000 foot contour lines on Mauna Kea Volcano that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Surveys for adult and larval mosquitoes have not been conducted in these areas. Their windward location makes them possible sources for wind-dispersed mosquitoes that could threaten higher elevation habitats, but their distance from recovery area makes them lower priority.	2
2.5.3.1.1.5	H	Portions of parcels on Kīlauea Volcano that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Results of surveys for larval mosquitoes conducted by U.S. Geological Survey-BRD in Hawai`i Volcanoes National Park and Keauhou Ranch indicate that primary larval habitats are feral pig damaged tree ferns, cattle troughs and stock ponds, and infrastructure associated with human dwellings. Mosquito survey work on parcels on Kīlauea Volcano near recovery area should determine relative contributions of human-associated dwellings and infrastructure and forest habitat to mosquito populations. High priority areas include Volcano Village and surrounding subdivisions and agricultural lands.	2
2.5.3.1.1.6	H	Portions of parcels on Hualālai Volcano that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Surveys for adult and larval mosquitoes have not been conducted in these areas. Their close proximity to recovery area on Hualālai and role as potential sources of dispersing adult mosquitoes give them high priority for surveys.	2

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.7	M	Multiple land parcels in recovery area between 2,500 and 5,000 foot contour lines	Limited surveys by U.S. Geological Survey-BRD from 4,000-6,000 feet on parcels 224016002 and 223005004 suggest that tree ferns damaged by feral pigs may be a primary larval habitat for mosquitoes and a major contribution to mosquito populations. The importance of temporary and permanent pools in stream drainages is less clear. Additional surveys throughout recovery area in this elevation zone are needed to prioritize mosquito control efforts.	1
2.5.3.1.1.8	M	Multiple land parcels on the northern slope of Haleakalā between the 2,500 foot contour line and Hāna Highway	Mosquito surveys in these parcels have not been conducted and their relative contribution to mosquito populations on East Maui is not known. These parcels could be a significant source of wind-dispersed mosquitoes that could threaten higher elevation habitats, but are classified as lower priority because of their distance from recovery area.	2
2.5.3.1.1.9	M	217004006	Manawainui Valley incursion into recovery area, from 2,500 to 1,600 feet. Deep valleys may serve as natural corridors for dispersal of wind-blown mosquitoes. Because of their potential role as natural funnels, priority ranking for mosquito surveys is higher.	1
2.5.3.1.1.10	M	215001001	Waiho`i Valley incursion into recovery area, from 2,500 to 2,000 feet.	1
2.5.3.1.1.11	M	216001002	Kīpahulu Valley incursion into recovery area, from 2,500 to 1,600 feet.	1
2.5.3.1.1.12	M	211002002	Ke`anae Valley incursion into recovery area, from 1,800 to 2,500 feet.	1

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.13	M	Multiple parcels below and within 3 kilometers (1.9 miles) of the 4,000 foot contour line on the southern and western slopes of Haleakalā	Surveys for adult and larval mosquitoes have not been conducted in these areas, but high density of rural development, particularly on the western slopes of Haleakalā, could be a significant source of mosquitoes. Priority for this area is low until suitable recovery area has been restored.	3
2.5.3.1.1.14	M	Multiple land parcels in recovery area between 2,500 and 5,000 foot contour lines	Surveys for adult and larval mosquitoes have not been conducted in these areas. Detailed knowledge about the dynamics of disease transmission in the West Maui mountains is needed.	1
2.5.3.1.1.15	M	233003003, 235003001, 233003004, and multiple smaller parcels within `Īao Valley	`Īao Valley incursion into recovery area, from 2,500 to 600 feet. Low elevation parcels located in deep valleys in the West Maui mountains could be a significant source of wind-dispersed mosquitoes that could threaten higher elevation habitats.	2
2.5.3.1.1.16	M	232014001, 233003003	Waiehu Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.17	M	232014001	Waihe`e Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.18	M	231006001	Kahahuloa Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.19	M	241001017	Honokōhau Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.20	M	236003001, 235003001	Waikapū Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.21	M	241001017	Honolua Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.22	M	242001001	Honokahua Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.23	M	242001001	Kahana Valley incursion into recovery area, from 2,500 to 600 feet.	2

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.24	M	244007004, 244007011, 244007001, 244007005	Honokōwai Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.25	M	245022001	Kahoma Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.26	M	246025002	Kanahā Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.27	M	246025001, 247001002	Mākila Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.28	M	248001002	Olowalu Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.29	M	248001002	Ukumehame Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.30	M	236003001	Pōhākea Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.31	M	245022003	Waihikuli Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.32	M	245022004	Hanakea Valley incursion into recovery area, from 2,500 to 600 feet.	2
2.5.3.1.1.33	M	Multiple parcels below and up to 3 kilometers (1.9 miles) from the 2,500 contour line around the West Maui mountains	Surveys for adult and larval mosquitoes have not been conducted in these areas, but they could be important sources for wind-dispersed mosquitoes, particularly rural and urban areas in and near Kahului and Lahaina. Priority for surveying these areas is lower because of their distance from recovery area.	3
2.5.3.1.1.34	MO	Multiple land parcels in recovery area	Surveys for adult and larval mosquitoes have not been conducted in these areas and virtually nothing is known about disease threats to forest birds. Vector surveys and disease studies should be done prior to attempts to reintroduce endangered birds.	1

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.35	MO	261001002, 259006011, 259006002 and smaller windward parcels in Waihānau, Wai`ale`ia, Waikolu, Pelekunu, and Wailau Valleys that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Surveys for adult and larval mosquitoes have not been conducted in these areas. Their windward location increases the possibility they funnel mosquitoes into higher elevation habitats.	2
2.5.3.1.1.36	MO	Parcels in Kaunakakai Gulch	Kaunakakai Gulch may act as a natural corridor for dispersal of mosquitoes from urban/suburban Moloka`i directly into recovery area.	2
2.5.3.1.1.37	MO	Portions of parcels 252014003, 253003005, 254003025, 254003001, 255001006 and others that are adjacent to or within 3 kilometers (1.9 miles) of the southern and eastern boundaries of recovery area on leeward Moloka`i	Surveys for adult and larval mosquitoes have not been conducted in these areas. Since the region is deeply dissected by numerous stream valleys that could funnel mosquitoes into recovery area, vector surveys should ideally extend from the lower boundary of recovery area to the coastline, particularly in locations with rural agricultural development.	2
2.5.3.1.1.38	O	Portions of parcels that include recovery area	Surveys for adult and larval mosquitoes have not been done and nothing is known about the dynamics of disease transmission in these areas.	1
2.5.3.1.1.39	O	Portions of parcels that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Detailed surveys for adult and larval mosquitoes have not been done in these areas. It is likely that urban and suburban development and agriculture are primary contributors to mosquito populations that may disperse into recovery area, but this needs to be documented.	2

Table 12. Areas where mosquito surveys are needed				
Recovery Action #	Island	Land Parcel, Tax Map Keys	Current Landowner/Comments	Priority
2.5.3.1.1.40	K	Portions of parcels 414001020, 414001014, 414001013, 459001016, 459001001, 414001003, 417001001, 458001001 and others that include recovery area	Preliminary surveys of parcels 414001013 and 414001003 by U.S. Geological Survey-BRD have failed to find larval mosquitoes in extensive bogs on the lower Alaka`i Plateau. Mosquito larvae were rarely found in stagnant areas of stream margins. Additional detailed surveys needed to determine whether stream margins are the primary sources for adult mosquitoes in remote areas of the plateau. Detailed vector surveys are needed in developed areas of Kōke`e to determine relative role that human housing and infrastructure plays on generation of mosquitoes.	1
2.5.3.1.1.41	K	Portions of parcels 459001001, 458001001, 458002002, 459001003, 459001002 that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Surveys for adult and larval mosquitoes have not been conducted in windward valleys of the Alaka`i Plateau and it is not clear whether wind dispersal through these natural corridors could be a source of mosquito vectors at higher elevations.	2
2.5.3.1.1.42	K	Portions of parcels 414001014, 414001020, 414002040, 414001003, 417001001 that are adjacent to or within 3 kilometers (1.9 miles) of recovery area	Surveys for adult and larval mosquitoes have not been conducted in leeward valleys and slopes of the Alaka`i Plateau; it is not clear whether wind dispersal up steep canyons that abut the southern plateau rim could be a source of mosquito vectors at higher elevations. Surveys should extend into stream drainages in Waimea Canyon to determine extent of mosquito habitat at lower elevations and its potential threat to higher elevation forests.	2

2.5.3.1.2 Eliminate or treat larval habitats in recovery areas and adjacent areas with BTI (*Bacillus thuringensis israeliensis* toxin), Dunk®, or other environmentally compatible pesticides that are safe for non-target organisms. (Priority 1) Known mosquito sources within recovery areas or within 3 kilometers (1.9 miles) of the lower, windward boundaries of recovery areas have the highest priority for control. Adjacent leeward parcels and stream valleys are lower in priority because of lower rainfall and location in the wind shadow of major topographic features. Windward areas more than 3 kilometers (1.9 miles) from the lower boundaries of recovery areas have the lowest priority. BTI currently is the most specific, environmentally compatible pesticide available for use against *Culex* mosquitoes. It has not been evaluated on all related Nematoceran diptera (other members of the order Diptera, suborder Nematocera, to which mosquitoes belong) and the potential non-target effects of this pesticide should be evaluated against endemic diptera prior to broad scale use over large areas. Use is recommended in situations where application is limited to stock ponds and other man-made bodies of water where non-target effects are not at issue. In remote areas where primary larval habitats are associated with feral pig damaged tree ferns, fencing and elimination of feral ungulates, coupled with manual drainage of all damaged ferns, can eliminate larval habitats and reduce mosquito populations if coverage is adequate and treatment areas are large enough to buffer emigration of adult mosquitoes from adjacent non-recovery area.

2.5.3.1.3 **Eliminate or treat larval habitats associated with human development (e.g., residential areas, agricultural sites, game bird waterers) that are located within or adjacent to recovery areas; coordinate efforts with the State Department of Health.** (Priority 1)

In locations where human development is close to recovery area (e.g., subdivisions and ranches adjacent to Hawai`i Volcanoes National Park, Kōke`e State Park, and the Alaka`i Wilderness Preserve), larval habitats associated with residential and agricultural development may be primary sources for mosquitoes responsible for seasonal epizootics of pox and malaria. Outreach efforts should be made to inform the public about eliminating refuse, cleaning gutters, covering catchment tanks, and treating stock ponds and cattle troughs and increasing public awareness about threats to human (e.g., Japanese B encephalitis, West Nile Fever), animal (dog heartworm), and wildlife (avian malaria and pox) health from mosquitoes. These efforts should be coordinated with the State Department of Health.

2.5.3.1.3.1 Eliminate or treat cattle troughs and stock ponds. (Priority 1)

2.5.3.1.3.2 Eliminate or treat game bird waterers in areas where they might impact native forest birds. (Priority 1)

2.5.3.1.3.3 Repair rain gutters, cover catchment tanks, and eliminate containers that catch and hold rainwater in agricultural and residential locations near recovery areas. (Priority 1)

2.5.3.1.3.4 Initiate public outreach efforts to inform the public about potential human and animal diseases transmitted by mosquitoes and how source reduction can reduce those threats. (Priority 1)

2.5.3.1.4 Eliminate larval habitats associated with feral animals in recovery area and adjacent lands. (Priority 1) Primary sources of mosquitoes in these areas are fallen tree ferns (*Cibotium* spp.) that have been hollowed enough by feral pigs and rodents to catch and hold rain water. Reduction of numbers of feral pigs through fencing and hunting followed by manual drainage of these bodies of water can significantly reduce available larval habitat, but more than 75 percent of these tree ferns must be eliminated and the treatment area must exceed the minimal dispersal range of adult *Culex* mosquitoes to be effective (C. Atkinson and D. LaPointe, U.S. Geological Survey, unpubl. data). Rodents may contribute to less than 10 percent of these sites (D. LaPointe, U.S. Geological Survey, unpubl. data), but additional research is needed.

2.5.3.1.4.1 Identify and fence priority recovery areas below 1,520 meters (5,000 feet) and control feral ungulates to prevent creation of new larval habitats. (Priority 1)

2.5.3.1.4.2 Manually drain feral pig-damaged tree ferns that hold water and fill or drain pig wallows in

appropriate areas to reduce mosquito breeding sites. (Priority 2)

2.5.3.1.5 Identify natural sites (e.g., stream margins, tree holes) that serve as larval habitat and determine feasibility of treatment or elimination. (Priority 2)

Streams, stream margins, tree holes, bogs, and natural ponds are potential larval habitat for *Culex* mosquitoes. The importance of these larval habitats should be documented through additional research.

2.5.4 Foster ability of native birds to tolerate or develop resistance to avian pox and malaria. In the absence of continual introductions of new strains or genetic variants of avian pox and malaria to Hawai`i, the disease system (vector, parasite, and avian hosts) will begin to evolve new relationships through processes of natural selection. Current evolutionary theory predicts that the virulence of the disease agents will decrease and the resistance of highly susceptible forest birds to these introduced diseases will increase (van Riper *et al*. 1986, Atkinson *et al*. 1995, Cann and Douglas 1999, Jarvi *et al*. 2001, Shehata *et al*. 2001). Direct evidence for this process is still limited and based primarily on observations of breeding populations of more common native species (e.g., O`ahu `amakihi, O`ahu `elepaio, `apapane) at elevations where transmission of pox and malaria is believed to be stable and endemic.

2.5.4.1 Ensure that existing low elevation native bird populations and habitats within current zones of disease transmission are protected to preserve disease tolerant genotypes. (Priority 1)

2.5.4.2 Use birds that occur in areas with disease transmission as founders for translocations to establish new populations. (Priority 2)

2.5.5 Monitor long-term changes in the prevalence and transmission of avian diseases in forest bird recovery areas. (Priority 2)

Monitoring that documents the long-term patterns of change in the epidemiology and pathogenicity of introduced avian diseases will be important for measuring the effectiveness of management actions and for determining how complex interactions between abiotic and biotic environmental factors, anthropogenic factors, native and nonnative hosts, vectors and diseases are evolving.

2.6 Reduce or eliminate effects of alien species.

Introductions of nonnative species to the Hawaiian Islands have caused changes to native ecosystems and harm to native forest birds through habitat modification, disease, and competition. Efforts to reduce the numbers of new introductions of detrimental species and to control nonnative species that are already introduced are necessary to conserve and recover Hawaiian forest birds.

2.6.1 Prevent introductions of new detrimental species.

Prevention of the introduction of new detrimental species to the Hawaiian Islands is the most efficient way to protect native ecosystems. Once an invasive species has become established, technologies may not exist for its removal or control, and control programs can be very expensive. The most efficient way to prevent further damage to native ecosystems due to effects of new detrimental species is to prevent their introduction.

2.6.1.1 Encourage Hawai`i Department of Agriculture to modify import lists to exclude reptiles and amphibians from commercial sale. (Priority 2) Reptiles and amphibians that escape into the wild may impact listed forest birds by preying on insects or other foods upon which these species feed, predating eggs, nestlings and adults, and as food for forest bird predators, increasing predator populations.

2.6.1.2 Encourage the Hawai`i Department of Agriculture to modify import lists to decrease the numbers of vertebrate species allowed into the State. (Priority 2)

2.6.1.3 Assist the Hawai`i Department of Agriculture with obtaining an enforcement branch to pursue smuggling and release violations. (Priority 2)

2.6.1.4 Encourage the adoption of State injurious species lists as part of Federal injurious wildlife listed under the Lacey Act. (Priority 2)

2.6.1.5 Encourage the Hawai`i Department of Agriculture, Hawai`i Department of Land and Natural Resources, U.S. Fish and Wildlife Service, and County police departments to develop a task force to pursue smuggling and release violations.
(Priority 2)

2.6.1.6 Provide single point-of-exit at airports to help facilitate inspection of cargo and interdiction of alien species. (Priority 2)

2.6.1.7 Increase the numbers of Hawai`i Department of Agriculture and U.S. Department of Agriculture inspectors to better cover nursery cargo and passenger baggage/hand-carry. (Priority 2)

2.6.1.8 Secure Congressional approval of U.S. Department of Agriculture quarantine of goods imported from the U.S. mainland. (Priority 2)

2.6.1.9 Prevent inter-island expansion of established vertebrates with currently restricted ranges. (Priority 1)

2.6.2 Eradicate all incipient populations of new nonnative vertebrate species. (Priority 1)

2.6.2.1 Prevent spread of *Eleutherodactylus* frogs to new areas. (Priority 1) The coqui frog, *Eleutherodactylus coqui*, was accidentally introduced into Hawai`i from Puerto Rico in about 1988. It is established on Hawai`i and Maui, and there are incipient populations in other areas. Coqui frogs can reach extremely high densities, up to 10,000 animals per hectare, and are known to consume large numbers of insects. Insectivorous birds in particular may be threatened by competition for food with the coqui, and all forest birds, regardless of their usual diet, may be affected during the breeding season when they rely on insects to feed their young.

2.6.2.2 Eradicate/control populations of *Eleutherodactylus* where possible. (Priority 1)

2.6.3 Reduce or eliminate the detrimental effects of *vespulid* wasps (yellow jackets) on forest birds within forest ecosystems. (Priority 2)

Vespulid wasps are known to consume large biomass of insect foods. Insectivorous birds in particular are likely to be affected by the consequent reduction in available prey, and all forest birds may be affected during the breeding season, when they rely more on insects to feed their young.

3. Develop Captive Propagation and Related Recovery Strategies. Establish or augment populations of endangered species in suitable, managed habitat using captive propagation and reintroduction techniques. (Priority 1)

Captive propagation programs are developed in accordance with the guidelines established by the U.S. Fish and Wildlife Service's Policy on Controlled Propagation (U.S. Fish and Wildlife Service 2000c) the International Union for the Conservation of Nature, World Conservation Union's Conservation Breeding Specialist Group's policy on captive propagation (International Union for the Conservation of Nature 1987, 2000), the World Conservation Union's Reintroduction Specialist Group's Guidelines for Reintroduction (International Union for the Conservation of Nature 1998), the American Association of Zoological Parks and Aquariums Reintroduction Advisory Group's guidelines (Beck 1992), Conservation Breeding Specialist Group's Conservation Assessment Management Plan recommendations (Ellis *et al*. 1992), and Small Population Management Advisory Group Guidelines (AZA, Small Population Management Group 2000).

3.1 Periodically evaluate and identify the target species that will require captive propagation for recovery and the appropriate strategy to be used. (Priority 1)

Evaluation of the importance of captive propagation in recovery of each species requires consideration of criteria such as taxonomic uniqueness, urgency (degree of threat), and cause of decline in the wild. Also of consideration are the available knowledge of species' natural history, status of current research, habitat management efforts in the field, and the potential for collaboration, practical considerations (funding and expertise/labor), population size, probability that the species will breed in captivity in sufficient numbers to reestablish a wild population, release history, availability of suitable release sites, political environment (existence of habitat conservation plans, safe harbor agreements, etc.), the species' value as a basic component of the ecosystem (e.g., significance as a seed disperser or pollinator), cultural value, educational value, and value as a model for the recovery of other endangered species. The relative cost versus benefit for maintaining a self-sustaining or genetically viable reproducing flock of birds in captivity versus the cost for maintaining a field team to locate nests, collect eggs, incubate, rear, and release need to be weighed. The most effective recovery programs are those that can accomplish their goals for the least amount of investment. The appropriate captive propagation strategy should be selected based on the recovery imperative, the status of the wild population, the accessibility of eggs and the difficulty in locating nests, and the relative effectiveness of alternative recovery strategies. Table 13 provides an overview of recovery strategies and priorities for the use of captive propagation facilities for Hawaiian forest bird species. Refer to Appendix B for a more detailed discussion of prioritization considerations.

3.2 Develop captive propagation programs for target species, including both endangered and surrogate species. (Priority 1) Such programs will require review of known avicultural and release technology in order to address an array of ecologically diverse species, from obligate nectarivores to generalists and insectivores. All aspects of captive management must be considered, including the demographics of small populations, adult diets, incubation, neonatal hand-feeding regimes, enclosure requirements (dimensions, enrichment, and construction materials), veterinary requirements, mate selection, and proper socialization of captive-reared birds. Aviculture and release technology is

Table 13. Captive propagation program strategies and priorities for facilities use. Captive propagation strategies are as follows: 1) No Captive Program Necessary (other recovery strategies more appropriate), 2) Translocation, 3) Rear and Release, 4) Captive-breeding/Immediate Release, 5) Captive-breeding/Self-sustaining Population, 6) Captive-breeding/Production for Restoration, 7) Emergency Search and Rescue, and 8) Technology Development (see Appendix B for more detailed definitions of these strategies). Captive breeding priorities are defined as follows: 1) Species in critical need of recovery efforts involving captive propagation techniques; 2) Species in great need of recovery efforts involving captive propagation techniques, but with somewhat larger population numbers; 3) Species in need of recovery efforts, but for which techniques involving captive propagation are less effective than translocation, habitat management, or habitat restoration; and 4) Non-endangered surrogate species for which captive breeding techniques could be developed to aid the recovery of endangered species. Further details are provided in Appendix B.

Table 13. Captive propagation program strategies and priorities for facilities use.

Species	Captive Propagation Strategies	Captive Breeding Priority
\`alalā	5, 6	1
kāma\`o, oloma\`o, Kaua\`i oo, Bishop's \`o\`o, \`o\`u, \`akialoa, Kaua\`i nukupu\`u, Maui nukupu\`u, O\`ahu \`alauahio, kākāwahie, Maui \`ākepa, po\`ouli	5, 6, 7	1
palila	8, 4	2
nēnē	4	2
Maui parrotbill	8, 4	2
puaiohi	4	2
Kaua\`i creeper	8, 4	3
\`akiapōlā\`au	8, 4	3
O\`ahu \`elepaio	1, 2, 3	3
Hawai\`i \`ākepa	8, 4	3
Hawai\`i creeper	8, 4	3
\`ākohekohe	8, 2, 3	3
Hawai\`i \`elepaio	8	4
\`i\`iwi	8	4
\`ōma\`o	8	4

recognized to be a process of continuous development, refinement, and enhancement. The development of this technology comes only with the experience gained from working with each Hawaiian species and incorporating that experience across the entire spectrum of Hawaiian forest birds. Between 1994 and 2000, the technology to incubate, rear, and maintain 12 species of Hawaiian forest birds was developed, including the endangered Hawai`i creeper, Hawai`i `ākepa, palila, `alalā, Maui parrotbill, and puaiohi. In the future, similar programs may be initiated for `ō`ū, `akiapōlā`au, Maui nukupu`u, Maui `ākepa, oloma`o, po`ouli, O`ahu creeper, kāma`o, Kaua`i nukupu`u, Kaua`i `akialoa, and Kaua`i `ō`ō if nests can be located and eggs collected. Captive management of the Hawai`i `elepaio as a surrogate species will provide propagation and release techniques required for future work with the endangered O`ahu `elepaio. The development of translocation methods for the `ākohekohe should continue, and captive breeding technology should be developed if translocation efforts fail. The appropriate captive propagation strategy for each species should be evaluated and implemented through the development of annual Work Plans and Five-Year Work Plans established between the operators of the captive propagation facilities, Division of Forestry and Wildlife, and the Service, and will include input from the public and Recovery Team(s) and Working Groups. The plans should incorporate the most current information on dynamics of the wild population, available funding, research developments, disease information, available release sites, the relative benefit of captive release strategies compared to other recovery strategies, and the progress made in the captive maintenance and propagation of these species.

3.2.1 `Ō`ū, Maui nukupu`u, Maui `ākepa, oloma`o, O`ahu creeper, kāma`o, Kaua`i nukupu`u, Kaua`i `akialoa, and Kaua`i `ō`ō. (Priority 1)

For these species, which are considered nearly or possibly extinct, efforts should be made to search for adults, and to collect eggs for incubation and captive rearing to establish captive breeding flocks whose progeny will be used for reintroduction into managed habitats in the future. Should no breeding pairs exist in the wild, efforts should be made to create pairs by translocation, bringing birds into captivity, or other appropriate means.

3.2.2 Po`ouli. (Priority 1)
There has been no known reproduction of the po`ouli in the wild since 1995, and a translocation attempt in 2002 failed to produce a wild pairing (see species account). Efforts are currently underway to bring the two po`ouli that may remain in the wild into captivity for propagation. Habitat management to prepare for reintroduction to the wild also must continue.

3.2.3 Puaiohi. (Priority 2)
Maintain a captive breeding flock to produce offspring for reintroductions into managed habitat. Current efforts to maintain a captive flock for reintroduction of progeny have been very successful, with high survival of released birds and subsequent breeding in the wild.

3.2.4 `Akiapōlā`au. (Priority 2)
Collect eggs for incubation and captive rearing to establish a captive breeding flock whose progeny will be used for reintroduction into managed habitat. Because `akiapōlā`au nests are difficult to locate and access, a strategy to maintain a captive breeding flock for release of progeny is recommended.

3.2.5 Maui Parrotbill.
Because Maui parrotbill nests are difficult to locate and access, a strategy to maintain a captive breeding flock for release of progeny is recommended.

3.2.5.1 Collect eggs of Maui parrotbills and maintain a captive breeding flock whose progeny will be used for reintroduction into managed habitat in the future. (Priority 2)

3.2.5.2 **Develop methods for releasing captive birds into managed habitat** on Haleakalā, or on West Maui or Moloka`i if disease is known to no longer be a threat in these areas. (Priority 2)

3.2.6 `Ākohekohe.

3.2.6.1 **Translocate wild birds to West Maui or Moloka`i to establish a second population**, if disease is known to no longer be a threat in these areas. (Priority 2)

3.2.6.2 **Collect eggs for incubation and captive rearing**. (Priority 2) If translocations fail, use “rear and release” of progeny from wild-collected eggs, or establish a captive breeding flock whose progeny will be used for reintroduction into managed habitat in the future.

3.2.7 Palila.

3.2.7.1 **Collect eggs for incubation and captive rearing.** (Priority 2)

3.2.7.2 **If the genetic diversity of palila in the captive flock drops below acceptable levels (defined as less than 90 percent), collect wild eggs.** (Priority 2)

3.2.7.3 **Maintain a captive breeding flock whose progeny will be used for reintroduction into managed habitat.** (Priority 2) Initial attempts at translocation of wild palila have not been successful. Releases of captive reared birds may be a more effective strategy to establish a new and disjunct population of palila on Mauna Loa or Mauna Kea.

3.2.8 Hawai`i `Ākepa and Hawai`i Creeper.
Because nests of these species are difficult to locate and access, a strategy to maintain a captive breeding flock for release of progeny is recommended.

3.2.8.1 Collect eggs for incubation and captive rearing. (Priority 3)

3.2.8.2 Maintain captive flocks of Hawai`i `ākepa and Hawai`i creeper whose progeny will be used for reintroduction into native, managed habitat in the future, or rear and release in managed habitat. (Priority 3)

3.2.9 O`ahu `Elepaio. (Priority 3)
Collect the eggs of Hawai`i `elepaio to serve as a surrogate to develop techniques to breed, incubate, rear, and release the endangered O`ahu subspecies. At this time recovery strategies other than captive propagation and release, such as predator control, are likely to be most effective for recovering the O`ahu `elepaio. If these strategies are not successful, rear and release methods may be needed.

3.3 Develop methods of evaluating, selecting, and preparing sites for releases and/or translocation of endangered birds to ensure long-term persistence of reintroduced populations, including potentially suitable habitat outside the species' known historic range. The goal is to select and restore habitat that fulfills the year-round requirements for the species to ensure that birds remain in the managed habitat (e.g., sufficient seasonal food resources, nesting and roosting sites). Site selection and subsequent management should include the evaluation of the species' natural history requirements, vegetative analysis, physical qualities (area), elevation, elevational gradient, topography, soil characteristics, prevailing weather patterns, corridor potential, proximity to other congeneric populations, biological limiting factors (e.g., diseases, mosquitoes, predators, food availability, feral ungulates, alien competitors), anthropogenic threats, historical habitat modification and cultural practices of pre-contact Hawaiians, and current level of management and landowner cooperation and integration (habitat conservation plans, safe harbor agreements, etc.). Methods also should consider prevalence of threats identified, and the species' likely response to novel habitat and threats. If areas available for releases may not provide all requirements during some periods of the year but logistical or other concerns necessitate release in these areas, then technologies must be available to support released birds during periods when essential niche characteristics are temporarily absent. Species and areas currently in need of habitat evaluation and selection for releases of endangered birds include:

3.3.1 Leeward Haleakalā, West Maui, and Moloka`i for Maui forest birds. (Priority 2)

3.3.2 Upland dry forest areas on Mauna Kea and Mauna Loa for palila. (Priority 2)

3.3.3 Additional sites for ongoing releases of puaiohi. (Priority 2)

3.3.4 South Kona, Kapāpala/Ka`ū, and upland forests of Mauna Kea for `akiapōlā`au. (Priority 2).

3.4 Acquire funding to build additional facilities to maintain, propagate, incubate, and rear endangered species and, if necessary, surrogate species. (Priority 1)

The U.S. Fish and Wildlife Service and the State of Hawai`i will attempt to provide funding to operate the existing captive breeding facilities and to construct additional facilities, supplemented by private sector funding. Funding needs and availability will be considered in Annual Workplans and Five-Year Work Plans that prioritize the captive propagation activities for the year as well as for the long-term.

3.5 Identify wild populations and/or individuals with potential natural disease resistance on a species-by-species basis.

(Priority 1)

It is possible that populations or individual birds exist that have some natural resistance to introduced pathogens. If so, these birds could serve as the founder stock for reestablishing populations within a species' historical range. Whenever possible, those populations or individuals with demonstrated resistance through multiple generations should be exploited as a recovery resource, either through translocation or through captive propagation. Currently there is anecdotal evidence of disease resistance or tolerance in some individuals within populations of the O`ahu `elepaio (VanderWerf 2006) and the non-endangered O`ahu `amakihi (*Hemignathus flavus*) (Shehata *et al*. 2001) and Hawai`i `amakihi (*Hemignathus virens virens*) (Jarvi *et al*. 2001), but this needs to be more fully examined and confirmed. Similar resistance or tolerance should be sought in other endangered species. However, if captive-breeding of founders from potentially disease-resistant populations is undertaken in the future, management of captive flocks also should continue to focus on the preservation of genetic diversity in order to avoid any potentially adverse effects associated with artificial selection in a captive environment (American Zoological and Aquarium Association, Small Population Management Group 2000).

3.6 Develop and refine techniques for the release of captive-reared birds into managed habitat.

Options include both hard- and soft-release, with the difference being the amount of support the released birds receive during their transition to independence. Initially, releases should be conservative and provide as much support as logistically possible (soft release); for example, providing supplemental food, protection from weather if necessary, and veterinary attention if required. When more is known regarding a species' tolerance to the rigors of release, harder releases can be considered.

3.6.1 Monitor dispersal, survival, and mortality of released birds to refine propagation and release techniques. (Priority 1)
The value of this aspect is often overlooked or underestimated as a component of captive propagation for recovery. It is important to monitor released birds to determine their long-term survivorship, potential to utilize managed habitat, and capacity reproduce and expand their population.

3.6.2 Develop and refine release (hacking) procedures. (Priority 2)
Various release methods should be considered for each species, subject to constraints of the release site. To be considered are microhabitat, size, dimension, and exact location of the hacking aviary; location and positioning of supplemental food stations; locations of field observations; and logistical considerations for the construction and dismantling of each release aviary. Continue to develop and refine species specific (or program specific) reintroduction guidelines based on risk assessments that consider the behavioral, disease, demographic, and genetic needs of the species, with the ultimate goal being the reestablishment and recovery of wild populations.

3.7 For each of the species identified as candidates for captive propagation, establish demographic goals for the captive propagation program, e.g., how many birds to produce using which demographic strategy over what period of time and released into how many sites. (Priority 2)
The augmentation of wild populations using captive propagation requires the development of cost-effective management programs that are designed to maintain population genetic diversity and demographic security considering the resources available.

3.8 Develop species specific reintroduction guidelines based on risk assessments that consider the behavioral, disease, demographic, and genetic needs of the species, with the ultimate goal being the re-establishment of wild populations. (Priority 2)

3.9 **Provide biological samples from captive held birds** to an approved holding location or locations determined on a species-by-species basis for use in genetic and veterinary examination. (Priority 2)

Biological samples, such as blood, taken from captive birds can be used for a variety of purposes, including testing genetic relatedness of founder populations or their progeny, development of genetic libraries, and veterinary health studies. These studies may be crucial to understanding the threats endangered Hawaiian forest birds face in their native habitat and developing effective recovery and captive management strategies.

3.10 **If egg collections fail, develop methods of bringing nestling birds, juveniles, and/or adults into captivity with concomitant quarantine procedures.** (Priority 2)

3.11 **Establish a cryogenic cell culture of germplasm of the endangered Hawaiian avifauna at two partner institutions willing to hold the cell line in perpetuity.** Although the advancement of several technologies (e.g., cloning and embryo transfers) may still be several years in the future, it will be increasingly important to anticipate the future potential of such options and to preserve the cell lines while there is still the chance to do so. Collaborating institutions with laboratory resources, institutional stability, and long-term interest need to be identified. The goals of such efforts should be established in advance.

3.11.1 **Obtain and hold cryogenic germplasm of the rarest species in the event of death, or if a population is below 300 individuals.** (Priority 1)

3.11.2 **Obtain and hold cryogenic germplasm for all other endangered forest birds.** (Priority 2)

3.12 Evaluate the outplacement of endangered species currently at the Keauhou Bird Conservation Center and Maui Conservation Center to the Honolulu Zoo or other qualified institutions.

3.12.1 Evaluate the Honolulu Zoo or other qualified institutions as repositories for those endangered species and/or individuals that are not contributing to the captive propagation program. (Priority 2)
These would include non-reproductive, non-releasable individuals, individuals of species that are in the captive program but for which it is not a high priority to continue to enlarge the captive inventory through breeding, and species which do not have a release component at the present time. Benefits would include public education as well as freeing up aviary space for higher priority species.

4. Conduct Research as Needed.
The complexity of threats to endangered forest birds and the large number of actions proposed to deal with these threats require that research and management go hand-in-hand. The relative importance of different threats may vary in space and time among species of birds, so it is important to identify the threats to particular populations through research. Adaptive threat management requires the development of methods to control identified threats and evaluation of the effectiveness of those control methods. In addition, populations may be subject to intrinsic natural properties, such as vulnerability to demographic and environmental stochasticity, low reproductive rates and dispersal, source/sink relations, and social habitat selection. Thus we need to determine the role of food, nest-sites, forest structure, diseases, predators, and competitors as the basis for different densities of birds. Opportunities for applied research are available using both experimental approaches as well as observational studies that take advantage of correlational patterns in the distribution of the bird species and their threats. The knowledge gained from research is the basis for identifying threats,

prioritizing management actions for ecosystems as well as individual species, determining the effectiveness of implemented actions, and developing new or improving existing management approaches.

4.1 Identify the threats that cause geographical variation in density and that maintain populations at or below carrying capacity within particular locations.

4.1.1 Identify species-specific niche requirements and the role of habitat degradation and competition in reducing carrying capacity. (Priority 2)

The availability of resources such as prey types, foraging substrates, nest-sites, and roost sites can dictate the carrying capacity of the environment. Knowledge of species niche requirements and the availability of required resources, in relation to the expected and actual number of individuals, is an effective method of identifying the magnitude of a threat. Habitat degradation and competition are threats that can reduce carrying capacity, and therefore population density and size.

4.2 Study the magnitude of threats and, if appropriate, develop and evaluate effective methods for control.

The numerous species that threaten forest birds have their own life histories, including feeding habits, breeding biology, and dispersal characteristics. Effective control of plants and animals that threaten forest birds can be greatly enhanced by knowledge of their biology. Experimental approaches to control will be needed to assess the effectiveness of the methods developed in reducing populations of these species.

4.2.1 Develop improved methods for controlling alien mammalian predators over large areas.

4.2.1.1 Continue efforts to register hand and aerial broadcast methods for dispersing diphacinone toxicants for controlling predators. (Priority 1) Experimental studies on Hawai`i and O`ahu have demonstrated that diphacinone can be effective in reducing numbers of introduced rodents (VanderWerf and Smith 2002) and mongooses (Keith *et al.* 1989, Stone *et al*. 1994, Smith *et al*. 2000). The current registration allows only application using bait stations, which is very labor-intensive and limits effective use of this tool to small areas. For control of predators over a spatial scale that is meaningful for recovery of endangered forest birds, additional efforts leading to registration labels that allow hand- or aerial-broadcasting of diphacinone are needed. A public education campaign that explains the need for use of diphacinone and its relative safety is also necessary.

4.2.1.2 Evaluate the efficacy of toxicants other than diphacinone for controlling mammalian predators and take the steps needed for their registration. (Priority 2)

4.2.1.3 Develop and evaluate improved methods for controlling predators, such as more efficient traps, contraceptives, and predator-proof fences for important areas. (Priority 1)

4.2.2 Rat control study. (Priority 1)
Study rat ecology in forest bird habitats to determine food habits, breeding success, and selection of foraging, roosting, and breeding habitat at appropriate spatial scales in order to determine which aspects of their ecology might be the weakest link in their ability to survive control programs.

4.2.3 Feral cat control study. (Priority 1)

Study feral cat ecology in forest bird habitats to determine habitat selection, food habits, range, and density so control methods can be designed more efficiently.

4.2.4 Mongoose control study. (Priority 1)

Study mongoose ecology in forest bird habitats to determine habitat selection, food habits, range, and density so control methods can be designed more efficiently.

4.2.5 Mosquito control study. (Priority 1)

4.2.6 Ungulate exclusion and control study. (Priority 2)

Experimental tests are needed of alternative methods for controlling and/or excluding feral pigs, goats, sheep, mouflon, and axis deer.

4.2.7 Weed control study. (Priority 2)

4.2.8 Yellow jacket wasp control study. (Priority 2)

Determine the factors that limit yellow jacket populations seasonally in some areas in order to develop effective methods of control. In addition, dietary work is needed to increase understanding of the potential impacts of yellow jackets on insectivorous forest birds that specialize on different components of the forest arthropod community.

4.2.9 Barn owl (*Tyto alba*) and pueo (*Asio flammeus sandwichensis*) study. (Priority 2)

Study barn owls and pueo in forest bird habitats to determine densities and impacts on native forest birds.

4.2.10 Avian competitor control study.

Study nonnative passerines in forest habitats to determine food habits, breeding success, range, density, nesting habitat, and direct and indirect competitive interactions with native forest birds in order to determine the extent of niche overlap and competition with native forest birds and, if necessary, how their populations might be best controlled.

4.2.10.1 Investigate red-billed leiothrix (*Leiothrix lutea*) as a competitor and reservoir for disease on Maui and Hawai`i. (Priority 2)

4.2.10.2 Investigate competition for food and space and disease relations between O`ahu `elepaio and introduced birds such as red-vented bulbul (*Pycnonotus cafer*), white-rumped shama (*Copsychus malabaricus*), and Japanese white-eye (*Zosterops japonicus*). (Priority 2)

4.2.10.3 Investigate role of Japanese white-eye and Japanese bush-warbler (*Cettia diphone*) as competitors and reservoirs of disease for on all islands. (Priority 2)

4.2.11 Determine best methods for conducting reforestation efforts. (Priority 2)
Habitat degradation poses threats to species by reducing the carrying capacity of the habitat. Development of effective methods for restoration is needed to mitigate this threat.

4.2.12 Investigate nonnative invertebrates in forest habitats to determine distribution, direct and indirect interactions with native invertebrates, role as a prey base for nonnative birds and mammals, and effects on flora. (Priority 2)

4.3 Evaluate the effectiveness of threat management actions.
Partial or total removal of a threat should result in an increase in population size through changes in demographic parameters. This means that knowledge of the natural history of the Hawaiian forest birds should include refined estimates of demographic rates,

including nesting success, seasonal fecundity of females, proportion of females and males attempting to breed, annual survival of adults and juveniles, and sex ratio. Knowledge of causes of nest failure and mortality can provide a link between demographic parameters and a particular threat. Measuring the increase in a demographic parameter or in the number of individuals following an experimental management action is the best way of assessing the magnitude of a threat and the effectiveness of the management action.

4.3.1 **Examine response of bird populations to habitat restoration,** including the provisioning of food, foraging substrates, nest-sites, and roost sites, as well as the effects of habitat restoration on threats such as mosquitoes, predators, and competitors. (Priority 2)
Responses include stage of restoration at which species first appear (if not present at time restoration work commences), the resources used for feeding and nesting, the stage at which species become permanently resident, and population growth in relation to change in habitat.

4.4 Determine safety of threat management to non-target species and address public health and other concerns regarding threats management.

4.4.1 **Address public health concerns regarding aerial broadcast of rodenticide** and its effects on both game and non-game non-target species, and its persistence in watershed and sediments. (Priority 1)

4.5 Investigate the role of natural selection in dealing with threats. Threats represent natural selection pressures on endangered birds, and because natural selection can lead to adaptation, it is appropriate to view natural selection as a means of threat management. Evolutionary responses to selection are expected when there is time for appropriate genetic variation to arise and the surviving individuals are capable of maintaining a viable population.

4.5.1 Identify geographical variation in behavior and reproduction of forest birds that may make them less susceptible to threats.

4.5.1.1 Determine if roost site selection and specific mosquito avoidance behaviors (e.g., nocturnal roosting posture) reduce exposure to mosquitoes and predators. (Priority 2)

4.5.1.2 Determine if nest structure and location may provide protection from high winds, rain and cold, and predators. (Priority 2)

4.5.2 Identify individuals and genotypes that are tolerant or resistant to disease.

In the absence of continual introductions of new strains or genetic variants of avian pox and malaria to Hawai`i, the disease system (vector, parasite, and avian hosts) will begin to evolve new relationships through processes of natural selection. Current evolutionary theory predicts that the virulence of the disease agents will decrease and resistance of highly susceptible forest birds to these introduced diseases will increase (van Riper *et al.* 1986, Atkinson *et al*. 1995, Cann and Douglas 1999, Jarvi *et al.* 2001, Shehata *et al*. 2001). Direct evidence for this process is still limited and based primarily on observations of breeding populations of O`ahu `amakihi, O`ahu `elepaio, `apapane, and Hawai`i `amakihi at elevations where transmission of pox and malaria is stable and endemic. The genetic and physiological characteristics that allow some individuals to survive malaria and pox infection while others die are still poorly understood. Whether an individual survives infection is related to sex, age, and overall pre-infection body condition (Atkinson *et al.* 1995, 2000; Yorinks and Atkinson 2000). Other genetic factors probably are involved (Cann and Douglas 1999, Jarvi *et al.* 2001, Shehata *et al*. 2001) and may explain why some honeycreeper species (e.g., \`i\`iwi) are more susceptible to disease than others (e.g., Hawai\`i \`amakihi and \`apapane).

4.5.2.1 Develop molecular methods for identifying individuals that are more likely to resist or survive pox and malaria infections. (Priority 1) Research that identifies specific genetic markers for disease resistance should be supported so that informed decisions about maintaining genetic diversity in isolated populations can be made. For example, failure to identify specific haplotypes associated with disease resistance might eventually lead to their loss from a small population if other, more easily identified markers are used as the measure of genetic variability. This is especially important for native species that are extremely susceptible to disease.

4.5.2.2 Refine diagnostic methods for identifying individuals that have survived diseases and have acquired immunity to reinfection. (Priority 1) Recently developed polymerase chain reaction (PCR) (Feldman *et al*. 1995) and serological (Atkinson *et al.* 2001b) tests for avian malaria should be refined to adapt them for use under field conditions. In particular, quantitative competitive PCR tests should be refined to detect low level chronic infections of malaria and fluctuations in parasitemia that may occur over time. New diagnostic tests for avian pox are urgently needed both to easily identify active pox infections and to identify survivors of past infections.

4.6 Conduct research that may lead to new tools for managing forest birds or their habitat, or to identification of emerging or unrecognized threats.

4.6.1 Investigate ways to enhance resource availability for particular species within existing habitat. (Priority 2)

4.6.1.1 Determine if additional nesting sites, including artificial devices, can be provided and used.

4.6.1.1.1 Determine if experimental artificial cavities increase the density of breeding pairs of Hawai`i `ākepa or expand the range of the birds through colonization of habitat without natural cavities. (Priority 2)

4.6.1.1.2 Test the design and efficacy of rat-proof artificial nest structures for puaiohi on Kaua`i. (Priority 2)

4.6.1.2 Determine if application of fertilizer to host plants increases growth, flowering, and abundance of arthropods as a means of increasing the prey base for insectivorous birds. (Priority 2)

4.6.1.3 Develop effective techniques for restoration of degraded and deforested lands. (Priority 2) See Recovery Action 4.2.11.

4.6.2 Document population structure.

A population is not a static entity either in space or time. Individuals may move within a year to track food resources, or engage in natal or breeding dispersal. In addition, source/sink dynamics are expected between populations at carrying capacity and those below carrying capacity. Isolated small populations may suffer from inbreeding depression. Research on population structure extends the results of research on a single population or a limited number of populations. In addition, knowledge of population structure is essential for translocation and reintroduction programs that seek to establish new populations or to augment small populations.

4.6.2.1 Develop a comprehensive library of informative microsatellite loci for all species. (Priority 2) Such loci, when neutral, are useful identifying geographic patterns, alternative patterns of gene flow (dispersal), and state-based dispersal. They can also be used for estimating effective population size and levels of inbreeding, as well as population assignment of individuals for identifying immigrants. Eventually, microsatellites under natural selection can be used for quantitative trait mapping, a procedure involving linkage analysis with functional loci that may be useful in identifying individuals tolerant or resistant to disease.

4.6.2.2 Document genetic population structure of species with single populations. (Priority 2)

4.6.2.3 Document source/sink metapopulation structure along gradients in density, particularly elevational gradients. (Priority 2) If disease is truly a major threat, then populations at upper elevations may be sources and populations at lower elevations may be sinks. There is an expectation that dispersal rates will be biased: more birds will disperse from upper elevations to lower elevations. One consequence of this is that tolerant or resistant genotypes of birds from lower elevations will not be present at upper elevations. Management for disease, especially in light of climate change, requires knowledge of metapopulation structure.

4.6.2.4 **Document genetic relationships among individuals in isolated populations** such as may be found on different volcanoes or in different areas of a fragmented population. Such populations may exhibit a different type of metapopulation structure than found along a gradient. (Priority 2)

4.6.2.5 **Determine patterns of dispersal by age and sex.** (Priority 2)

4.6.2.6 **Determine seasonal patterns of movement by age and sex.** (Priority 2)

4.6.3 **Conduct population and metapopulation viability analyses.** (Priority 2)
Recovery criteria specify the calculation of the population growth rate, or lambda (λ), as an indicator of stable or increasing populations. The Nature Conservancy's Population Viability Handbook specifies additional analyses that can be used to assess population viability within a single population or a metapopulation (Morris *et al.* 1999).

4.6.3.1 **Conduct trend analysis using count data.** (Priority 2)

4.6.3.2 **Use demographic data for estimating lambda.** (Priority 2)

4.6.4 **Investigate natural and alien species-induced native plant species die-back phenomena affecting forest bird habitats.** (Priority 2)

Recent die-back of over 60 percent of the koa (*Acacia koa*) tree canopy in Kīpahulu Valley, Maui, possibly caused by the native moth *Scotorythra paludicola* and the wilt-causing fungus *Fusarium oxysporum f.sp koae*, for example, raises concerns regarding the effects of local die-back of key plant species in forest bird habitats and the impacts of plant species die-back phenomena on listed species distributions and population numbers.

4.7 Special research considerations for translocations and reintroduction programs.

Translocations and reintroductions of captive-bred birds are recognized as important managerial tools for expanding the range of a species, for supplementing a small population, or for genetic management.

4.7.1 Evaluate the effectiveness of translocations of both disease survivors and disease resistant forest birds for restoration of populations in areas with active disease transmission. (Priority 1)

In the absence of specific genetic markers for disease resistance, applied research should be supported to determine whether translocation of survivors of past pox and malaria infections can be used to establish self-sustaining populations in native forests where disease transmission is now endemic, and whether such individuals can be incorporated into a captive breeding population for reintroduction programs.

4.7.2 Determine optimal parameters for translocation and reintroduction efforts. (Priority 2)

Translocation efforts require estimates of carrying capacity in alternative translocation sites, determination of the number of individuals and timing to achieve establishment of the new population, and assessment of the translocation on population structure.

4.7.3 Evaluate the relative costs of habitat suitability analysis versus experimental translocation or reintroduction. (Priority 3)

Translocation or reintroduction of individuals requires an assessment of the likelihood of success. This may take the form of assessments of habitat suitability prior to the releases, or alternatively, of experimental releases followed by careful monitoring of the released birds. The relative cost-effectiveness of these alternatives will vary among species and sites. Thus, evaluation of the relative costs of the alternatives will provide guidance for the effective use of funds.

4.8 Special research considerations for disease and parasitism.

Disease is the most complex threat to Hawaiian forest birds because characteristics of the hosts, vector, and pathogens are all involved. In addition, this is the one threat for which the birds can evolve tolerance or resistance. The numerous topics in this section reflect these issues and possibilities.

4.8.1 Determine the effects of land use changes on disease transmission. (Priority 2)

Changing patterns of land use and their effects on mosquito populations and movement may be one of the most important factors affecting stability of disease transmission, particularly in regions where residential and agricultural use occurs near recovery areas. Land use changes that affect mosquito productivity and movements should be identified so that mosquito free reserves and conservation easements can be located around forest bird recovery areas. These factors may be particularly important for the design of safe, disease-free corridors to link recovery areas at different elevations or geographic locations of the same island.

4.8.2 Determine effects of long-term climate change on disease transmission. (Priority 2)

The key role that environmental temperature plays in limiting the development of malarial parasites in the mosquito vector and increasing the duration of the gonotrophic cycle* of *Culex* makes it likely that climate chang could shift patterns of disease transmission from mid-elevation habitats into the last high elevation refugia on Hawai`i, Maui and Kaua`i. Research that predicts the magnitude of possible warming, its effects at fine spatial scales on precipitation patterns, and its effects on mean daily temperatures should be supported. This information should be used to develop disease risk maps for recovery areas under different scenarios of climatic change.

4.8.3 Conduct research on the feasibility of vaccines for avian pox and malaria, methods for their delivery, and possible effects on host-parasite coevolutionary adaptations. (Priority 2)

Research on experimental vaccines for control of pox and malaria transmission, methods for their delivery to wild free-ranging birds, and their effects on host-parasite coevolutionary adaptations should be supported. The use of vaccines for control of both malaria and viral infections is an active field of investigation concerning human and domestic animal health that may have direct application to Hawai`i. Developments in this field should be followed closely, even though practical application of these technologies to disease control may be years away. Modeling methods should also be used to examine the potential effects of vaccine use on the stability of disease transmission and overall effects on selection for parasite virulence and host resistance.

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* the cycle of egg maturation and oviposition (egg laying) following a blood meal in female mosquitoes; the length of the cycle depends on external temperature

4.8.4 Conduct research on genetic variability, virulence, and interactions between avian pox virus and malarial parasites and how these variants interact with susceptible and resistant host genotypes. (Priority 2)

It is possible that concurrent pox and malaria infections interact in susceptible and resistant hosts in ways that are not immediately predictable, with effects on disease transmissibility and selection for parasite and viral variants that are either more or less virulent than predicted. The role that these interactions play in how the disease system is evolving and how interventions in the disease cycle, e.g., use of a pox vaccine or reduction in mosquito densities, may affect stability of the system are unknown.

4.8.4.1 Use molecular methods to identify specific markers that correlate with phenotypic differences in virulence. (Priority 2)

Research that identifies specific molecular markers that correlate with parasite phenotypic traits should be supported. These can be used to identify specific strains of the disease organisms for incorporation into plans to prevent further spread of pox and malaria variants between and within islands. This information will be particularly useful in translocation studies involving individuals that have survived acute malarial infections and that now carry the parasite at chronic levels. These individuals should not be introduced into areas where their parasite variants do not occur to prevent further spread of the disease organisms.

4.8.4.2 Determine whether concomitant infections with pox and malaria affect virulence and transmissibility. (Priority 2)

Experimental studies that document the interactions of concurrent pox and malarial infections on host survivorship are needed. This information is important for understanding the epidemiology of the diseases and for being able to identify and possibly manage conditions that might affect the severity of future disease outbreaks.

4.8.5 Determine dispersal distances of adult mosquitoes from point sources outside of recovery areas. (Priority 1)
Dispersal of adult *Culex* mosquitoes along natural and man-made corridors from low elevation source areas may be the primary factor supporting transmission of avian pox and malaria in some habitats. A good example of this is the Alaka`i Plateau, where adult mosquitoes and disease transmission have been documented (D. LaPointe and C. Atkinson U.S. Geological Survey, unpubl. data), but where larval *Culex* have rarely been found. In these situations, the identification of source areas and primary routes of dispersal will be essential for determining feasibility and methods for vector control.

4.8.6 Determine the feasibility of decreasing malarial transmission through genetic manipulation of vector populations. (Priority 2)
Research on the control of malarial transmission through genetic manipulation of vector populations is an active field of investigation concerning human and domestic animal health that may have direct application to Hawai`i. Practical application of these technologies to disease control may be years away, but this research should be supported since Hawai`i's isolation and absence of an endemic mosquito fauna make the islands an exceptional location for testing new technologies.

4.8.7 Determine the role that ectoparasites such as ticks and lice play in transmission of avian pox, particularly during the nesting cycle when adults may pass infections to offspring. (Priority 2)

Studies that document the affects of ectoparasites on transmission of avian pox are needed to help in the design of disease control strategies at the nest for critically endangered species where intensive management may be desirable. Treatment of nests, nestlings, and adult birds with insecticides may be practical in some situations and might prevent the transfer of virus to offspring in situations where one or both parents carry active infections.

4.8.8 Determine the role that endoparasites such as *Coccidea* play in demography of birds. (Priority 2)

4.8.9 Monitor long-term changes in the prevalence and transmission of avian diseases in forest bird recovery areas. (Priority 2)

Research and monitoring that documents the long-term patterns of change in the epidemiology and pathogenicity of introduced avian diseases will be important for measuring the effectiveness of management actions and for determining how complex interactions between abiotic and biotic environmental factors, anthropogenic factors, native and nonnative hosts, vectors and diseases are evolving.

4.9 Special research considerations for monitoring. (Priority 2)

Develop and test improved survey and monitoring techniques for extremely rare species and species that are difficult to monitor using standard methods.

4.10 Research needs and priorities by species.

Species differ in their threats and research needs. Table 14 identifies priority research needs for each species, with special reference to populations and locations that provide opportunities conducive to research or in which research needs are especially pressing. In a few instances priorities for individual species may differ from the priorities assigned to the general research categories of the research needs section of the recovery action narrative.

Table 14. Research needs and priorities by species. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. Species Codes: AKEP = Hawai`i `ākepa; AKIP = `akiapōlā`au; AKOH = `ākohekohe; HCRE = Hawai`i creeper; KAAK = Kaua`i `akialoa; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nukupu`u; MAPA = Maui parrotbill; OAEL = O`ahu `elepaio; OO = Kaua`i `ō`ō; OU = `ō`ū; PALI = palila; POOU = po`ouli; PUAI = puaiohi.

Table 14. Research needs and priorities by species

	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.1	Identify the threats that cause geographical variation in density (4.1)	AKEP HCRE AKIP	H	Hawai`i	Determine the basis for variation in density of birds and termination of range.	2
4.10.2	Identify the threats that cause geographical variation in density (4.1)	HCRE	H	Hakalau Forest NWR, Honohina Tract	Determine the basis for low nesting success documented at Honohina Tract (wet habitat) using cameras on nests while documenting rainfall.	2
4.10.3	Identify the threats that cause geographical variation in density (4.1)	AKEP HCRE AKIP	H	Hawai`i	Determine the role of food in timing of breeding, attempts to breed, and breeding success.	2

Table 14. Research needs and priorities by species						
	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.4	Identify the threats that cause geographical variation in density (4.1)	AKOH MAPA	MA	Maui	Determine why these birds are limited to high elevations.	2
4.10.5	Identify the threats that cause geographical variation in density (4.1)	KACR PUAI	K	Alaka`i Wilderness Area	Examine factors that determine abundance and distribution, including elevational range.	2
4.10.6	Identify the threats that cause geographical variation in density (4.1)	KACR	K	Alaka`i Wilderness Area	Determine the role of food as the basis for different densities of the bird in continuous habitat.	2
4.10.7	Evaluate the effectiveness of threat management actions; determine response of bird population to removal or reduction of a threat (4.3)	PALI	H	Mauna Kea and Mauna Loa	Determine population response to predator control efforts.	2
4.10.8	Evaluate the effectiveness of threat management actions; determine response of bird population to removal or reduction of a threat (4.3)	MAPA AKOH POOU	MA	Maui	Determine population response to predator control efforts.	1

Table 14. Research needs and priorities by species						
	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.9	Evaluate the effectiveness of threat management actions; determine response of bird population to removal or reduction of a threat (4.3)	OAEL	O	O`ahu	Determine the effect of predator control on survival of female O`ahu `elepaio.	2
4.10.10	Evaluate the effectiveness of threat management actions: determine response of bird population to removal or reduction of a threat (4.3)	KACR PUAI	K	Alaka`i Wilderness Area	Measure effect of experimental test of broad-scale predator control on nest success, adult and post-fledging survival, and population trends.	1
4.10.11	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3)	PALI	H	Mauna Kea and Mauna Loa	Determine population response to forest regeneration and restoration efforts.	2
4.10.12	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3)	AKEP HCRE AKIP	H	Hawai`i	Determine use of regenerating/restored canopy trees as substrates for feeding.	2
4.10.13	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3)	MAPA AKOH	MA	Maui	Determine population response to forest regeneration and restoration efforts.	2

Table 14. Research needs and priorities by species

	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.14	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3)	KACR PUAI	K	Kaua`i	Determine population response to experimental control of weeds (e.g., ginger).	2
4.10.15	Evaluate the effectiveness of threat management actions; develop molecular methods for identifying individuals that are more likely to survive pox and malaria infections or to resist them (4.5.2.1)	AKEP HCRE AKIP	H	Hawai`i	Determine if tolerance or resistance to malaria and pox virus is evolving at the lower portion of the elevational range of these birds.	1
4.10.16	Investigate role of natural selection in dealing with threats; develop molecular methods for identifying individuals that are more likely to survive pox and malaria infections or to resist them (4.5.2.1)	OAEL	O	O`ahu	Determine if tolerance or resistance to malaria and pox virus is evolving in any of the fragmented populations.	2
4.10.17	Document population structure; document genetic population structure of species with single populations (4.6.2.2)	POOU MAPA AKOH	MA	Maui	Document genetic population structure.	2

Table 14. Research needs and priorities by species						
	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.18	Document population structure; document source/sink metapopulation structure along gradients in density, particularly elevational gradients (4.6.2.3)	AKEP HCRE AKIP	H	Hawai`i	Document dispersal characteristics in populations along lateral and elevational gradients of density.	2
4.10.19	Document population structure; document source/sink metapopulation structure along gradients in density, particularly elevational gradients (4.6.2.3)	AKIP	H	Hawai`i	Determine the basis of variation in size of home range in areas of different density of the bird and in areas with different forest structure.	2
4.10.20	Document population structure; determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations (4.6.2.4)	AKEP HCRE AKIP	H	Mauna Kea, Mauna Loa, and Hualālai	Determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations.	2
4.10.21	Document population structure; determine genetic, morphological, behavioral, ecological, and vocal variation among core populations (4.6.2.4)	OAEL	O	O`ahu	Determine morphological, genetic, behavioral, ecological, and vocal variation among core populations.	2

Table 14. Research needs and priorities by species						
	Category of Research (Recovery Action Narrative general action number)	Species	Island	Area	Research Description	Priority
4.10.22	Document population structure; determine patterns of dispersal by age and sex (4.6.2.5)	OAEL	O	O`ahu	Determine patterns of dispersal by age and sex.	2
4.10.23	Conduct population and metapopulation viability analyses (4.6.3)	OAEL	O	O`ahu	Determine survival of juveniles, calculate lambda in different populations, and conduct sensitivity analysis to help prioritize recovery actions.	2
4.10.24	Conduct population and metapopulation viability analyses (4.6.3)	AKEP HCRE AKIP	H	Hawai`i	Calculate lambda in populations in different portions of the recovery area.	2
4.10.25	Special research considerations for monitoring (4.9)	KACR PUAI	K	Alaka`i Wilderness Area	Conduct development and testing of improved survey and monitoring techniques.	2

5. Monitor Changes in the Distribution and Abundance of Forest Birds.

5.1 Conduct systematic surveys of all forest bird habitat on Kaua`i, O`ahu, Moloka`i, Lāna`i, Maui, and Hawai`i at least once every 5 years to determine changes in distribution and population size of all native and nonnative forest birds. At a minimum, surveys should include all transects surveyed during the Hawai`i Forest Bird Surveys in 1976 to 1981, and additional transects should be established on O`ahu to adequately survey all recovery area on that island. (Priority 1) Recovery of any of the species included in this plan requires documentation of stable or increasing populations by either periodic surveys or calculation of the population growth rate (lambda, λ) in cases where more detailed population parameters have been estimated. Populations of all forest birds must be monitored at regular intervals using standardized methods to determine trends in population size, changes in distribution, and whether management practices are sustaining bird populations. Since the late 1970s, various agencies have cooperated in an attempt to resurvey at 5-year intervals each of the transects first surveyed during the Hawai`i Forest Bird Surveys.  Surveys of all forest bird habitat on the major islands at 5-year intervals through an interagency effort should continue.  The Island of O`ahu was not surveyed by the Hawai`i Forest Bird Surveys, and it will be necessary to establish transects on that island that adequately survey all recovery area.

5.2 Conduct systematic annual surveys of selected forest areas to more carefully monitor changes in distribution and population size and efficacy of management actions.

Areas supporting core populations of endangered species and areas where management actions are being carried out should be surveyed at more frequent intervals to more carefully monitor variation in populations and provide for adaptive modification of management actions, as described in Table 15.

5.3 Establish and support an interagency Forest Bird Monitoring Coordinator position to coordinate monitoring and provide regular reports on the status and trend of forest bird populations. (Priority 1)

A permanent interagency coordinator is needed to serve as the "resident expert" on forest bird monitoring in Hawai`i.  This person would coordinate all aspects of forest bird monitoring in Hawai`i, including scheduling and organizing field surveys, conducting training sessions, ensuring that data collected during each survey are entered into a standardized database that is available to all agencies, analyzing data from each survey and producing status and trend reports at regular intervals, and producing updated GIS maps of current distributions of each species.

Table 15. Recovery areas requiring avian monitoring more frequently than every 5 years. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 15. Recovery areas requiring avian monitoring more frequently than every 5 years				
Recovery Action #	Island	Study Area	Survey Need/ Comments	Priority
5.2.1	H	Mauna Kea, māmane forest	Annual survey	2
5.2.2	H	Hakalau Forest NWR	Annual survey	2
5.2.3	H	Kona Unit, Hakalau Forest NWR	Annual survey	2
5.2.4	H	Ka`ū Forest	Every 2 years	2
5.2.5	H	Pu`u Wa`awa`a Forest Bird Sanctuary	Every 2 years	2
5.2.6	H	Kūlani	Annual survey	2
5.2.7	H	Keauhou Ranch/Kīlauea Forest	Annual survey	2
5.2.8	H	Mauna Loa Strip	Biannual survey	2
5.2.9	MA	Hanawī NAR	Annual survey	2
5.2.10	MA	Waikamoi Preserve	Annual survey	2
5.2.11	MA	Kīpahulu Valley	Annual survey	2
5.2.12	O	Wailupe Valley, to monitor efficacy of predator control	Annual survey	2
5.2.13	O	Pia Valley, to monitor efficacy of predator control	Annual survey	2
5.2.14	O	Honouliuli Preserve, to monitor efficacy of predator control	Annual survey	2
5.2.15	O	Schofield Barracks West Range, to monitor efficacy of predator control	Annual survey	2
5.2.16	O	Any other areas where active management is undertaken	Annual survey	2
5.2.17	K	Alaka`i Wilderness Preserve puaiohi "core" habitat	Annual survey	2

6. Public Awareness and Information.

Inform and educate the general public and lawmakers about Hawai`i's native and endemic species, and their habitats, to create a Statewide conservation ethic and to build alliances for conservation within the State of Hawai`i. Public information plays an important role in all recovery programs. Without public and lawmaker support, recovery actions may be impossible to attain. An informed public will support recovery actions, reduce time and budget costs, reduce controversy, and even persuade lawmakers to support changes necessary to preserve and protect endangered species and their habitat.

6.1 Build alliances with the public through outdoor experience with native forest birds and their forest habitats.

People are more likely to support programs for native species that they have observed first hand, rather than those with which they have had no experience. Hawaii's native forest birds are generally only found on private lands or in remote places where the public is unlikely to visit. Providing roadside stops, trails, and better visitor access within native forest habitat will increase public experience with native bird species and their habits. This will expand community knowledge and create alliances between the public and conservation agencies, leading to more public support for protection of natural places and species.

6.1.1 Promote and support public native species awareness and environmental education through increased visitor access on trails with interpretive and educational displays. The first line of action in promoting public environmental education is bringing the public in direct contact with native species and habitats. The development of new trails and enhancement of existing trails with interpretive displays will increase public access and exposure to native species, bringing about awareness and support for these species and their native habitats (see Table 16).

6.1.2 Promote increased access and interpretation programs on Federal, State, County, and private refuges, parks, preserves, and other lands where native species are found (see Table 17).

Table 16. Sites where interpretive information is needed (scenic overlooks and trails where interpretive information should be developed or where existing trails need enhancement). Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. NWR = National Wildlife Refuge, NAR = Natural Area Reserve.

Table 16. Sites where interpretive information is needed				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.1.1	H	Saddle Road 21 mile marker overlook and trail	Develop a scenic overlook with parking, a nature trail, and interpretive signage that discusses native forest birds and their habitat.	3
6.1.1.2	H	Saddle Road, Pu`u `ō`ō Trail	Trailhead access and parking area need improvement, interpretive displays should be installed to bring attention to native forest birds.	3
6.1.1.3	H	Hawai`i Volcanoes National Park, Mauna Loa Strip Road.	Develop short loop trails, pullouts, and interpretive displays along the Mauna Loa Strip Road.	3
6.1.1.4	H	Hakalau Forest NWR	Expand visitor use with a loop trail and interpretive displays.	2
6.1.1.5	H	Mauna Kea Pu`u Lā`au	Establish a loop trail within palila habitat and provide interpretive signs about the bird and its habitat. This would concentrate visitor usage and minimize disturbance, spread of weeds, and potential for fires.	2
6.1.1.6	H	`Ainapō Trail	Work with Nā Ala Hele to add a bird component to their brochure and interpretive signs at parking areas.	3
6.1.1.7	H	Pu`u Wa`awa`a Forest Bird Sanctuary	Develop a system of trails with interpretive signs.	3

Table 16. Sites where interpretive information is needed				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.1.8	H	Pu`u Maka`ala, Laupāhoehoe, Kīpāhoehoe, Manukā, and Pu`u O`umi NAR	Develop a system of trails with interpretive signs.	3
6.1.1.9	MA	Haleakalā National Park, Hosmer Grove	Develop interpretive signs for the nature trail.	3
6.1.1.10	MA	Polipoli State Park	Develop an interpretive kiosk for the parking area and signs and brochures for the Waiakoa Loop Trail that include bird information.	3
6.1.1.11	MA	Pu`u Kukui, Maui Land and Pineapple	Develop access, trails, and interpretive signs for the Pu`u Kukui Trail.	3
6.1.1.12	MA	Waihe`e Ridge Trail	Develop an interpretive display at the top of the trail.	3
6.1.1.13	MA	Kahakuloa NAR	Po`elua Road, develop trail and interpretation on birds and other native biota.	3
6.1.1.14	MO	Hanalilolilo Trail	Develop an interpretive trail to rim of Pēpē`ōpae Bog.	3
6.1.1.15	MO	Moloka`i Forest Reserve Pu`u Ali`i NAR	Develop an interpretive kiosk at the Waikolu Lookout describing native forest birds and their habitat.	3
6.1.1.16	O	Kuli`ou`ou Trail, `Aiea Loop Trail	Develop interpretive signs and brochures for trails focusing on common native forest birds and the endangered O`ahu `elepaio.	2
6.1.1.17	K	Kōke`e State Park	Develop interpretive signs at Kalalau and Pu`u O Kila lookouts and educational brochures for all Kōke`e State Park trails that include native forest birds.	2

Table 17. Sites where increased access and interpretation are needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu. NAR = Natural Area Reserve.

Table 17. Sites where increased access and interpretation are needed				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.2.1	H	Hakalau Forest NWR, Hakalau and Kona Forest Units	Conduct open houses on a basis regular basis and develop open public access opportunities.	3
6.1.2.2	H	Pu`u Wa`a Wa`a Wildlife Sanctuary	Improve public access and interpretation.	3
6.1.2.3	MA	Waikamoi Preserve The Nature Conservancy	Expand public access opportunities into areas with native forest birds.	3
6.1.2.4	MA	Makawao Forest Reserve	Develop public access and interpretation of the Idyllwild entrance to the reservoir on the 4,300 foot contour road.	3
6.1.2.5	MA	Hanawī NAR	Increase limited public access for bird study and permitted public access.	3
6.1.2.6	MA	Haleakalā National Park	Increase public access opportunities for bird viewing in consultation with park staff.	3
6.1.2.7	MO	Kamakou Preserve, The Nature Conservancy	Improve public access by connecting the preserve with Hanalilolilo trail.	3
6.1.2.8	O	Barber's Point	Develop interpretive displays and sponsor regular trips to sinkholes at Barber's Point to see fossil bird bones.	3
6.1.2.9	O	Honouliuli Preserve, The Nature Conservancy	Support public education through the Project Stewardship program run by The Nature Conservancy of Hawai`i.	2

6.1.3 Expand visitor awareness with development of visitor centers, displays, facilities, and public interpretive programs (see Table 18).

Table 18. Sites where visitor centers, displays, and interpretive programs are needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 18. Sites where visitor centers, displays, and interpretive programs are needed				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.3.1	H	Hakalau Forest National Wildlife Refuge	Develop a visitor center with interpretive displays and docents promoting refuge programs to protect Hawaii's endangered flora, fauna, and ecosystems.	2
6.1.3.2	MA	Haleakalā National Park	Construct an interpretive display in the campground at Palikū providing information on programs by the NP and State for Maui parrotbill, `ākohekohe and other native forest birds, and create a bird identification brochure for visitors park-wide.	2
6.1.3.3	O	Honolulu Zoo	Provide support for developing a Hawai`i forest bird display at Honolulu Zoo.	2

6.1.4 Promote the opening of State Forest Reserve trails to the general public for nature walks and birding on all islands. (Priority 2)

6.1.5 Support the Nā Ala Hele Trail System. (Priority 3)

6.2 Fund, support, and promote programs that inform teachers and educate children, lawmakers, local public, and visitors about Hawaii's native and endangered flora and fauna.

Most people in Hawai`i are unfamiliar with Hawaii's native species and the problems associated with their decline. Raising the level of awareness on endangered species issues at the community level is the key to the success of the recovery of these species. Informed teachers will aid in educating the community and lawmakers, and with public backing, will support habitat protection and endangered species recovery.

6.2.1 Fund and support teacher education programs that promote native species issues.

Teachers provide the basis for educating a large segment of the population, therefore educating teachers about endangered species issues should be paramount. Providing teachers with interesting, appropriate, and up to date teaching materials for classroom use is an important part of this educational program.

6.2.1.1 Institute core curriculum programs at the university level emphasizing Hawaii's native species for elementary and high school teacher education programs. (Priority 2)

6.2.1.2 Develop an interpretation internship program for university students specializing in the field of forest bird information and education. (Priority 2)

6.2.1.3 Provide permanent funding for programs such as Imi Pono No Ka Aina, an Environmental Educator program at Hawai`i Volcanoes National Park that educates teachers through accredited workshops in environmental and native species issues.
(Priority 2)

6.2.1.4 Fund the development and distribution of educational materials that provides teachers with "student friendly" information about native and endangered species.

6.2.1.4.1 Develop forest bird posters for schools, emphasizing each of the native forest birds and keyed to each island's endemic species. (Priority 3)

6.2.1.4.2 Keauhou Ranch/Kīlauea Forest Reserve. Assist Kamehameha Schools with ongoing development of environmental learning opportunities. (Priority 3)

6.2.2 Support and fund programs that educate children about Hawai`i's natural environments and that inform the public through non-traditional partnerships. Classroom learning is only one facet of the learning process. Outdoor programs at organized learning centers give students the opportunity to relate to the natural environment that they might not ordinarily experience. Intimate knowledge of native environments and species through the outdoor experience likely will produce future supporters for these environments. The use of non-traditional partnerships also can help children attain experience from members of the community in environmental education programs.

**6.2.2.1 Fund and support programs at nature centers on all islands that provide school children with a "hands on" approach to learning about Hawai`i's native species**: Keokeolani Outdoor Education Program on the Big Island; Maui Outdoor Education Center on Maui; Hawai`i Nature Center on O`ahu; The Discovery Outdoor Education Center on Kaua`i; and funding for the establishment of a Moloka`i Outdoor Education Center. (Priority 2)

6.2.2.2 Fund and support organizations such as \`Ōhi\`a Productions and Keauhou Bird Conservation Center that provide environmental educational programs to Hawaii's school children. (Priority 2)

6.2.2.2.1 Provide funding for \`Ōhi\`a Productions to perform on other islands and to produce videos of previous performances for distribution to schools throughout Hawai\`i. (Priority 2)

6.2.2.3 Develop and support programs such as Mālama Hawai\`i that encourage widespread awareness of conservation goals through a diverse coalition of traditional and non-traditional partnerships. (Priority 2)

6.2.3 Create a clearinghouse, such as a website or "hotline," for information and educational materials about Hawai\`i's native species.

Teachers, students, lawmakers, businesses, conservation groups, and the general public should have the most current information available to them. Scientists from Federal and State agencies have the current information.

6.2.3.1 Fund, create, and support continuous maintenance of an informational website focused on native species and their habitats, as well as alien species and their effects on native species, and provide up to date information that can be utilized and copied onto other web sites to spread the information. (Priority 2)

6.2.3.1.1 Obtain funding to develop technology for remote digital broadcast from an

O`ahu `elepaio "nest cam" to local schools through a web site. (Priority 3)

6.2.4 Provide information and promote awareness of the harmful effects of some alien species to public health, native species, and native ecosystems.
Alien species are the leading cause endangerment and extinction of native species in Hawai`i. Harmful effects include habitat degradation caused by alien ungulates and weeds; native bird extinctions caused by exotic mosquito-borne diseases; predation from introduced rats, cats, and mongooses; and possible impacts to Hawaii's ecosystems and economy.

6.2.4.1 Initiate and support public outreach efforts about the effect of rats and cats as vectors for human disease, agricultural pests, and predation on native species, such as the Cats Indoors program of the American Bird Conservancy. Provide film and video footage of the harmful effects rats and cats have on native species and humans. (Priority 1)

6.2.4.2 Initiate public outreach efforts to inform the public about potential human and animal diseases transmitted by mosquitoes and how source reduction can reduce those threats. Provide film and video footage of the harmful effects alien mosquitoes and disease have on native species and humans. (Priority 1)

6.2.4.3 Inform the public on the value of feral ungulate control and weed control in native forests by providing film and video footage of the harmful effects alien weeds and ungulates have on native species and agriculture. (Priority 2)

6.3 Use a professional marketing agency and business marketing techniques (television, radio, internet, newspapers, advertising, and magazines) to promote awareness of the uniqueness of Hawai`i's native species and gain local support for endangered species and related conservation issues. Radio, television, contests, and promotions featuring local entertainers, celebrities, and heroes to promote public information and awareness of environmental issues and other mass marketing techniques are effective and should be used to increase the public's awareness of native and endangered species and their associated problems.

6.3.1 Conduct market research on the public's knowledge of native species and attitudes towards conservation in order to provide information on the most direct ways to inform the public and gain support for native species. (Priority 2)

6.3.2 Promote and fund the development of Public Service Announcements for television and radio about native species and their habitat.

6.3.2.1 Assist in the development of public service announcements about native species by providing local television stations with footage of native species with natural sounds and suggest their use as background visuals or sounds during credits for local or other programming. (Priority 2)

6.3.2.2 Use local heroes, entertainers, sports figures, or other role models to promote local pride in native common and endangered species. (Priority 2)

6.3.2.3 Promote the use of sponsored prize-winning contests on local radio, television stations, and newspapers to promote native species awareness. (Priority 3)

6.3.2.3.1 **Sponsor and support contests**, such as a forest bird website contest among high school students, a forest bird essay contest in schools with prizes for different grade levels, a forest bird photo contest, or a song writing contest with the song to be used for as a theme for a locally produced nature program. (Priority 3)

6.3.2.4 Fund daily, weekly, or monthly programs in newspapers, radio, and television stations that provide a short informative environmental education story. (Priority 3)

6.3.2.4.1 Develop a weekly column provided to all newspapers in Hawai`i with information on native species and ecosystem issues, and the writing shared by conservation organizations throughout the State. (Priority 3)

6.3.2.4.2 Develop a weekly program for radio stations on all islands providing information on native species and ecosystem issues, with the writing shared by conservation organizations throughout the State. (Priority 3)

6.3.2.4.3 Develop a half-hour weekly or monthly television program about Hawaii's native species and their habitat. (Priority 3)

6.3.3 Promote private business use of native species likenesses, images, and names on old and new products and use them in advertising and logos.

6.3.3.1 Promote the use of the `i`iwi or a caricature of `i`iwi as the "poster child" for native species in advertising and in education. (Priority 3)

6.3.3.2 Provide native species images and promote the use of these images in advertising by marketing agencies, local and national fast food corporations, and advertising on tray-liners, milk cartons, and other heavily-used advertising media. (Priority 3)

6.3.4 Promote fund raisers and solicit corporate funding and promotion to expand the economic base for public awareness and information campaigns.

6.3.4.1 Promote the hosting of special events in cooperation with major local hotels and corporations as funding partners to champion native species and ecosystem awareness. (Priority 3)

6.4 Promote the creation of and support "Friends" groups, partnerships, environmental outreach programs, and other groups to provide support for parks, refuges, reserves, and natural areas to cultivate understanding and conservation of Hawaii's natural and cultural resources. Funding and labor support for environmental education is often in short supply. The establishment of Friends groups and partnerships helps fill the need by supplying volunteers and funds to maintain these important programs. Many refuges and parks rely greatly on these resources to champion new programs and maintain old ones at little or no cost.

6.4.1 Recruit, train, and support volunteer community leaders to organize native species outreach and awareness programs at the community level.

6.4.1.1 Support conservation outreach organizations to promote conservation at a "grass roots" level. (Priority 2)

6.4.1.2 Develop a "mentor" program in which natural science professionals provide field opportunities for young people to learn about Hawaii's native species. (Priority 3)

6.4.1.3 Support the use of volunteers in projects on State, Federal, and private lands that will contribute to the enhancement of native habitat and increase the level of awareness and pride in native species within the local populace. (Priority 2)

6.4.1.4 Support the development of a volunteer "clearinghouse" to provide volunteers for resource management, education, and outreach. (Priority 3)

6.4.2 Develop and support partnership and outreach programs with other conservation agencies, native Hawaiian groups, hunter groups, and private landowners. (Priority 2)

6.4.2.1 Develop and maintain partnerships with Kamehameha Schools, The Nature Conservancy of Hawai`i, Hawai`i Audubon Society, Pig Hunters of Hawai`i, Hawai`i Conservation Alliance, and other non-governmental organizations to promote environmental awareness. (Priority 2)

V. IMPLEMENTATION SCHEDULE

Recovery actions in the Implementation Schedule are prioritized in a two-part ranking system. First, each action is assigned a “priority number” from 1 (highest priority) to 3 (lowest priority) (see Definition of Action Priorities, below). Second, within each priority number, actions are broken down into “priority tiers” from 1 (highest priority) to 3 (lowest priority). For example, an action with a priority number of 1 and a priority tier of 1 has higher priority than an action with a priority number of 1 and a priority tier of 2. The recovery tier rankings are based on several criteria, including whether the land in question is currently occupied by the species, the current suitability of the habitat for the species, the number of existing populations, and the probability of species extinction. Higher tier rankings are assigned to actions for species with only one population, actions for species that could go extinct more rapidly, and actions for habitat that is currently occupied. Numbers in the Action Number column correspond to descriptions of recovery actions in the recovery action narrative (Section IV) of this recovery plan. This implementation schedule is provided to assist in selecting the most important (highest priority) recovery actions for implementation. Appendix A provides a list of land parcels and recovery actions as an aid to landowners and land managers who may wish to see a complete list by parcel of habitat-based recovery actions for their lands. Recovery actions in Appendix A are from Tables 7, 8, 9, and 11 of the Recovery Actions Narrative. Many recovery actions benefit multiple species, including habitat-based actions.

During the writing of this plan, the Hawaiian Forest Bird Recovery Team suggested developing “Five-year Recovery Work Plans” to make the larger recovery plan more accessible to landowners and resource managers. These Work Plans include key near-term recovery actions for each species. The Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service completed these Work Plans in 2003. Each Work Plan provides a brief species summary, a description of the primary threats to the species, and lists 10 to 15 key recovery actions to be completed in the next 5 years. Species Five-year Recovery Work Plans are available from the Pacific Islands Fish and Wildlife Office, Honolulu, Hawai`i, and are also provided here as Appendices F through L to this plan.

1. Definition of Action Priorities.

Priority 1 – An action that must be taken to prevent extinction or to prevent a 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 recovery objectives.

2. Threat Categories.

We consider five major categories of threats to species in order 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 – The inadequacy of existing regulatory mechanisms; and

E – Other natural or manmade factors affecting its continued existence.

The Listing Factor column in the Implementation Schedule indicates which of the five threat categories each recovery action is meant to address in order to meet the recovery criteria of creating viable populations or metapopulations and management of recovery areas (see Recovery Criteria, page 3-2). The majority of recovery actions in this plan address threats to habitat (factor A) and disease or predation (factor C). The overutilization of Hawaiian forest birds for commercial, recreational, scientific, or educational purposes (factor B) and inadequacies of existing regulatory mechanisms (factor D) are not considered to be significant current threats. Population monitoring does not fit under the above threat categories, but in order to determine whether recovery criteria have been met, it is essential to evaluate population trends, the effects of threats on populations, and measure population responses to management.

3. Definitions of Action Durations.

Continual – An action that will be implemented on a routine basis once begun and will continue until recovery has been achieved (estimated at 30 years).

Ongoing – An action that has already been initiated and will continue until the action is no longer necessary. If no discrete time frame is provided, it is assumed that the action will continue until recovery has been achieved (estimated at 30 years).

Unknown – Action duration is not known at this time or action is not being implemented currently.

Complete – Action has been completed.

4. Responsible Parties for Action Implementation.

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. The recovery actions identified here are intended as a guide for meeting the recovery goals in this plan, and imply no legal obligations of State and local government agencies or private landowners to implement them. However, in most cases the recovery of the listed species included in this plan will require the involvement and cooperation of Federal, State, local, and private interests. For each recovery action described in the Implementation Schedule, the column titled "Responsible Parties" lists the primary Federal and State agencies with the authority or responsibility for implementing or funding recovery actions and conservation groups, partnerships, and private landowners that may also wish to be involved in recovery implementation. An asterisk (*) identifies the logical lead partner(s) for implementing recovery actions. The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s). Access to private lands and implementation of recovery actions on land parcels that are privately owned will be by mutual agreement with the landowner in cooperation with the Service and any other appropriate parties.

5. Cost Estimates for Recovery Actions.

In addition to providing a prioritized list of recovery actions, the Implementation Schedule provides estimated costs of implementing recovery actions. The method used to estimate costs of different types of recovery actions are described below. Estimates for these actions are based on average costs of similar actions implemented to date. Differences in local conditions likely will result in variation from estimates for some of these actions in some areas. Slight differences between total costs and annual costs for some continual and ongoing actions are due to rounding of annual costs. In these instances, total cost is the most accurate approximation of funding needed to complete a recovery action. In some cases, as described below, although we were able to estimate the total cost of an action, it was not possible to accurately break that cost down into annual estimates, because those costs varied widely between years depending on the stage of work or because the point at which funding would become available to carry out the action was highly uncertain.

Secure Recovery Areas: Costs to secure recovery areas cannot be determined at this time because numerous methods are available (conservation easement, partnership agreement, safe harbor agreement, change in land use designation, change of jurisdiction, lease, or purchase from willing seller) that vary widely in their potential cost, and it is not possible to speculate which method might be most appropriate or effective in the future. Many land parcels in question are owned by State or local governments or private interests, and the most appropriate method of securing habitat will depend on the disposition and willingness of the landowner.

Reforestation and Restoration: Cost for each action number equals total acreage in the recovery area parcel(s) to be reforested or restored multiplied by cost per acre for reforestation or restoration. The current cost per acre for reforestation is estimated at $600/acre for high intensity effort, $400/acre for moderate intensity effort, and $200/acre for low intensity effort; $200/acre is used for areas that only require management to assist natural forest regeneration. Costs for forest restoration at Kōke`e State Park on Kaua`i are by expert opinion.

Fencing and Feral Ungulate Removal: Cost for each action number equals total acreage in the recovery area parcel(s) requiring fencing multiplied by cost per acre for fencing added to the total acreage in the recovery area parcel(s) requiring ungulate removal multiplied by cost/acre for ungulate removal. Cost/acre for fencing = $312.50 for Hawai`i, $570.50 for Maui and Kaua`i, and $891 for deer fencing. Because populations of Axis deer on Maui and Moloka`i are expanding their range and growing rapidly, it is anticipated that deer-proof fencing will be required for these two islands. Costs are based on the cost of fencing to enclose 1 square mile of area (4 linear miles of fence) or 640 acres. Detailed plans for fencing were not available for most areas. For larger units fencing costs may be somewhat less than estimated, and it may be possible to reduce costs in some cases by strategic placement of fencing segments.

Hunting to reduce feral ungulates in unfenced areas is beneficial to forest bird habitat and will contribute to forest bird recovery. However, fencing and complete removal of feral ungulates will provide the most benefit to forest bird habitats and is most cost effective over the long-term. Hunting alone in fenced areas may reduce feral ungulate numbers, but is unlikely to result in complete removal. Cost per acre for ungulate removal ($22.00/acre/3-year period) therefore is based on snaring within fenced areas to reduce ungulates to zero. One-way gates and other means of reducing numbers of ungulates in fenced areas are included in the cost for fencing designs.

There will be costs to maintain fences and to monitor for and remove ungulates from ungulate free fenced areas should a breach in exclosures occur. It is difficult to predict these costs because it is not possible to know when damage to fencing might occur or how extensive this might be, whether or if ungulates entered into the fenced area and when, and because fence maintenance requirements will likely differ depending upon climate, terrain, vegetation over-story and other factors. We have estimated these costs to be on average $6.25/acre/year to monitor and repair fencing and $3.57/acre/year to monitor for ungulate presence inside fenced areas. We have added fence maintenance and ungulate monitoring costs on a per acre basis multiplied by 30 (the number of years estimated to recovery) to the cost for fence construction and ungulate removal.

Funding is not currently available for most reforestation, restoration, fencing, and feral ungulate removal, and opportunities to implement these actions are often determined by availability of funds and personnel, access to lands, and cooperation of parties involved. Therefore, cost estimates for these recovery actions are presented only under total costs and are not broken down by year. Highest priority projects should be implemented first as funding becomes available.

Predator Control: The cost for each action number equals total acreage in the recovery area parcel where predators (primarily cats, mongoose, and rats) are to be controlled, multiplied by cost/acre/year for control. The cost per year for ground-based rodent baiting and cat/mongoose removal combined = $40/acre/trip, or $160/acre/year for four trips. Recovery of most species included in this plan will require large-scale predator control, and many of the land parcels involved are too large and the terrain is too rugged for ground-based methods to be effective. Adequate predator control in many areas will require aerial broadcast application of toxicants, and approval of this method is still pending from the Environmental Protection Agency. Costs for predator control for many parcels at this time may change and could be substantially lower depending on the methodology approved by the Environmental Protection Agency for aerial broadcast application of diphacinone rodenticide for conservation purposes in Hawai`i.

Captive Propagation: Currently, captive propagation and reintroduction programs for Hawaiian forest birds receive approximately $1 million each year. As more species and larger numbers of captive-reared birds are released into the wild, costs are expected to increase because of greater demands for space in propagation facilities, increased facilities maintenance costs, larger releases, and more post-release monitoring. Total costs for captive propagation and reintroduction programs can reasonably be expected to increase to approximately $1.5 to $2 million per year. Because program priorities will of necessity shift over time, specific costs for captive propagation and related recovery strategies have not been assigned by year. We have estimated total costs of $60 million for all activities under the general heading of captive propagation and related recovery strategies, or $2 million per year for a 30-year period.

<u>Total Costs</u>: Cost totals for each recovery action in the Total Costs column of the Implementation Table are the total costs for the completion of a recovery action over the time it will take until a species has been recovered. Some species with larger current populations and wider distribution may be recovered in less than 30 years, whereas recovery of other species will require substantial habitat restoration, which could take more than 30 years. For the purposes of this recovery plan, we have estimated that we can expect all the species in this plan with current populations of greater than 300 individuals to be recovered in 30 years. For actions that are continual or ongoing, the total cost is based on the annual costs summed over 30 years, unless otherwise noted.

6. Key to Acronyms and Responsible Parties (not all are mentioned in the Implementation Schedule)**:**

ADWG – Avian Disease Working Group
APHIS-WS-NWRC – (USDA) Animal Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center
AZA – American Association of Zoological Parks and Aquariums
BIGHA – Big Island Gamebird Hunters Association
BIISC – Big Island Invasive Species Committee
CPWG – Captive Propagation Working Group
DHHL – Department of Hawaiian Home Lands
DOI – U.S. Department of Interior
DLNR – Hawai`i Department of Land and Natural Resources
DOD – Department of Defense
DOFAW – Hawai`i Division of Forestry and Wildlife
EMOWP – East Moloka`i Watershed Partnership
EMWP – East Maui Watershed Partnership
FAA – Federal Aviation Administration
FHWA – Federal Highway Administration
HDOA – Hawai`i Department of Agriculture
HDOE – Hawai`i Department of Education
HDPH – Hawai`i Department of Public Health
HFBRT – Hawai`i Forest Bird Recovery Team
HVNP – Hawai`i Volcanoes National Park
HZ – Honolulu Zoo
KMWP – Ko`olau Mountains Watershed Partnership

KS – Kamehameha Schools
LHWRP – Leeward Haleakala Watershed Restoration Partnership
MFBRP – Maui Forest Bird Recovery Program
MWP – Maui Watershed Partnership
NAPS – Natural Areas Partnership
NAR – Natural Area Reserve
NGO – Nongovernmental Organization
NHPS – Native Hawaiian Plant Society
NPS – National Park Service
NWR – National Wildlife Refuge
OKP –` Ōla`a/Kīlauea Partnership
TBD – To Be Determined
TMK – Tax Map Key
TNCH – The Nature Conservancy of Hawai`i
TPF – The Peregrine Fund
UH – University of Hawai`i
UNK – Unknown
USDA – U.S. Department of Agriculture
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
VC – Veterinary Consortium
WDTF – Wildlife Disease Task Force
WMWP – West Maui Mountains Watershed Partnership
ZSSD – Zoological Society of San Diego

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	1.1	A	Describe and delineate recovery areas	Complete	*USFWS, *HFBRT						
2	1	1.2.1	A	Continue existing and develop new partnerships: \`Ōla\`a/Kīlauea Partnership, Hawai\`i	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.2.2	A	Continue existing and develop new partnerships: Kahikinui Forest Partnership Working Group, Maui	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.2.3	A	Continue existing and develop new partnerships: East Maui Watershed Partnership	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.2.4	A	Continue existing and develop new partnerships: Leeward Haleakalā Watershed Restoration Partnership, Maui	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.2.5	A	Continue existing and develop new partnerships: West Maui Mountains Watershed Partnership	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	1.2.6	A	Continue existing and develop new partnerships: East Moloka`i Watershed Partnership	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.2.7	A	Continue existing and develop new partnerships: Ko`olau Mountains Watershed Partnership, O`ahu	Ongoing	*All Landowners, Land Managers, and Other Parties	TBD[1]					
2	1	1.3.1	A	Secure recovery area: Portions of TMKs 344014002 344014003 343010002 343010008	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i DLNR. Currently leased for cattle grazing. By lease, conservation easement, change of jurisdiction, or change in land use designation to protective subzone of conservation.
1	2	1.3.2	A	Secure recovery area: Kanakaleonui Corridor, TMK 338001009	Ongoing	*DHHL	TBD[1]					Hawai`i DHHL. Provides vital link between mesic koa forest and dry māmane forest. By conservation easement, lease, or partnership. Remove grazing and enhance natural communities.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	1.3.3	A	Secure recovery area: Hilo Forest Reserve, Laupāhoehoe Section, TMK 337001004	Unknown	*DLNR, *DOFAW	TBD[1]					Hawai`i DOFAW. Currently the Laupāhoehoe Section of Hilo Forest reserve Area. By change in land use designation to conservation protective subzone. Mid-elevation forest with native tree canopy vulnerable to destruction by continued sustained yield pig hunting.
2	1	1.3.4	A	Secure recovery area: Hilo Forest Reserve, Pīhā Section, TMK 333001004	Unknown	*DLNR, *DOFAW	TBD[1]					Hawai`i DOFAW. Important wet and mesic forest remnants. Currently the Pīhā Section of Hilo Forest Reserve, bounded on both sides by Hakalau Forest National Wildlife Refuge. By conservation easement or change in land use designation to protective subzone of conservation. Mid-elevation forest with intact native tree canopy vulnerable to destruction by sustained yield pig hunting.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	1.3.5	A	Secure recovery area: Kīpuka `Āinahou Nēnē Sanctuary, TMK 338001008	Unknown	*DHHL, *DOFAW	TBD[1]					Hawai`i DHHL, leased by DOFAW and currently under annual lease. A long-term lease should be negotiated.
1	3	1.3.6	A	Secure recovery area: Humu`ula, TMK 338001002	Unknown	*DHHL	TBD[1]					Hawai`i DHHL. Restorable. A vital link between wet and dry forest communities. Former lease for cattle grazing recently terminated. By lease, conservation easement, cooperative agreement, or partnership.
2	2	1.3.7	A	Secure recovery area: Humu`ula, Portions of TMK 338001007	Unknown	*DHHL	TBD[1]					Hawai`i DHHL. Leased to Parker Ranch for grazing. Restorable. A vital link between wet and dry forest communities. By lease, conservation easement, cooperative agreement, or partnership.
1	3	1.3.8	A	Secure recovery area: TMK 326018002	Unknown	*DHHL	TBD[1]					Hawai`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Highest mesic forest remnant on the eastern slope of Mauna Kea. By lease, conservation easement, cooperative agreement, or partnership.

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	3	1.3.9	A	Secure recovery area: TMK 326018001	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i DLNR, Land Division. Leased for cattle grazing. Important mesic and wet koa/`ōhi`a forest remnants, link between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
1	2	1.3.10	A	Secure recovery area: TMK 344015002	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i DLNR, Land Division, currently leased for cattle grazing. Restore link between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
2	2	1.3.11	A	Secure recovery area: Keauhou Ranch, TMK 399001004	Unknown	*KS	TBD[1]					Kamehameha Schools. Remnant mesic koa and `ōhi`a forest. By lease or conservation easement. Currently a member of the Ōla`a-Kīlauea Partnership.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	1.3.12	A	Secure recovery area: Kapāpala Ranch, Portions of TMK 398001010	Unknown	*DLNR, State Land Division, Kapāpala Ranch	TBD[1]					Hawai`i DLNR, Land Division, Kapāpala Ranch. Currently leased for cattle grazing. Restorable. A link between forest to the east and west. By lease, conservation easement, or change in land use designation to conservation.
2	2	1.3.13	A	Secure recovery area: Ka`ū Forest Reserve, TMK 397001007	Unknown	*Mauna Kea Agribusiness	TBD[1]					The Nature Conservancy of Hawai`i. Protect wet forest habitat from development.
2	2	1.3.14	A	Secure recovery area: Ka`ū Forest Reserve, Portions of TMKs 397001006 and 397001005	Unknown	*KS	TBD[1]					Kamehameha Schools. Protect wet forest habitat from development. By lease, conservation easement, partnership agreement, or purchase from willing seller.
1	1	1.3.15	A	Secure recovery area: Kahuku Ranch, Portions of TMK 392001002	Unknown	*Samuel M. Damon Trust, Kahuku Ranch	TBD[1]					Recently purchased by Hawai`i Volcanoes National Park. Valuable wet and mesic forest habitat that links Ka`ū Forest and South Kona Forest. Restorable.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	1.3.16	A	Secure recovery area: Honomalino, TMKs 389006004 and 389006029	Unknown	*Scott C. Rolles Trust	TBD[1]					Scott C. Rolles Trust. Links Ka`ū Forest and South Kona Forest. By lease, conservation easement, partnership, change in land use designation, or purchase from willing seller.
2	3	1.3.17	A	Secure recovery area: Pāpā, TMK 388001001	Complete	*The Nature Conservancy	UNK					The Nature Conservancy, Kona Hema Preserve. Recently sold by Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest.
2	2	1.3.18	A	Secure recovery area: Portions of TMKs 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011 387001004	Unknown	*Yee Hop Ranch Ltd.	TBD[1]					Yee Hop Ranch Ltd. Provides links between state owned land parcels and protects contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	1.3.19	A	Secure recovery area: `Alae Ranch, Portions of TMK 387001014	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i DLNR, Land Division. Currently leased for cattle grazing. By conservation easement, lease, change of jurisdiction, or change in land use designation to conservation protective subzone.
2	1	1.3.20	A	Secure recovery area: McCandless Ranch, Portions of TMKs 392001003 and 386001001	Unknown	*McCandless Ranch	TBD[1]					McCandless Ranch. Protect contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	1	1.3.21	A	Secure recovery area: Waiea Tract, TMK 386001003	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i DLNR. Land Division. Protect contiguous forest habitat in South Kona from continued degradation. Currently leased for cattle grazing. By conservation easement, lease, change of jurisdiction, or change in land use designation to conservation protective subzone.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	1.3.22	A	Secure recovery area: Keālia Ranch, TMK 385001001	Unknown	*KS	TBD[1]					Kamehameha Schools. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	1	1.3.23	A	Secure recovery area: Hōnaunau Forest, TMKs 384001001 384001002 383001001 383001002	Unknown	*KS	TBD[1]					Kamehameha Schools. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	1	1.3.24	A	Secure recovery area: Keālia Ranch, Portions of TMK 385001002	Unknown	*Elizabeth Stack *et al.*	TBD[1]					Elizabeth Stack *et al.* Protect contiguous forest habitat in South Kona from development. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	1	1.3.25	A	Secure recovery area: Portions of TMK 382001001	Unknown	*Kealakekua Development Corp.	TBD[1]					Protect contiguous forest habitat in South Kona from development, and provide habitat for a second palila population. Restorable. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	1	1.3.26	A	Secure recovery area: Pu`u Lehua, Portions of TMKs 378001003 378001007 372002001 378001001	Unknown	*KS	TBD[1]					Kamehameha Schools. Provides habitat for a second palila population. Restorable. By lease, conservation easement, partnership agreement, change in land use designation to conservation, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	2	1.3.27	A	Secure recovery area: Ko`olau Forest Reserve, TMKs 224016003 224016004 228008001 228008007	Unknown	*Alexander and Baldwin, *East Maui Irrigation, *EMWP	TBD[1]					Alexander and Baldwin, East Maui Irrigation. Additional measures may be needed to ensure forest bird recovery. By partnership, safe harbor agreement, easement, change of land use designation to protective subzone of conservation, or purchase from willing seller.
3	3	1.3.28	A	Secure recovery area: Kīpahulu Forest Reserve, Kukui`ula, TMK 216001007	Unknown	*J. Haili, *EMWP	TBD[1]					J. Haili. Small parcel at lower edge of recovery area. By partnership with LHWRP.
3	3	1.3.29	A	Secure recovery area: Kīpahulu Forest Reserve, Kukui`ula, TMK 216001006	Unknown	*Kalalau, Cleveland, *EMWP	TBD[1]					Cleveland Kalalau. Small parcel at lower edge of recovery area. By partnership with LHWRP.
1	3	1.3.30	A	Secure recovery area: Kīpahulu Forest Reserve, TMKs 216001005 217001033 217002035 217004006 218001007	Unknown	*DLNR, *EMWP, *NPS	TBD[1]					Hawai`i DOFAW. Isolated; secure access for management needed. By continuing partnership with LHWRP.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	1.3.31	A	Secure recovery area: Kīpahulu Forest Reserve, TMK 217001032	Unknown	*A. Kaapana *et al.*, *EMWP	TBD[1]					A. Kaapana *et al.* Small parcel at lower edge of recovery area. By partnership with LHWRP.
2	2	1.3.32	A	Secure recovery area: Kīpahulu Forest Reserve, TMK 217001024	Unknown	*Kaupō Ranch Ltd., *EMWP	TBD[1]					Kaupō Ranch Ltd. Small parcel at lower edge of recovery area. By partnership with LHWRP.
3	1	1.3.33	A	Secure recovery area: Nu`u, TMK 218001001	Unknown	*Kaupō Ranch Ltd., *EMWP, *NPS	TBD[1]					Kaupō Ranch Ltd. Degraded former forest land in need of active management. By continuing partnership with LHWRP, safe harbor agreement, conservation easement, change of land use designation, or purchase from willing seller. Acquisition being negotiated by NPS.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	1.3.34	A	Secure recovery area: Nu`u, TMK 218001002	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest land in need of active management. By continuing partnership with LHWRP, safe harbor agreement, conservation easement, change of land use designation, or purchase from willing seller. Acquisition being negotiated by NPS.
1	2	1.3.35	A	Secure recovery area: Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Unknown	*DLNR, *EMWP	TBD[1]					Hawai`i DOFAW. Isolated; secure better access for management. Degraded former forest land in need of active management. By continuing partnership with LHWRP.
1	2	1.3.36	A	Secure recovery area: Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	Unknown	*DHHL, USFWS, *EMWP	TBD[1]					Hawai`i DHHL. Degraded former forest land in active forest stewardship program with FWS. By continuing partnership with LHWRP.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	1.3.37	A	Secure recovery area: Upper Auwahi, TMKs 219001006 221009001 222001001 222001034	Unknown	*`Ulupalakua Ranch Inc., DOI, NHPS, *EMWP	TBD[1]					`Ulupalakua Ranch Inc. Pasture with ongoing restoration at selected sites in partnership with DOI and NHPS. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.
2	2	1.3.38	A	Secure recovery area: Kula Forest Reserve, TMK 222007001	Unknown	*DLNR, *EMWP	TBD[1]					Hawai`i DOFAW. By continuing partnership with LHWRP. Degraded forest dominated by alien species. Resolve conflicting management as game management area.
2	3	1.3.39	A	Secure recovery area: Kēōkea, TMK 222004033	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest in need of active management. By partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	1.3.40	A	Secure recovery area: Waiohuli, TMK 222005052	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.
2	3	1.3.41	A	Secure recovery area: Ka`ono`ulu, TMKs 222007002 222006009 222006032 222007010	Unknown	*Ka`ono`ulu Ranch Co. Ltd., *EMWP	TBD[1]					Ka`ono`ulu Ranch Co. Ltd. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.42	A	Secure recovery area: Waiakoa, TMK 222008001	Unknown	*Lucky Shoji USA Inc., *EMWP	TBD[1]					Lucky Shoji USA Inc. *et al.* Degraded former forest in need of active management. By partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	3	1.3.43	A	Secure recovery area: Kamehame Nui/Kealahou, TMK 223005002	Unknown	*John Zwaanstra, *EMWP	TBD[1]					John Zwaanstra. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.
1	2	1.3.44	A	Secure recovery area: Haleakalā Ranch (Pūlehu Nui /Kalialinui), TMK 223005003	Unknown	*Haleakalā Ranch Co., *EMWP	TBD[1]					Haleakalā Ranch Co. Degraded former forest in need of active management. By continuing partnership with LHWRP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.
1	1	1.3.45	A	Secure recovery area: Waikamoi Preserve, TMK 223005004	Unknown	*Haleakalā Ranch Co., *TNCH, *EMWP	TBD[1]					Haleakalā Ranch Co. Under active management by The Nature Conservancy of Hawai`i through conservation easement. In EMWP and NAPS. Support continued management by TNCH, or by purchase from willing seller.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	1.3.46	A	Secure recovery area: West Maui Forest Reserve, Wailuku, TMKs 233003003 235003001 236003001	Unknown	*Wailuku Agriculture, *WMWP	TBD[1]					Wailuku Agriculture. In West Maui Watershed Partnership (WMWP). By conservation easement or purchase from willing seller.
2	3	1.3.47	A	Secure recovery area: West Maui Forest Reserve, Launiupoko, TMK 247001002	Unknown	*Amfac/JMB Hawai`i Co., *WMWP	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.48	A	Secure recovery area: West Maui Forest Reserve, Kaua`ula, TMK 246025001	Unknown	*Amfac/JMB Hawai`i Co., *WMWP	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.49	A	Secure recovery area: West Maui Forest Reserve, Kahoma, TMK 245022001	Unknown	*KS, *WMWP	TBD[1]					Kamehameha Schools. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	1.3.50	A	Secure recovery area: West Maui Forest Reserve, Pu` u Kī/Haakea, TMKs 245022002 245022004	Unknown	*Amfac/JMB Hawai`i Co., *WMWP	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.51	A	Secure recovery area: Kapunakea Preserve, Amfac/ JMB Hawai`i Co., TNCH, TMK 244007001	Unknown	*Amfac/JMB Hawai`i Co., *TNCH, *WMWP, NAPS	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. Currently managed by TNCH through conservation easement. In WMWP and NAPS. By purchase from willing seller.
2	3	1.3.52	A	Secure recovery area: West Maui Forest Reserve, Kapāloa, TMK 244007007	Unknown	*WMWP	TBD[1]					Unknown. In WMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.
2	1	1.3.53	A	Secure recovery area: Pu`u Kukui Watershed Management Area, TMKs 242001001 241001017	Unknown	*Maui Land and Pineapple, *WMWP, NAPS	TBD[1]					Maui Land and Pineapple. In WMWP and NAPS. Support continued conservation management by Maui Land and Pine, or by purchase from willing seller.
2	2	1.3.54	A	Secure recovery area: Moloka`i Forest Reserve, Kahanui, TMK 252014001	Unknown	*R. W. Myer Ltd., *et al.*	TBD[1]					R. W. Myer Ltd., *et al.* By easement, safe harbor agreement, or purchase from willing seller.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	1.3.55	A	Secure recovery area: Moloka`i Forest Reserve, Pelekunu Valley, TMK 259006011	Unknown	*TNCH	TBD[1]					The Nature Conservancy of Hawai`i. Support continued Management by TNCH.
2	3	1.3.56	A	Secure recovery area: Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, TMK 259008017	Unknown	*William Hitchcock, *et al.*	TBD[1]					Wm. Hitchcock *et al.* By easement, safe harbor agreement, or purchase from willing seller.
2	2	1.3.57	A	Secure recovery area: Moloka`i Forest Reserve, Pelekunu Valley, TMK 254003032	Unknown	*TNCH	TBD[1]					The Nature Conservancy of Hawai`i. Support continued Management by TNCH.
2	1	1.3.58	A	Secure recovery area: Moloka`i Forest Reserve, Wailau Valley and Oloku`i, TMK 259006004	Unknown	*G. Brown III, *et al.*	TBD[1]					G. Brown III *et al.* By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.59	A	Secure recovery area: Moloka`i Forest Reserve, Laeokapuna, TMK 257005027	Unknown	*P. Hodgins	TBD[1]					P. Hodgins. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.60	A	Secure recovery area: Moloka`i Forest Reserve, Keanakoholua, TMK 257005001	Unknown	*M. Hustice Trust	TBD[1]					M. Hustice Trust. By easement, safe harbor agreement, or purchase from willing seller.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	1.3.61	A	Secure recovery area: Moloka`i Forest Reserve, Manawai, TMK 256006013	Unknown	*P. Petro Trust	TBD[1]					P. Petro Trust. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.62	A	Secure recovery area: Moloka`i Forest Reserve, West `Ōhi`a Gulch, TMK 256006010	Unknown	*E. Wond Trust	TBD[1]					E. Wond Trust. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.63	A	Secure recovery area: Moloka`i Forest Reserve, Keawa Nui, TMK 256006007	Unknown	*KS	TBD[1]					Kamehameha Schools. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.64	A	Secure recovery area: Moloka`i Forest Reserve, Pua`ahala, TMK 256006002	Unknown	*K&H Horizons Hawai`i	TBD[1]					K&H Horizons Hawai`i. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.65	A	Secure recovery area: Moloka`i Forest Reserve, Kumu`eli, TMK 256006001	Unknown	*D. Fairbanks III Trust	TBD[1]					D. Fairbanks III Trust. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.66	A	Secure recovery area: Moloka`i Forest Reserve, Kamalō, TMKs 255001016 255001006 255001017	Unknown	*KS	TBD[1]					Kamehameha Schools. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	3	1.3.67	A	Secure recovery area: Moloka`i Forest Reserve, Mākolelau, TMK 255001015	Unknown	*Ashton Pitts Jr. Trust	TBD[1]					Ashton Pitts Jr. Trust. By easement, safe harbor agreement, or purchase from willing seller.
2	2	1.3.68	A	Secure recovery area: Kamakou Preserve, Kawela, TMK 2540003026	Unknown	*Moloka`i Ranch Ltd., TNCH	TBD[1]					Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. In EMOWP. By easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.69	A	Secure recovery area: Moloka`i Forest Reserve, Kawela, TMKs 254003001 254003028	Unknown	*Kawela Plantation Homes Association	TBD[1]					Kawela Plantation Homes Association. By easement or purchase from willing seller. In EMOWP.
2	3	1.3.70	A	Secure recovery area: Moloka`i Forest Reserve, Kaunakakai, TMK 253003005	Unknown	*Moloka`i Ranch Ltd.	TBD[1]					Moloka`i Ranch Ltd. By easement, safe harbor agreement, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	1.3.71	A	Secure recovery area: Pia Valley, TMKs 37003073 37003033	Unknown	*Benjamin Cassiday, *James Pflueger, *KMWP	TBD[1]					Benjamin Cassiday, James Pflueger. Upper valley in KMWP, but additional measures may be needed to ensure protection of large `elepaio population. Lower valley zoned conservation, but no other protection. By enrollment in KMWP, easement, or purchase from willing seller.
1	3	1.3.72	A	Secure recovery area: Lower Wailupe Valley, TMK 36004001	Unknown	*City and County of Honolulu	TBD[1]					City and County of Honolulu. Contains lower edge of large `elepaio population. Currently zoned urban. By enrollment in KMWP, easement, change in land use designation, or purchase from willing seller.
1	2	1.3.73	A	Secure recovery area: Kūpaua Valley, TMKs 37004001 and 37004002	Unknown	*Hawai`i Humane Society, *KMWP	TBD[1]					Hawai`i Humane Society. Upper valley in KMWP, but additional measures needed to ensure protection of large `elepaio population. By easement, SHA, enrollment in KMWP, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	2	1.3.74	A	Secure recovery area: Kuli`ou`ou Valley, TMK 38013001	Unknown	*Joseph Paiko Trust, *KMWP	TBD[1]					Joseph Paiko Trust. Contains western half of small `elepaio population. By easement, SHA, enrollment in KMWP, or purchase from willing seller.
2	3	1.3.75	A	Secure recovery area: Ka`alākei Valley, TMK 39009001	Unknown	*Hawai`i Kai Development Co., *KMWP	TBD[1]					Hawai`i Kai Development Co. Contains small `elepaio population. By easement, SHA, enrollment in KMWP, or purchase from willing seller.
3	3	1.3.76	A	Secure recovery area: Kapālama, TMK 14015009	Unknown	*Julius Chung Trust, *KMWP	TBD[1]					Julius Chung Trust. Small parcel. By partnership in KMWP.
1	1	1.3.77	A	Secure recovery area: Moanalua Valley, TMK 11013001	Unknown	*Amon Estate, *KMWP	TBD[1]					Damon Estate. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, SHA or purchase from willing seller.
1	1	1.3.78	A	Secure recovery area: South Hālawa Valley, Tripler Ridge, TMK 99011001	Unknown	*Queen's Medical Center, *KMWP	TBD[1]					Queen's Medical Center. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, SHA, or purchase from willing seller.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	1.3.79	A	Secure recovery area: Waikāne Valley, TMK 48014005	Unknown	*SMF Enterprises, *KMWP	TBD[1]					SMF Enterprises. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, SHA, or purchase from willing seller.
2	3	1.3.80	A	Secure recovery area: Waianu Valley, TMKs 48014003 and 48013014	Unknown	*Waiāhole Irrigation Co. Ltd., *KMWP	TBD[1]					Waiāhole Irrigation Co. Ltd. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement, SHA, or purchase from willing seller.
1	2	1.3.81	A	Secure recovery area: Southern Alaka`i Plateau, Portion of TMK 417001001	Unknown	*Robinson Family Partners	TBD[1]					Robinson Family Partners. Develop cooperative management agreement or purchase from willing seller.
2	1	1.3.82	A	Secure recovery area: Upper Wainiha Pali, Portion of TMK 458001001	Unknown	*Alexander and Baldwin, Hawai`i Inc., *DLNR	TBD[1]					Alexander and Baldwin Hawai`i Inc. Currently under surrender agreement to DLNR. Area under management of DLNR. Land is remote, no public access. Adequately protected at present and for foreseeable future. Any change in this status should be reassessed.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.1.1	A	Reforest areas on the Northeast slope of Mauna Kea, Portions of TMKs 344014002 344014003 343010002 343010008	Unknown	*DLNR, State Land Division	31.5					Hawai`i DLNR, Land Division. Reforest and restore pasturelands to dry māmane and mesic koa forest.
1	3	2.1.2	A	Reforest areas of the Kanakaleonui Corridor, TMK 338001009	Unknown	*DHHL	15.1					Hawai`i DHHL. Provides a vital link between mesic koa forest and dry māmane forest. Restore upper pasturelands.
3	1	2.1.3	A	Reforest areas of the Hilo Forest Reserve, Laupāhoehoe Section, TMK 337001004	Unknown	*DLNR, *DOFAW	0.9					Hawai`i DOFAW. Remove alien trees, restore transition forest from wet `ōhi`a to mesic koa.
3	2	2.1.4	A	Reforest areas of the Hilo Forest Reserve, Pīhā Section, TMK 333001004	Unknown	*DLNR, *DOFAW	1.4					Hawai`i DOFAW. Remove alien trees. Restore transition forest from wet `ōhi`a to mesic koa. Facilitate understory regeneration.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.1.5	A	Reforest areas of Hakalau Forest NWR, TMKs 337001010 329005005 333001007 329005003	Ongoing	*USFWS	33.7					USFWS. Remove alien trees and continue successful forest restoration program.
3	2	2.1.6	A	Reforest areas of Kīpuka \`Āinahou Nēnē Sanctuary, TMK 338001008	Unknown	*DHHL, *DOFAW	17.8					Hawai\`i DHHL, leased by DOFAW. Facilitate canopy tree and understory regeneration.
2	3	2.1.7	A	Reforest areas of Humu\`ula, TMK 338001002	Unknown	*DHHL	29.8					Hawai\`i DHHL. Restorable. A vital link between wet and dry forest. Reforest pasturelands to transition forest from mesic koa to dry māmane.
2	2	2.1.8	A	Reforest areas of Humu\`ula, Portions of TMK 338001007	Unknown	*DHHL, Parker Ranch	71.6					Hawai\`i DHHL, leased to Parker Ranch. Reforest pasturelands to native montane dryland habitat.
2	2	2.1.9	A	Reforest areas of Lama\`ia Section, TMK 326018002	Unknown	*DHHL	14.3					Hawai\`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Vital link between montane mesic forest and montane dry forest. Protect existing forest and reforest pasturelands.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.1.10	A	Reforest areas of Pu`u `Ō`ō Ranch, TMK 326018001	Unknown	*DLNR, State Land Division, Pu`u `Ō`ō Ranch	17.8					Hawai`i DLNR, Land Division, leased to Pu`u `Ō`ō Ranch. Important mesic and wet koa/`ōhi`a forest remnants, and vital link between wet and dry forest communities. Protect and reforest.
2	2	2.1.11	A	Reforest areas of Ka`ohe, TMK 344015002	Unknown	*DLNR, State Land Division	0.9					Hawai`i DLNR, Land Division. Protect and reforest.
1	3	2.1.12	A	Reforest areas of Mauna Kea Forest Reserve, TMK 344015002	Unknown	*DLNR	3.9					Hawai`i DLNR. Restore montane dry māmane/naio forest.
3	1	2.1.13	A	Reforest areas of Keauhou Ranch, TMK 399001004	Unknown	*KS, Keauhou Ranch	108.7					Kamehameha Schools. Reforest transition wet `ōhi`a, mesic koa and dry māmane/sandalwood.
3	1	2.1.14	A	Reforest areas of HVNP, TMK 399001002	Unknown	*HVNP	13.1					Hawai`i Volcanoes National Park. Continue dryland forest restoration.
2	2	2.1.15	A	Reforest areas of Kapāpala Ranch, Portions of TMK 398001004	Unknown	*DLNR, State Land Division, Kapāpala Ranch	11.9					Hawai`i DLNR, Land Division, Kapāpala Ranch. A link between forest communities to the east and west. Remove alien trees, restore montane dry koa, `ōhi`a and māmane forest.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	1	2.1.16	A	Reforest areas of Ka`ū Forest Reserve, TMK 397001007	Unknown	*Mauna Kea Agribusiness	1.1					Mauna Kea Agribusiness. Protect and facilitate natural regeneration.
2	1	2.1.17	A	Reforest areas of Ka`ū Forest Reserve, Portions of TMKs 397001006 and 397001005	Unknown	*KS	5.3					Kamehameha Schools. Protect and facilitate natural regeneration.
2	1	2.1.18	A	Reforest portions of TMK 392001002	Unknown	*Samuel M. Damon Trust	11.2					Samuel M. Damon Trust. Valuable wet and mesic forest habitat needs restoring. A link between Ka`ū Forest and the South Kona Forest.
3	1	2.1.19	A	Reforest areas of Honomalino, TMKs 389006004 389006029	Unknown	*Scott C. Rolles Trust	0.5					Scott C. Rolles Trust. A link between Ka`ū Forest and South Kona Forest. Protect and restore montane mesic koa forest.
3	1	2.1.20	A	Reforest areas of Papa, TMK 388001001	Unknown	*Koa Aina Ventures	8.2					The Nature Conservancy, Kona Hema Preserve. Recently sold by Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. Restore montane mesic koa forest.
3	1	2.1.21	A	Reforest areas of Honomalino, TMK 389001001	Unknown	*TNCH	12.0					The Nature Conservancy of Hawai`i. Continue forest restoration program.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.1.22	A	Reforest areas of Honomalino Forest Reserve, TMK 389001002	Unknown	*DLNR	1.3					Hawai`i DOFAW. Restore montane mesic koa and `ōhi`a forest.
2	3	2.1.23	A	Reforest areas of Yee Hop Ranch, Portions of TMKs 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011 387001004	Unknown	*Yee Hop Ranch Ltd.	27.9					Yee Hop Ranch Ltd. Provides links between State land parcels and protects contiguous forest habitat in South Kona from development. Protect and restore wet `ōhi`a, mesic koa and dry māmane/naio forest.
1	3	2.1.24	A	Reforest areas of Kona Forest NWR, TMK 386001001	Unknown	*USFWS	2.0					USFWS. Restore montane mesic koa and `ōhi`a forest.
3	2	2.1.25	A	Reforest areas of `Alae Ranch, Portions of TMK 387001014	Unknown	*DLNR, State Land Division	0.9					Hawai`i DLNR, Land Division, leased to `Alae Ranch. Protect and restore wet `ōhi`a forest.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.1.26	A	Reforest areas of McCandless Ranch and E. Stack *et al.*, Portions of TMKs 392001003 386001001 385001002	Unknown	*McCandless Ranch	12.9					Protects contiguous forest habitat in South Kona from development. Restore pasture to mesic koa and dry māmane/naio forest.
2	1	2.1.27	A	Reforest areas of Waiea Tract, TMK 386001003	Unknown	*DLNR, State Land Division	1.9					Hawai`i DLNR, Land Division. Protects contiguous mesic koa forest habitat in South Kona.
2	1	2.1.28	A	Reforest areas of Keālia Ranch, TMK 385001001 and Portions of TMKs 384001001 and 383001001	Unknown	*KS	4.2					Kamehameha Schools. Restore mesic koa forest and dry māmane/naio forest.
3	2	2.1.29	A	Reforest areas of TMK 382012001	Unknown	*Kealakekua Development Corp.	31.9					Kealakekua Development Corp. Protect contiguous forest habitat in South Kona, provide habitat for a second palila population. Restore wet `ōhi`a, mesic koa and dry montane māmane forest.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.1.30	A	Reforest areas of Pu`u Lehua, Portions of TMKs 378001003 378001007 378001002 378001001	Unknown	*KS	145.8					Kamehameha Schools. Protects contiguous forest habitat in South Kona from development, and provide habitat for a second palila population. Restore mesic koa and dry montane māmane forest.
2	1	2.1.31	A	Reforest areas of Pu`u Wa`awa`a Forest Bird Sanctuary, TMKs 371001001 371001006	Unknown	*DOFAW	34.3					Hawai`i DOFAW, Pu`u Wa`awa`a Forest Bird Sanctuary. Restore montane mesic koa and māmane/naio forest habitat.
2	3	2.1.32	A	Reforest areas of Hualālai Ranch, TMK 372002001	Unknown	*KS	11.8					Kamehameha Schools. Restore mesic and dry montane forest.
1	3	2.1.33	A	Reforest areas of Haleakalā National Park, TMK 218001007	Unknown	*NPS	8.8					National Park Service. Restore montane mesic forest in Kaupō Gap.
2	2	2.1.34	A	Reforest areas of Kīpahulu Forest Reserve, TMK 217004006	Unknown	*DLNR, *DOFAW	0.2					Hawai`i DOFAW. Restore montane mesic forest along cliffs and head of Manawainui Valley.
3	2	2.1.35	A	Reforest areas of Nu`u, TMK 218001001	Unknown	*Kaupō Ranch Ltd.	2.7					Kaupō Ranch Ltd. Restore montane mesic forest and shrubland.
3	1	2.1.36	A	Reforest areas of Nu`u, TMK 218001002	Unknown	*James Campbell Est.	4.3					James Campbell Est. Restore montane mesic forest and shrubland.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	3	2.1.37	A	Reforest areas of Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Unknown	*DLNR, *DOFAW	2.8					Hawai`i DOFAW. Restore montane mesic forest and shrubland.
1	3	2.1.38	A	Reforest areas of Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	Unknown	*DHHL	21.1					Hawai`i DHHL. Support ongoing restoration of montane mesic forest and shrubland.
2	2	2.1.39	A	Reforest areas of Upper Auwahi, TMKs 219001006 221009001 222001001 222001034	Unknown	*`Ulupalakua Ranch Inc.	8.1					`Ulupalakua Ranch Inc. Support ongoing restoration of montane mesic forest and shrubland.
2	3	2.1.40	A	Reforest areas of Kula Forest Reserve, TMK 222007001	Unknown	*DLNR	11.7					Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.
2	3	2.1.41	A	Reforest areas of Kēōkea, TMK 222004033	Unknown	*James Campbell Est.	0.5					James Campbell Est. Restore montane mesic forest and shrubland. Replace nonnative trees.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.1.42	A	Reforest areas of Waiohuli, TMK 222005052	Unknown	*James Campbell Est.	1.7					James Campbell Est. Restore montane mesic forest and shrubland. Replace nonnative trees.
3	3	2.1.43	A	Reforest areas of Ka`ono`ulu, TMKs 222007002 222006009 222007010 222006032	Unknown	*Ka`ono`ulu Ranch Co. Ltd.	3.5					Ka`ono`ulu Ranch Co. Ltd. Restore montane mesic forest and shrubland. Replace nonnative trees.
3	1	2.1.44	A	Reforest areas of Waiakoa, TMK 222008001	Unknown	*Lucky Shoji USA Inc.	0.7					Lucky Shoji USA Inc. *et al.* Restore montane mesic forest and shrubland. Replace nonnative trees.
3	2	2.1.45	A	Reforest areas of Kamehame Nui/Kealahou, TMK 223005002	Unknown	*John Zwaanstra	3.3					John Zwaanstra. Restore montane mesic forest and shrubland.
1	3	2.1.46	A	Reforest areas of Haleakalā Ranch (Pūlehu Nui/Kalialinui), TMK 223005003	Unknown	*Haleakalā Ranch Co.	4.1					Haleakalā Ranch Co. Restore montane mesic forest and shrubland.
1	3	2.1.47	A	Reforest areas of Waikamoi Preserve, TMK 223005004	Unknown	*Haleakalā Ranch Co., *TNCH	29.8					Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Restore montane mesic forest and shrubland at high elevation. Replace nonnative trees.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	2	2.1.48	A	Reforest areas of Makawao Forest Reserve, TMK 224016001 224016002	Unknown	*DLNR	6.9					Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.
2	3	2.1.49	A	Reforest areas of West Maui NAR, Kahakuloa, TMK 231006001	Unknown	*DLNR	5.8					Hawai`i DOFAW. Restore montane wet forest and shrubland.
2	3	2.1.50	A	Reforest areas of West Maui Forest Reserve, Kaheawa, TMK 248001001	Unknown	*DLNR	0.6					Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.
2	2	2.1.51	A	Reforest areas of West Maui Forest Reserve, Ukumehame/ Olowalu, West Maui NAR, Līhau, TMK 248001002	Unknown	*DLNR	18.4					Hawai`i DOFAW. Restore montane wet forest and shrubland.
2	1	2.1.52	A	Reforest areas of Pu`u Kukui Watershed Management Area, TMK 241001017	Unknown	*Maui Land and Pineapple	11.6					Maui Land and Pineapple. Restore montane wet forest and shrubland. Replace nonnative trees.
2	2	2.1.53	A	Reforest areas of Moloka`i Forest Reserve, Kalamāula, TMK 252014003	Unknown	*DLNR	1.6					Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.
2	3	2.1.54	A	Reforest areas of Moloka`i Forest Reserve, Kahanui, TMK 252014001	Unknown	*R. W. Myer Ltd., *et al.*	3.4					R. W. Myer Ltd., *et al.* Restore montane wet forest and shrubland. Replace nonnative trees.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	3	2.1.55	A	Reforest areas of Moloka`i Forest Reserve, Kahanui, TMK 261001004	Unknown	*DLNR	0.05					Hawai`i DOFAW. Restore montane wet forest and shrubland. Replace nonnative trees.
2	3	2.1.56	A	Reforest areas of Moloka`i Forest Reserve, Kamalō, TMKs 255001016 255001006 255001017	Unknown	*KS	6.0					Kamehameha Schools. Restore montane mesic forest and shrubland.
3	3	2.1.57	A	Reforest areas of Moloka`i Forest Reserve, Mākolelau, TMK 255001015	Unknown	*Ashton Pitts Jr. Trust	1.0					Ashton Pitts Jr. Trust. Restore montane mesic forest and shrubland.
2	2	2.1.58	A	Reforest areas of Kamakou Preserve, Kawela, TMK 2540003026	Unknown	*Moloka`i Ranch Ltd., *TNCH	11.1					Moloka`i Ranch Ltd, The Nature Conservancy of Hawai`i. Restore montane mesic forest and shrubland. Replace nonnative trees.
3	2	2.1.59	A	Reforest areas of Moloka`i Forest Reserve, Kawela, TMK 254003001	Unknown	*Kawela Plantation Homes Association	3.7					Kawela Plantation Homes Association. Restore montane mesic forest and shrubland.
2	2	2.1.60	A	Reforest areas of Moloka`i Forest Reserve, Kamiloloa/Makakupaīa, TMK 254003025	Unknown	*DLNR	5.3					Hawai`i DOFAW. Restore montane mesic forest and shrubland. Replace nonnative trees.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	2.1.61	A	Reforest areas of Moloka`i Forest Reserve, Kaunakakai, TMK 253003005	Unknown	*Moloka`i Ranch Ltd.	2.5					Moloka`i Ranch Ltd. Restore montane mesic forest and shrubland. Replace nonnative trees.
3	3	2.1.62	A	Reforest areas of Mākua Military Reservation	Unknown	*U.S. Army	6.0					U.S. Army. Portions of upper valley recently burned, need reforestation.
3	2	2.1.63	A	Reforest areas of Kōke`e State Park, TMKs 414001013 459001016 414001020 414001014 414001002 and numerous small parcels within	Unknown	*DLNR, Division of State Parks	20.0					Hawai`i DLNR, Division of State Parks. Additional protection may be needed to secure remaining forested habitat.
2	1	2.2.1	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation on the northeast slopes of Mauna Kea, Portions of TMKs 344014002 344014003 343010002 343010008	Continual	*DLNR, State Land Division	48.7					Hawai`i DLNR, Land Division.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	2	2.2.2	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kanakaleonui Corridor, TMK 338001009	Continual	*DHHL	33.4					Hawai`i DHHL. Provides vital link between mesic koa forest and dry māmane forest. Currently under lease for cattle grazing.
2	2	2.2.3	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, TMKs 337001004 333001004	Continual	*DLNR, *DOFAW	63.1					Hawai`i DOFAW. Currently managed for game hunting.
1	1	2.2.4	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hakalau Forest NWR, TMKs 337001010 329005005 333001007 329005005 329005003	Continual	*USFWS	114.4					USFWS. Ungulate control under way. Construct additional fences and control ungulates in unmanaged areas.
2	1	2.2.5	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lama`ia Section, TMK 326018002	Continual	*DHHL	44.3					Hawai`i DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Encourage fencing and ungulate removal.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.6	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pu`u `Ō`ō Ranch, TMK 326018001	Continual	*DLNR, State Land Division, Pu`u `Ō`ō Ranch	36.7					Hawai`i DLNR, Land Division, Pu`u `Ō`ō Ranch lease. Encourage fencing and ungulate removal.
2	1	2.2.7	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpuka `Āinahou Nēnē Sanctuary, TMK 338001008	Continual	*DHHL	55.0					Hawai`i DHHL. Encourage fencing and ungulate removal.
2	2	2.2.8	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ka`ohe, TMK 344015002	Continual	*DLNR, State Land Division	2.8					Hawai`i DLNR, Land Division. Suspend lease. Fence and remove ungulates.
1	1	2.2.9	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Mauna Kea Forest Reserve, TMKs 344015001 344016003 338001004	Continual	*DLNR, *DOFAW	127.7					Hawai`i DLNR. Palila critical habitat. Continue to remove ungulates.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	3	2.2.10 and 2.2.11	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiākea Forest Reserve, TMK 324008001	Continual	*DLNR, *DOFAW	229.8					Hawai`i DOFAW. Fence and remove ungulates.
1	2	2.2.12	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within `Ōla`a/Kīlauea Partnership, TMKs 324008009 399001007 399001004 324008025 319001001 319001007	Continual	*KS, Keauhou Ranch, Kūlani Correctional Facility, *Maka`ala NAR, *HVNP	218.7					Kamehameha Schools, Keauhou Ranch. Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP.
2	1	2.2.13	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kapāpala Forest Reserve, Portions of TMK 398001004	Continual	*DLNR, State Land Division	92.0					Hawai`i DLNR, Land Division, Kapāpala Forest Reserve. Fence and remove ungulates.
1	1	2.2.14	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ka`ū Forest Reserve, TMK 397001001	Continual	*DLNR, *DOFAW	306.7					Hawai`i DOFAW, Ka`ū Forest Reserve. Fence and remove ungulates.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	2	2.2.15	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahuku Ranch, Portions of TMK 392001002	Continual	*NPS	231.6					Recently purchased by NPS. Fence and remove ungulates, particularly mouflon sheep.
2	2	2.2.16	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Manukā NAR, Upper Portions of TMK 391001002	Continual	DLNR, DOFAW	21.3					Hawai`i DOFAW. Fence and remove ungulates.
3	1	2.2.17	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Honomalino, TMK 389001001	Continual	*TNCH	0.9					The Nature Conservancy of Hawai`i. Fence and remove ungulates.
3	1	2.2.18	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Yee Hop Ranch, TMK 392001005	Continual	*Yee Hop Ranch Ltd.	38.0					Yee Hop Ranch Ltd. Fence and remove ungulates.
2	1	2.2.19	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kona Forest NWR, TMK 386001001	Continual	*USFWS	24.6					USFWS. Fence and remove ungulates.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.2.20	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within McCandless Ranch, Portions of TMKs 392001003 386001001 385001002	Continual	*McCandless Ranch and E. Stack *et al.*	92.2					McCandless Ranch and E. Stack *et al.* Fence and remove ungulates.
2	2	2.2.21	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiea Tract, TMK 386001003	Continual	*DLNR, State Land Division	5.8					Hawai`i DLNR, Land Division. Fence and remove ungulates.
2	2	2.2.22	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hōnaunau Forest, TMKs 384001001 384001002 383001001 383001002	Continual	*KS	50[2]					Kamehameha Schools. Fence and remove ungulates

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	2.2.23	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pu`u Lehua, Portions of TMKs 378001003 378001007 372002001 378001001	Continual	*KS	135.2					. Kamehameha Schools. Fence and remove ungulates.
1	1	2.2.24	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ko`olau Forest Reserve, TMKs 224016003 224016004 228008001 228008007	Continual	*Alexander and Baldwin, *East Maui Irrigation, EMWP, TNCH	50[2]					Alexander and Baldwin, East Maui Irrigation. EMWP fence protects lower boundary in east; TNCH protects upper boundary. Remove ungulates from protected areas. Additional ungulate removal needed from unprotected areas.
1	1	2.2.25	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ko`olau Forest Reserve, TMKs 211002002 212004005 229014001 211001050 211001044	Continual	*DLNR, *EMWP	50[2]					Hawai`i DOFAW. EMWP fencing underway to protect forest above about 3,600 ft. Remove ungulates above fence. Additional ungulate control needed from unprotected areas below fence. Proposed additions to Hanawī NAR would support forest bird recovery.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.2.26	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hanawī NAR and Ko`olau Forest Reserve, TMK 212004007	Continual	*DLNR	100[2]					Hawai`i DLNR. NAR fencing protects 1,734 acres, ungulate-free, above 5,400 ft. Fence and remove ungulates from remain portions of NAR (above 2,500 ft. for bird management).
1	3	2.2.27	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hāna Forest Reserve, TMK 210001001 214001001 215001001	Continual	*DLNR	106.9					Hawai`i DLNR. Fencing and ungulate control urgently needed. Proposed additions to Hanawī NAR would support forest bird recovery.
1	1	2.2.28	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Haleakalā National Park, TMK 213001003 216001002 216001001 216001003 217004016 216010001	Continual	*NPS	50[2]					NPS. Mostly protected by fencing, ungulate removal needs to be completed in some areas. Fence and remove ungulates from remaining areas, e.g., Ka`āpahu.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	2.2.29	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, Kukui`ula, TMK 216001007	Continual	*J. Haili	0.2					J. Haili. Encourage ungulate control and fencing.
3	2	2.2.30	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, Kukui`ula, TMK 216001006	Continual	*Kalalau, Cleveland	0.6					C. Kalalau. Encourage ungulate control and fencing.
1	3	2.2.31	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMKs 216001005 217001033 217002035 217004006	Continual	*DLNR	20.3					Hawai`i DLNR. Fence and remove ungulates.
3	2	2.2.32	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMK 217001032	Continual	*A. Ka`apana *et al.*	0.1					A. Ka`apana *et al.* Encourage ungulate control and fencing.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.33	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMK 217001024	Continual	*Kaupō Ranch Ltd.	0.2					Kaupō Ranch Ltd. Encourage ungulate control and fencing.
3	3	2.2.34	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Nu`u, TMK 218001001	Continual	*Kaupō Ranch Ltd.	8.1					Kaupō Ranch Ltd. Encourage ungulate control and fencing.
3	3	2.2.35	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Nu`u, TMK 218001002	Continual	*James Campbell Estate	13.0					James Campbell Est. Encourage ungulate control and fencing.
1	2	2.2.36	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Continual	*DLNR	50[2]					Hawai`i DOFAW. Fencing of portion underway. Complete fencing and ungulate removal from Forest Reserve above 4,000 ft.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	2	2.2.37	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	Continual	*DHHL	50[2]					Hawai`i DHHL. Fencing of portions underway. Continue fencing through partnership programs. Ungulate removal above 4,000 ft.
1	2	2.2.38	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Upper Auwahi, TMKs 219001006 221009001 222001001 222001034	Continual	*`Ulupalakua Ranch Inc.	50[2]					`Ulupalakua Ranch Inc. Some exclosures for plant protection in place or underway. Encourage fencing and ungulate removal above 4,000 ft.
2	1	2.2.39	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kula Forest Reserve, TMK 222007001	Continual	*DLNR	35.1					Hawai`i DOFAW. Currently a sustained yield game management area. For portions within forest bird recovery area, fence and remove ungulates to allow regeneration of native forest.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.40	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kēōkea, TMK 222004033	Continual	*James Campbell Est.	1.6					James Campbell Est. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.
2	2	2.2.41	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiohuli, TMK 222005052	Continual	*James Campbell Est.	5.2					James Campbell Est. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.
2	2	2.2.42	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ka`ono`ulu, TMKs 222007002 222006009 222007010 222006032	Continual	*Ka`ono`ulu Ranch Co. Ltd.	10.6					Ka`ono`ulu Ranch Co. Ltd. Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.
2	3	2.2.43	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiakoa, TMK 222008001	Continual	*Lucky Shoji USA Inc. *et al.*	2.2					Lucky Shoji USA Inc. *et al.* Fence and remove ungulates within forest bird recovery area, manage with Kula Forest Reserve.
2	2	2.2.44	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kamehame Nui/Kealahou, TMK 223005002	Continual	* John Zwaanstra	10.0					John Zwaanstra. Fence and remove ungulates within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.45	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Haleakalā Ranch (Pūlehu Nui/Kalialinui), TMK 223005003	Continual	*Haleakalā Ranch Co.	12.2					Haleakalā Ranch Co. The ranch is formulating a conservation reforestation plan. Fence and remove ungulates within forest bird recovery area.
1	1	2.2.46	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waikamoi Preserve, TMK 223005004	Complete	*Haleakalā Ranch Co.	20[2]					Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Strategic fencing and ungulate control protects the Preserve. Additional protection, especially from deer, may be warranted.
1	3	2.2.47	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Makawao Forest Reserve, TMKs 224016001 224016002	Continual	*DLNR	20.5					Hawai`i DOFAW. Public hunting currently permitted. Fence and remove ungulates within forest bird recovery area.
2	2	2.2.48	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui NAR, Kahakuloa, TMK 231006001	Continual	*DLNR	17.5					Hawai`i DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.49	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Waihe`e, TMK 232014001	Continual	*Maui Board of Water Supply	31.8					Maui Board of Water Supply. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.50	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kou, TMK 232014002	Continual	*DLNR	0.8					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.51	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Wailuku, TMKs 233003003 235003001 236003001	Continual	*Wailuku Agriculture	59.7					Wailuku Agriculture. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.52	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, `Īao, TMK 233003004	Continual	*DLNR	0.8					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.53	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kealaloloa, TMK 236001014	Continual	*DLNR	4.1					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.54	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Manawainui Plant Reserve, TMKs 236001052 248001010	Continual	*DLNR	0.7					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.55	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kaheawa, TMK 248001001	Continual	*DLNR	1.7					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.56	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Ukumehame/Olowalu, West Maui NAR, Līhau, TMK 248001002	Continual	*DLNR	55.1					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.57	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Launiupoko, TMK 247001002	Continual	*Amfac/JMB Hawai`i Co.	14.1					American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.58	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Pūehuehu, TMK 247001004	Continual	*DLNR	2.6					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.59	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kaua`ula, TMK 246025001	3 years	*Amfac/JMB Hawai`i Co.	2.7					American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.60	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Pana`ewa, TMK 246025002	Continual	*DLNR	12.0					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.61	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kahoma, TMK 245022001	Continual	*KS	10.5					Kamehameha Schools. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.62	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kahoma, TMK 245022005	Continual	*DLNR	0.3					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.63	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kaua`ula/Haakea, TMKs 245022002 245022004	Continual	*Amfac/JMB Hawai`i Co.	2.5					American Factors (Amfac)/JMB Hawai`i Co. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.64	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Wahikuli, TMK 245022003	Continual	*DLNR	2.9					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	2	2.2.65	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kapunakea Preserve, Amfac/JMB, TNCH, TMK 244007001	Continual	*Amfac/JMB Hawai`i Co., *TNCH	9.1					American Factors (Amfac)/JMB Hawai`i Co., TNCH. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.66	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kapāloa, TMK 244007007	Continual	UNK	2.1					Unknown. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.67	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui NAR, Honokōwai, TMK 244007004	Continual	*DLNR	11.0					Hawai`i DLNR. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.68	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pu`u Kukui Watershed Management Area, TMKs 242001001 241001017	Continual	*Maui Land and Pineapple	48.8					Maui Land and Pineapple. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.69	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kalamāula, TMK 252014003	Continual	*DLNR	4.8					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.70	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kahanui, TMK 252014001	Continual	*R. W. Myer, *et al.*	10.3					R. W. Myer Ltd., *et al.* Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.71	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kahanui, TMK 261001004	Continual	*DLNR	0.2					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.72	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Waikolu and Pu`u Ali`i NAR, TMK 261001002	Continual	*DLNR	21.6					Hawai`i DOFAW. Ungulate control currently ongoing at Pu`u Ali`i NAR. Strategic fencing and ungulate removal within forest bird recovery area.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.2.73	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pelekunu Valley, TMK 259006011	Continual	*TNCH	15.7					The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.74	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, TMK 259008017	Continual	*William Hitchcock, *et al.*	0.2					Wm. Hitchcock, *et al*. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.75	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pelekunu Valley, TMK 254003032	Continual	*TNCH	1.4					The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.76	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Wailau Valley, TMK 259006002	Continual	*DLNR	25.6					Hawai`i DOFAW. Naturally isolated but vulnerable to incursion. Ungulate control ongoing. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.77	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Wailau Valley and Oloku`i, TMK 259006004	Continual	*G. Brown III, *et al.*	0.5					G. Brown III, *et al.* Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.78	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Laeokapuna, TMK 257005027	Continual	*P. Hodgins	1.4					P. Hodgins. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.79	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Keanakoholua, TMK 257005001	Continual	*M. Hustice Trust	4.3					M. Hustice Trust. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.80	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, `Uala`pue, TMK 256006026	Continual	*DLNR	1.2					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.81	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kahananui, TMK 256006014	Continual	*DLNR	1.1					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.82	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Manawai, TMK 256006013	Continual	*P. Petro Trust	1.5					P. Petro Trust. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.83	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, east `Ōhi`a Gulch, TMK 256006011	Continual	*DLNR	2.0					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.84	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, West `Ōhi`a Gulch, TMK 256006010	Continual	*E. Wond Trust	1.0					E. Wond Trust. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	3	2.2.85	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Keawa Nui, TMK 256006007	Continual	*KS	1.1					Kamehameha Schools. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.86	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pua`ahala, TMK 256006002	Continual	*K&H Horizons Hawai`i	0.8					K&H Horizons Hawai`i. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.87	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kumu`eli, TMK 256006001	Continual	*D. Fairbanks III Trust, EMOWP	50[2]					D. Fairbanks III Trust, (Austin Estate?). In EMOWP; currently fencing portions and removing ungulates. Continue strategic fencing and remove ungulates within forest bird recovery area.
2	2	2.2.88	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kamalō, TMKs 255001016 255001006 255001017	Continual	*KS, *EMOWP	50[2]					Kamehameha Schools. In EMOWP; currently fencing portions and removing ungulates. Strategic fencing and ungulate removal within forest bird recovery area.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.89	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Mākolelau, TMK 255001015	Continual	*Ashton Pitts Jr. Trust	3.1					Ashton Pitts Jr. Trust. Strategic fencing and ungulate removal within forest bird recovery area.
2	2	2.2.90	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kamakou Preserve, Kawela, TMK 2540003026	Continual	*Moloka`i Ranch Ltd., *TNCH, EMOWP	33.2					Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. In EMOWP. Ungulate control currently ongoing. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.91	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kawela, TMKs 254003001	Continual	*Kawela Plantation Homes Association	11.2					Kawela Plantation Homes Association. Strategic fencing and ungulate removal within forest bird recovery area.
2	3	2.2.92	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kamiloloa/ Makakupaīa, TMK 254003025	Continual	*DLNR	15.7					Hawai`i DOFAW. Strategic fencing and ungulate removal within forest bird recovery area.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.2.93	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kaunakakai, TMK 253003005	Continual	*Moloka`i Ranch Ltd.	0.7					Moloka`i Ranch Ltd. Strategic fencing and ungulate removal within forest bird recovery area.
1	2	2.2.94	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Honouliuli Preserve, TMK 92005013	Continual	*James Campbell Est., *TNCH	31.7					James Campbell Estate, managed by The Nature Conservancy of Hawai`i. One 40-acre exclosure completed, a second is planned. More, larger fences needed to exclude ungulates from as much of the preserve as possible.
2	2	2.2.95	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lualualei Naval Magazine, TMK 88001001	Continual	*U.S. Navy	13.7					U.S. Navy. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Not open to public hunting.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds													
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	3	2.2.96	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Schofield Barracks West Range, TMK 77001001	Continual	*U.S. Army	16.2					U.S. Army. Ungulate control to protect forest and reduce mosquito breeding habitat. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Not open to public hunting.
2	2	2.2.97	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pahole NAR, TMK 68001002	Continual	*DLNR	5.8					Hawai`i State. Fencing and ungulate eradication to protect forest, reduce mosquito breeding habitat. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Currently few `elepaio, but high potential for augmentation.
2	3	2.2.98	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahanahāiki Valley, TMK 81001012	Continual	*U.S. Army	2.2					U.S. Army. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	2.2.99	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within O`ahu Forest NWR, TMKs 95004001 and 76001001	Continual	*USFWS	57.6					U.S. Fish and Wildlife Service. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides. Currently no `elepaio, but high potential for reintroduction.
3	2	2.2.100	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lower Ka`ala NAR, TMK 67003025	Continual	*DLNR	9.5					Hawai`i State. Currently few `elepaio, but high potential for augmentation/ reintroduction. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	2.2.101	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Halehaha, Halepā`ākai, and Koai`e drainages, Alaka`i Wilderness Preserve, Portions of TMK 414001003	Continual	*DLNR, *DOFAW	8.7					Hawai`i DOFAW. Fencing of at least a 4 km square area in the Halepā`ākai and Koai`e Stream drainage and eradication of pigs is needed to protect key habitat. Fencing and ungulate control and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.
2	1	2.2.102	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Upper Mōhihi and upper Waiakoali drainages, Alaka`i Wilderness Preserve, Portions of TMK 414001003	Continual	*DLNR, *DOFAW	11.4					Hawai`i DOFAW. Fencing as much of the core puaiohi population as possible. Fencing and ungulate control and/or time/area closure to hunting in preparation for aerial broadcast of rodenticide.
2	1	2.2.103	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Alaka`i Wilderness Preserve, TMK 414001003	Continual	*DLNR, *DOFAW	100[2]					Hawai`i DOFAW. Strategic fencing to exclude ungulates from as much of the preserve as practical.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	2.2.104	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Southern Alaka`i Plateau, Portions of TMK 417001001	Continual	*Robinson Family Partners	20[2]					Gay and Robinson Partnership with DLNR/ DOFAW. Fencing and ungulate control may be needed in preparation for aerial broadcast of rodenticides.
1-3	1-3	2.3	A	Reduce or eliminate the detrimental effects of exotic plants through mechanical, chemical, or biological means, as appropriate	Ongoing	All Land Managers	TBD[3]					
2	2	2.4.1.1	C	Control alien mammalian predators by trapping, poisoning and other means on northeastern slopes of Mauna Kea, Portions of TMKs 344014002 344014003 343010002 343010008	Continual	*DLNR, State Land Division	378.3	12.6	12.6	12.6	12.6	Hawai`i State, DLNR, State Land Division.
2	1	2.4.1.2	C	Control alien mammalian predators by trapping, poisoning and other means in Kanakaleonui Corridor, TMK 338001009	Continual	*DHHL	181.3	6.0	6.0	6.0	6.0	Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.3	C	Control alien mammalian predators by trapping, poisoning and other means in Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, TMKs 337001002 and 333001004	Continual	*DLNR, *DOFAW	32.5	1.1	1.1	1.1	1.1	Hawai`i State, DLNR, DOFAW. Currently managed for game hunting.
1	1	2.4.1.4	C	Control alien mammalian predators by trapping, poisoning and other means in Hakalau Forest NWR, TMKs 337001010 333001007 329005005 329005003	Ongoing	*USFWS	404.4	13.5	13.5	13.5	13.5	Currently managed forest bird habitat.
2	1	2.4.1.5	C	Control alien mammalian predators by trapping, poisoning and other means in TMK 326018002	Continual	*DHHL	171.0	5.7	5.7	5.7	5.7	Hawai`i State DHHL, adjacent to Hakalau Forest National Wildlife Refuge.
2	2	2.4.1.6	C	Control alien mammalian predators by trapping, poisoning and other means in Pu`u Ō`ō Ranch, TMK 326018001	Continual	*DLNR, State Land Division, Pu`u `Ō`ō Ranch	213.7	7.1	7.1	7.1	7.1	Hawai`i State, DLNR, State Land Division, Pu`u Ō`ō Ranch lease.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.4.1.7	C	Control alien mammalian predators by trapping, poisoning and other means in Kīpuka `Āinahou Nēnē Sanctuary, TMK 338001008	Continual	*DHHL	213.6	7.1	7.1	7.1	7.1	Hawai`i State, DHHL.
2	1	2.4.1.8	C	Control alien mammalian predators by trapping, poisoning and other means in Ka`ohe 344015002	Continual	*DLNR, State Land Division	10.8	0.36	0.36	0.36	0.36	Hawai`i State DLNR, State Land Division.
1	1	2.4.1.9	C	Control alien mammalian predators by trapping, poisoning and other means in Mauna Kea Forest Reserve, TMKs 344015001 344016003 338001004	Continual	*DLNR	244.1	8.1	8.1	8.1	8.1	Hawai`i State DLNR. Palila critical habitat.
2	1	2.4.1.10 and 2.4.1.11	C	Control alien mammalian predators by trapping, poisoning and other means in Waiākea Forest Reserve, TMK 324008001	Continual	*DLNR, *DOFAW	1783.7	59.5	59.5	59.5	59.5	Hawai`i State DLNR, DOFAW.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	2.4.1.12	C	Control alien mammalian predators by trapping, poisoning and other means in `Ōla`a/Kīlauea Partnership, TMKs 324008009 399001007 399001004 324008025 319001001 319001007	Continual	*KS, Keauhou Ranch, *DOFAW, *HVNP	1373.2	45.8	45.8	45.8	45.8	Kamehameha Schools, Keauhou Ranch, Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP.
2	1	2.4.1.13	C	Control alien mammalian predators by trapping, poisoning and other means in Kapāpala Forest Reserve, Portions of TMK 398001004	Continual	*DLNR, State Land Division	142.8	4.8	4.8	4.8	4.8	Hawai`i State DLNR, State Land Division, Kapāpala Forest Reserve.
1	1	2.4.1.14	C	Control alien mammalian predators by trapping, poisoning and other means in Ka`ū Forest Reserve, TMK 397001001	Continual	*DLNR, *DOFAW	2380.6	79.4	79.4	79.4	79.4	Hawai`i State DLNR, DOFAW, Ka`ū Forest Reserve.
2	1	2.4.1.15	C	Control alien mammalian predators by trapping, poisoning and other means in Kahuku Ranch, portions of TMK 392001002	Continual	*Samuel M. Damon Trust	1348.4	44.9	44.9	44.9	44.9	Samuel M. Damon Trust. Purchase by NPS.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.16	C	Control alien mammalian predators by trapping, poisoning and other means in Manukā NAR, Upper portions of TMK 391001002	Continual	*DLNR, *DOFAW	42.8	1.4	1.4	1.4	1.4	
2	1	2.4.1.17	C	Control alien mammalian predators by trapping, poisoning and other means in TNCH, Honomalino, TMK 389001001	Continual	*TNCH	144.4	4.8	4.8	4.8	4.8	
2	2	2.4.1.18	C	Control alien mammalian predators by trapping, poisoning and other means in Yee Hop Ranch, TMK 392001005	Continual	*Yee Hop Ranch Ltd.	147.5	4.9	4.9	4.9	4.9	
1	1	2.4.1.19	C	Control alien mammalian predators by trapping, poisoning and other means in Kona Forest NWR, TMK 386001001	Continual	*USFWS	85.5	2.9	2.9	2.9	2.9	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.20	C	Control alien mammalian predators by trapping, poisoning and other means in McCandless Ranch, TMKs 392001003 386001001 385001002	Continual	*McCandless Ranch	154.5	5.1	5.1	5.1	5.1	
2	1	2.4.1.21	C	Control alien mammalian predators by trapping, poisoning and other means in Waiea Tract, TMK 386001003	Continual	*DLNR, State Land Division	45.3	1.5	1.5	1.5	1.5	
2	1	2.4.1.22	C	Control alien mammalian predators by trapping, poisoning and other means in Hōnaunau Forest, TMKs 384001001 384001002 383001001 383001002	Continual	*KS	574.3	19.1	19.1	19.1	19.1	
2	1	2.4.1.23	C	Control alien mammalian predators by trapping, poisoning and other means in Pu`u Lehua, Portion of TMK 378001003	Continual	*KS	839.7	28.0	28.0	28.0	28.0	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.4.1.24	C	Control alien mammalian predators by trapping, poisoning and other means in Pu`u Wa`awa`a Bird Sanctuary, TMKs 371001001 and 371001006	Continual	*DLNR, *DOFAW	411.8	13.7	13.7	13.7	13.7	
1	1	2.4.1.25	C	Control alien mammalian predators by trapping, poisoning and other means in Ko`olau Forest Reserve, TMKs 224016003 224016004 228008001 228008007	Continual	*Alexander and Baldwin, *East Maui Irrigation	438.2	14.6	14.6	14.6	14.6	Alexander and Baldwin, East Maui Irrigation. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.
1	1	2.4.1.26	C	Control alien mammalian predators by trapping, poisoning and other means in Ko`olau Forest Reserve, TMKs 211002002 212004005 229014001 211001050 211001044	Continual	*DLNR, *DOFAW	491.4	16.4	16.4	16.4	16.4	Hawai`i State, DLNR, DOFAW. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.4.1.27	C	Control alien mammalian predators by trapping, poisoning and other means in Hanawī NAR and Ko`olau Forest Reserve, TMK 212004007	Continual	*DLNR, *DOFAW	353.2	11.8	11.8	11.8	11.8	Hawai`i State, DLNR, DOFAW. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.
1	1	2.4.1.28	C	Control alien mammalian predators by trapping, poisoning and other means in Hāna Forest Reserve, TMKs 210001001 214001001 215001001	Continual	*DLNR, *DOFAW	428.7	14.3	14.3	14.3	14.3	Hawai`i State, DLNR, DOFAW. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.
1	1	2.4.1.29	C	Control alien mammalian predators by trapping, poisoning and other means in Haleakalā National Park, TMKs 213001003 216001002 216001001 216001003 217004016 216010001 218001007	Continual	*NPS	498.0	16.6	16.6	16.6	16.6	NPS. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.30	C	Control alien mammalian predators by trapping, poisoning and other means in Kīpahulu Forest Reserve, TMKs 216001005 217001033 217002035 217004006	Continual	*DLNR, *DOFAW	81.3	2.7	2.7	2.7	2.7	Hawai`i State, DLNR, DOFAW. Adjacent to known populations of AKOH and MAPA. Potential for range expansion.
2	3	2.4.1.31	C	Control alien mammalian predators by trapping, poisoning and other means in Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Continual	*DLNR, *DOFAW	106.2	3.5	3.5	3.5	3.5	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction.
2	3	2.4.1.32	C	Control alien mammalian predators by trapping, poisoning and other means in Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	Continual	*DHHL	253.3	8.4	8.4	8.4	8.4	Hawai`i State, DHHL. Potential long-term site for reintroduction.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
3	3	2.4.1.33	C	Control alien mammalian predators by trapping, poisoning and other means in Kula Forest Reserve, TMK 222007001	Continual	*DLNR, *DOFAW	140.8	4.7	4.7	4.7	4.7	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction.
3	2	2.4.1.34	C	Control alien mammalian predators by trapping, poisoning and other means in Haleakalā Ranch (Pūlehu Nui/Kalialinui), TMK 223005003	Continual	*Haleakalā Ranch Co.	48.8	1.6	1.6	1.6	1.6	Haleakalā Ranch Co. Adjacent to current range. Likely site of near-term range expansion for AKOH and MAPA.
1	1	2.4.1.35	C	Control alien mammalian predators by trapping, poisoning and other means in Waikamoi Preserve, TMK 223005004	Continual	*Haleakalā Ranch Co., *TNCH	357.3	11.9	11.9	11.9	11.9	Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Portions supporting breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.
2	3	2.4.1.36	C	Control alien mammalian predators by trapping, poisoning and other means in Makawao Forest Reserve, TMKs 224016001 224016002	Continual	*DLNR, *DOFAW	82.3	2.7	2.7	2.7	2.7	Hawai`i State, DLNR, DOFAW. Likely site of near-term range expansion for AKOH and MAPA.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.4.1.37	C	Control alien mammalian predators by trapping, poisoning and other means in West Maui NAR, Kahakuloa, TMK 231006001	Continual	*DLNR, *DOFAW	70.0	2.3	2.3	2.3	2.3	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction.
3	3	2.4.1.38	C	Control alien mammalian predators by trapping, poisoning and other means in West Maui NAR, Līhau, TMK 248001002	Continual	*DLNR, *DOFAW	221.0	7.4	7.4	7.4	7.4	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction.
3	3	2.4.1.39	C	Control alien mammalian predators by trapping, poisoning and other means in West Maui Forest Reserve, Pana`ewa, TMK 246025002	Continual	*DLNR, *DOFAW	48.3	1.6	1.6	1.6	1.6	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction.
2	3	2.4.1.40	C	Control alien mammalian predators by trapping, poisoning and other means in Kapunakea Preserve, Amfac/JMB Hawai`i Co., TNCH, TMK 244007001	Continual	*TNCH, *American Factors	36.5	1.2	1.2	1.2	1.2	American Factors (Amfac)/JMB Hawai`i Co., TNCH. Primary site for reintroduction.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	2.4.1.41	C	Control alien mammalian predators by trapping, poisoning and other means in West Maui NAR, Honokōwai, TMK 244007004	Continual	*DLNR, *DOFAW	43.9	1.5	1.5	1.5	1.5	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction.
2	2	2.4.1.42	C	Control alien mammalian predators by trapping, poisoning and other means in Pu`u Kukui Watershed Management Area, TMKs 242001001 241001017	Continual	*Maui Land and Pineapple	195.6	6.5	6.5	6.5	6.5	Maui Land and Pineapple. Primary site for reintroduction.
2	2	2.4.1.43	C	Control alien mammalian predators by trapping, poisoning and other means in Moloka`i Forest Reserve and Pu`u Ali`i NAR, Waikolu, TMK 261001002	Continual	*DLNR, *DOFAW	86.6	2.9	2.9	2.9	2.9	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction.
2	2	2.4.1.44	C	Control alien mammalian predators by trapping, poisoning and other means in Moloka`i Forest Reserve and Oloku`i NAR, Wailau Valley, TMK 259006002	Continual	*DLNR, *DOFAW	102.5	3.4	3.4	3.4	3.4	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.45	C	Control alien mammalian predators by trapping, poisoning and other means in Kamakou Preserve, Kawela, TMK 2540003026	Continual	*Moloka`i Ranch Ltd., *TNCH	133.2	4.4	4.4	4.4	4.4	Moloka`i Ranch Ltd, TNCH. Primary site for reintroduction.
1	1	2.4.1.46	C	Control alien mammalian predators by trapping, poisoning and other means in Honouliuli Preserve, TMK 92005013	Ongoing	*James Campbell Estate, *TNCH	173.7	5.8	5.8	5.8	5.8	James Campbell Estate. The Nature Conservancy of Hawai`i has controlled rodents in a 40 acre exclosure using snap traps and bait stations. Control should be continued and expanded, using aerial broadcast if possible.
2	2	2.4.1.47	C	Control alien mammalian predators by trapping, poisoning and other means in Lualualei Naval Magazine, TMK 88001001	Ongoing	*U.S. Navy	75.1	2.5	2.5	2.5	2.5	U.S. Navy. Control rodents using diphacinone bait stations, or by aerial broadcast if possible.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.4.1.48	C	Control alien mammalian predators by trapping, poisoning and other means in Schofield Barracks West Range, TMK 77001001	Ongoing	*U.S. Army	88.9	3.0	3.0	3.0	3.0	U.S. Army. Environmental Division has attempted small-scale rat control using snap traps and bait stations, but insufficient access to be effective. Aerial broadcast of rodenticide would increase scale, less access needed.
1	1	2.4.1.49	C	Control alien mammalian predators by trapping, poisoning and other means in Honolulu Watershed Forest Reserve (Wailupe), TMK 36004004	Ongoing	*DLNR, *DOFAW	47.8	1.6	1.6	1.6	1.6	Hawai`i State, DLNR, DOFAW. Rodent control conducted from 1999-2000 using snap traps and bait stations. Aerial broadcast would increase scale.
1	2	2.4.1.50	C	Control alien mammalian predators by trapping, poisoning and other means in North Hālawa Valley, TMK 99011002	Continual	*KS	6.0	0.2	0.2	0.2	0.2	Kamehameha Schools. Rodent control needed to protect core `elepaio population.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	2.4.1.51	C	Control alien mammalian predators by trapping, poisoning and other means in Control alien mammalian predators by trapping, poisoning and other means in Moanalua Valley, TMKs 11013001 and 11013002	Continual	*Damon Estate	13.1	0.4	0.4	0.4	0.4	Damon Estate. Rodent control needed to protect core `elepaio population.
1	2	2.4.1.52	C	Control alien mammalian predators by trapping, poisoning and other means in Waikāne Valley, TMK 48014005	Unknown	*SMF Enterprises	17.8	0.6	0.6	0.6	0.6	SMF Enterprises. Rodent control needed to protect core `elepaio population.
1	2	2.4.1.53	C	Control alien mammalian predators by trapping, poisoning and other means in Kahana Valley State Park, TMKs 52001001 and 52002001	Continual	*DLNR, *DOFAW	17.8	0.6	0.6	0.6	0.6	Hawai`i State. Rodent control needed to protect core `elepaio population.
1	2	2.4.1.54	C	Control alien mammalian predators by trapping, poisoning and other means in Mākaha Valley, TMKs 84002014 and 84002001	Continual	*City and County of Honolulu	6.0	0.2	0.2	0.2	0.2	City and County of Honolulu. Rodent control needed to protect core `elepaio population.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.4.1.55	C	Control alien mammalian predators by trapping, poisoning and other means in Pahole NAR, TMK 68001002	Ongoing	*DLNR, *DOFAW	31.5	1.0	1.0	1.0	1.0	Hawai`i State, DLNR, DOFAW. Rodent control conducted in 1999 using bait stations. Currently few `elepaio, but aerial broadcast would help prepare site for reintroduction/augmentation.
2	1	2.4.1.56	C	Control alien mammalian predators by trapping, poisoning and other means in Kahanahāiki Valley, TMK 81001012	Ongoing	*U.S. Army	11.9	0.4	0.4	0.4	0.4	U.S. Army. Rodent and mongoose control conducted from 1998-2000 using snap traps, bait stations, and live traps. Currently few `elepaio, but aerial broadcast would help prepare site for reintroduction/augmentation.
2	2	2.4.1.57	C	Control alien mammalian predators by trapping, poisoning and other means in O`ahu Forest NWR, TMKs 95004001 and 76001001	Continual	*USFWS	315.4	10.0	10.0	10.0	10.0	U.S. Fish and Wildlife. Currently few `elepaio, but rodent control would help prepare site for augmentation or reintroduction.
3	2	2.4.1.58	C	Control alien mammalian predators by trapping, poisoning and other means in Lower Ka`ala NAR, TMK 67003025	Continual	*DLNR, *DOFAW	52.2	1.7	1.7	1.7	1.7	Hawai`i State, DLNR, DOFAW. Currently few `elepaio, but aerial broadcast of rodenticide would help prepare site for reintroduction or augmentation.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	2.4.1.59	C	Control alien mammalian predators by trapping, poisoning and other means in Halehaha, Halepā`ākai, and Koai`e drainages, Alaka`i Wilderness Preserve, TMK 414001003	Continual	*DLNR, *DOFAW	47.4	1.6	1.6	1.6	1.6	Hawai`i State, DLNR, DOFAW. Recommend aerial broadcast of rodenticide in Halehaha and Halepā`ākai drainages, and a tributary to Koai`e Stream.
2	1	2.4.1.60	C	Control alien mammalian predators by trapping, poisoning and other means in Upper Mōhihi and upper Waiakoali drainages, Alaka`i Wilderness Preserve, TMK 414001003	Ongoing	*DLNR, *DOFAW	62.3	2.0	2.0	2.0	2.0	Hawai`i State, DLNR, DOFAW. Depending on outcome of study whether rats pose threat to core puaiohi population, recommend aerial broadcast of rodenticides in upper Mōhihi and Waiakoali drainages. Ground-based protection of active nest-sites.
2	1	2.4.1.61	C	Control alien mammalian predators by trapping, poisoning and other means in Upper Kawaikōī, Alaka`i Wilderness Preserve, TMK 459001001	Ongoing	*DLNR, *DOFAW	11.9	0.4	0.4	0.4	0.4	Hawai`i State, DLNR, DOFAW. Ground-based bait station rodent control in association with puaiohi release, and ground-based feral cat control.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	2.4.1.62	C	Control alien mammalian predators by trapping, poisoning and other means in Southern Alaka`i Plateau, portions of TMK 417001001	Continual	*Robinson Family Partners	12.0	0.4	0.4	0.4	0.4	Robinson Family Partners, in conjunction with release program for puaiohi. Total cost based continuous implementation for 30 years (estimated time to delisting).
1	1	2.4.2	C	Continue the public information campaign explaining the need for aerial broadcast of diphacinone for conservation purposes.	3 years	*State and Federal Agencies	4.0	2.0	1.0	1.0		
1	1	2.4.3	C	Examine feasibility/ appropriateness of time/area closure of public use areas when using broadcast application of diphacinone	2 years	*State and Federal Agencies	2.0	1.0	1.0			
1	1	2.5.1.1	C	Enforce existing quarantine laws for importation of pet birds	Ongoing	*State and Federal Departments of Agriculture, ADWG	30.0	1.0	1.0	1.0	1.0	Total cost based on equivalent of one additional enforcement officer per year for 30 years.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.5.1.2	C	Work with Postal Service and the State Department of Agriculture to ban shipments of day-old poultry and game birds to Hawai`i via first class mail	4 years	*U.S. Postal Service, *State Dept. of Agriculture, ADWG	4.0	1.0	1.0	1.0	1.0	
1	1	2.5.1.3.1	C	Develop a list of priority diseases that should be screened for in all imported cage birds and poultry, and establish monitoring program for new diseases	Ongoing	*ADWG	60.0	2.0	2.0	2.0	2.0	
1	1	2.5.1.3.2	C	Respond to and determine causes of avian disease outbreaks	Continual	*ADWG	60.0	2.0	2.0	2.0	2.0	
1	1	2.5.1.4	A, C, E	Work to stop global climate change	Continual	*Research Institutions, *USFWS, DOFAW, HFBRT	15.0	0.5	0.5	0.5	0.5	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	2.5.2.1	C	Initiate inspection programs for all interisland vessels, including ships, airplanes, and barges and their cargos, to intercept and kill mosquito larvae and adults	Continual	*State and Federal Departments of Agriculture, ADWG	30.0	1.0	1.0	1.0	1.0	
1	1	2.5.2.2	C	Enforce and toughen existing laws that require health certificates for interisland movement of pet birds and poultry	Ongoing	Research Institutions, *State and Federal Agencies	30.0	1.0	1.0	1.0	1.0	
2	3	2.5.2.3	C	Establish disease monitoring protocols for captive native birds to assess presence of avian disease in captive held populations and risk of transfer of disease strains between avian captive holding facilities	Ongoing	*ZSSD, USFWS, *USGS, DOFAW, ADWG	15.0	0.5	0.5	0.5	0.5	
2	3	2.5.2.3.1	C	Develop a list of diseases of concern for which captive birds should be routinely tested before they can be transferred between avian captive holding facilities	2 years	*ZSSD, USFWS, *USGS, DOFAW, *ADWG	5.0	2.5	2.5			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	1	2.5.3.1.1.1	C	Mosquito surveys on Hawai`i between 2,000 and 5,000 ft. on Mauna Loa and Kīlauea that include recovery area	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			
1	3	2.5.3.1.1.2	C	Mosquito surveys on Hawai`i between 3,400 and 5,000 ft. on Mauna Kea that include recovery area	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	
1	3	2.5.3.1.1.3	C	Mosquito surveys between 3,400 and 5,000 ft. on Hualālai that include recovery area, portions of TMKs 371001001, 372002001, 374002008, 374001003, 374002007, 374001002	1 year	*USGS, USFWS, DOFAW	2.5	2.5				
2	2	2.5.3.1.1.4	C	Mosquito surveys of windward Hāmākua between 3,400 and 2,000 ft. on Mauna Kea adjacent to or within 3 km of recovery area	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	
2	2	2.5.3.1.1.5	C	Mosquito surveys on Kīlauea adjacent to or within 3 kilometers of recovery area	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	2	2.5.3.1.1.6	C	Mosquito surveys on Hualālai adjacent to or within 3 km of recovery area	1 year	*USGS, USFWS, DOFAW	2.5	2.5				
1	3	2.5.3.1.1.7	C	Mosquito surveys between 2,500 and 5,000 ft. on Haleakalā that include recovery area	4 years	*USGS, NPS USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	East Maui Recovery area below the 5,000 ft. contour line.
2	2	2.5.3.1.1.8	C	Mosquito surveys, TMK 217004006	1 year	*USGS, USFWS, DOFAW	2.5	2.5				East Maui Manawainui Valley incursion into recovery area, below 2,500 ft. contour line.
1	3	2.5.3.1.1.9	C	Mosquito surveys, TMK 217004006	1 year	*USGS, USFWS, DOFAW	2.5	2.5				East Maui Manawainui Valley incursion into recovery area from 2,500 to 1,600 feet.
1	3	2.5.3.1.1.10	C	Mosquito surveys, TMK 215001001	1 year	*USGS, NPS, USFWS, DOFAW	2.5	2.5				East Maui Waiho`i Valley incursion into recovery area, below 2,500 to 2,000 feet.
1	3	2.5.3.1.1.11	C	Mosquito surveys, TMK 216001002	1 year	*USGS, USFWS, DOFAW	2.5	2.5				East Maui Kīpahulu Valley incursion into recovery area, from 2,500 to 1,600 feet.
1	3	2.5.3.1.1.12	C	Mosquito surveys, TMK 211002002	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	East Maui Ke`anae Valley incursion into recovery area from 2,500 to 1,800 feet.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
3	2	2.5.3.1.1.13	C	Mosquito surveys below and within 3 km of the 4,000 ft. contour line on the southern and western slopes of Haleakalā	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			East Maui land parcels adjacent to recovery area and also in need of extensive restoration.
1	3	2.5.3.1.1.14	C	Mosquito surveys of West Maui in recovery area between 2,500 and 5,000 ft. contour lines	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			Multiple land parcels in West Maui Mountains.
2	2	2.5.3.1.1.15	C	Mosquito surveys within `Īao Valley, West Maui, TMKs 233003003, 235003001, 233003004, and multiple smaller parcels	1 year	*USGS, USFWS, DOFAW	1.0	1.0				`Īao Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.16	C	Mosquito surveys of West Maui, TMKs 232014001 and 233003003	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Waiehu Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.17	C	Mosquito surveys of West Maui, TMK 232014001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Waihe`e Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.18	C	Mosquito surveys of West Maui, TMK 231006001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Kahakuloa Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.19	C	Mosquito surveys of West Maui, TMK 241001017	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Honokōhau Valley incursion into recovery area, between 2,500 ft. and 600 ft.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	2	2.5.3.1.1.20	C	Mosquito surveys of West Maui, TMKs 236003001 and 235003001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Waikapū Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.21	C	Mosquito surveys of West Maui, TMK 241001017	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Honolua Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.22	C	Mosquito surveys, of West Maui, TMK 242001001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Honokahua Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.23	C	Mosquito surveys of West Maui, TMK 242001001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Kahana Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.24	C	Mosquito surveys of West Maui, TMKs 244007004, 244007011, 244007001, and 244007005	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Honokōwai Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.25	C	Mosquito surveys of West Maui, TMK 245022001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Kahoma Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.26	C	Mosquito surveys of West Maui, TMK 246025002	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Kanahā Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.27	C	Mosquito surveys of West Maui, TMKs 246025001 and 247001002	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Mākila Valley incursion into recovery area, between 2,500 ft. and 600 ft.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.5.3.1.1.28	C	Mosquito surveys of West Maui, TMK 248001002	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Olowalu Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.29	C	Mosquito surveys of West Maui, TMK 248001002	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Ukumehame Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.30	C	Mosquito surveys of West Maui, TMK 236003001	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Pōhākea Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.31	C	Mosquito surveys of West Maui, TMK 245022003	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Waihikuli Valley incursion into recovery area, between 2,500 ft. and 600 ft.
2	2	2.5.3.1.1.32	C	Mosquito surveys of West Maui, TMK 245022004	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Hanakea Valley incursion into recovery area, between 2,500 ft. and 600 ft.
3	2	2.5.3.1.1.33	C	Mosquito surveys of multiple parcels in West Maui below and up to 3 km from the 2,500 contour line that do not include major stream valleys listed above	3 years	*USGS, USFWS, DOFAW	7.5	2.5	2.5	2.5		Land parcels around West Maui Mountains that are adjacent to recovery area.
1	3	2.5.3.1.1.34	C	Mosquito surveys in multiple parcels that include recovery area on Moloka`i	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.5.3.1.1.35	C	Mosquito surveys in Waihānau, Wai`ale`ia, Waikolu, Pelekunu, and Wailau Valleys on Moloka`i that are adjacent to or within 3 km of recovery area, TMK's 261001002, 259006011, 259006002 and smaller windward parcels	1 year	*USGS, USFWS, DOFAW	2.5	2.5				
2	2	2.5.3.1.1.36	C	Mosquito surveys in Kaunakakai Gulch on Moloka`i	1 year	*USGS, USFWS, DOFAW	1.0	1.0				Emphasis should extend to determining role of urban/suburban development in and around Kaunakakai on generation of mosquitoes.
2	2	2.5.3.1.1.37	C	Mosquito surveys adjacent to or within 3 km of the southern and eastern boundaries of recovery area on leeward Moloka`i, portions of TMKS 252014003, 253003005, 254003025, 254003001, 255001006 and others	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			Vector surveys should ideally extend from the lower boundary of recovery area to the coastline, particularly in areas with rural agricultural development.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	3	2.5.3.1.1.38	C	Mosquito surveys of parcels on O`ahu that include recovery area	4 years	*USGS, USFWS, DOFAW, DOD	10.0	2.5	2.5	2.5	2.5	
2	2	2.5.3.1.1.39	C	Mosquito surveys of parcels on O`ahu that are adjacent to or within 3 km of recovery area	4 years	*USGS, USFWS, DOFAW DOD	10.0	2.5	2.5	2.5	2.5	
1	3	2.5.3.1.1.40	C	Mosquito surveys on Kaua`i that include recovery area, TMKs 414001020, 414001014, 414001013, 459001016, 459001001, 414001003, 417001001, 458001001 and others	3 years	*USGS, USFWS, DOFAW	7.5	2.5	2.5	2.5		Surveys should focus on relative roles of human development in Kōke`e and natural oviposition sites in the central Alaka`i in generating mosquitoes.
2	2	2.5.3.1.1.41	C	Mosquito surveys on Kaua`i that are adjacent to or within 3 km of recovery area, portions of TMKs 459001001, 458001001, 458002002, 459001003, 459001002	1 year	*USGS, USFWS, DOFAW	2.5	2.5				Windward parcels that are adjacent to recovery area on the Alaka`i Plateau, including Wainiha Valley.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	2.5.3.1.1.42	C	Mosquito surveys on Kaua`i that are adjacent to or within 3 km of recovery area, portions of TMKs 414001014, 414001020, 414002040, 414001003, 417001001	1 year	*USGS, USFWS, DOFAW	2.5	2.5				Leeward parcels that are adjacent to recovery area on the Alaka`i Plateau, including Waimea Canyon.
1	1	2.5.3.1.2	C	Eliminate or treat mosquito breeding sites in recovery area and adjacent areas at elevations below 5,000 ft. with BTI (Dunk®) or other environmentally compatible pesticides that are safe for non-target organisms	Ongoing	*Land Managers, *State and Federal Agencies	100.0					Cost approximate; will depend on findings of vector surveys to identify and prioritize areas for treatment and results of experimental treatments of efficiency and effects on non-target species.
1	2	2.5.3.1.3	C	Eliminate or treat mosquito breeding habitat associated with human development (e.g., residential areas, agricultural sites); coordinate efforts with the State Department of Health	Ongoing	*Land Managers, *State and Federal Agencies, *State Departments of Health and Education	100.0					Cost approximate; will depend on findings of vector surveys to identify and prioritize areas for treatment and results of experimental treatments of efficiency and effects on non-target species.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.5.3.1.3.1	C	Eliminate or treat cattle troughs and stock ponds	Ongoing	*Land Managers, State Departments of Health and Education	15.0	0.5	0.5	0.5	0.5	Use findings from vector surveys to identify and prioritize areas for treatment.
1	1	2.5.3.1.3.2	C	Eliminate or treat game bird waterers in areas where they might impact native forest birds	Ongoing	*Land Managers, *State and Federal Agencies	3.0	0.1	0.1	0.1	0.1	Use findings from vector surveys to identify and prioritize areas for treatment.
1	1	2.5.3.1.3.3	C	Repair rain gutters, cover catchment tanks, and eliminate containers that catch and hold rainwater around residential and agricultural sites near recovery area	Ongoing	*Land Managers, *State Departments of Health and Education	20.0					Use findings from vector surveys to identify and prioritize areas for treatment.
1	2	2.5.3.1.3.4	C	Initiate public outreach efforts to inform the public about potential human and animal diseases transmitted by mosquitoes and how source reduction can reduce those threats	3 years	Land Managers, *State Departments of Health and Education	4.0	2.0	1.0	1.0		

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.5.3.1.4.1	C	Identify and fence priority recovery areas at elevations below 5,000 ft. and control feral ungulates to prevent creation of new larval habitats	Ongoing	*Land Managers, *State and Federal Agencies	100.0					Use findings from vector surveys to identify and prioritize areas for treatment.
2	1	2.5.3.1.4.2	C	Manually drain feral pig-damaged tree ferns that hold water and fill or drain pig wallows in appropriate areas to reduce mosquito breeding sites	Ongoing	*Land Managers, USGS, USFWS, DOFAW	20.0					Use findings from vector surveys to identify and prioritize areas for treatment.
2	1	2.5.3.1.5	C	Identify natural sites (e.g., stream margins, tree holes) that serve as larval habitat and determine feasibility of treatment or elimination	Ongoing	Land Managers, *USGS, USFWS, DOFAW	10.0					Use findings from vector surveys to identify and prioritize areas for treatment.
1	1	2.5.4.1	C	Insure that existing low elevation native bird populations and habitats within current zones of disease transmission are protected to preserve disease tolerant genotypes	Ongoing	Research Institutions, UH, *USFWS, USGS, *DOFAW, ADWG	100.0					Identify low elevation native bird populations through statewide surveys, monitor status and trends of those populations, and work to insure that habitat is protected.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds												
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.5.4.2	C	Use birds that occur in areas with disease transmission as founders for translocations to establish new populations	Ongoing	Research Institutions, UH, *USFWS, USGS, *DOFAW, ADWG	90.0	3.0	3.0	3.0	3.0	
2	2	2.5.5	C	Monitor long-term changes in the prevalence and transmission of avian diseases in recovery forest bird habitats	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, DOFAW, ADWG	75.0	2.5	2.5	2.5	2.5	Identify priority areas for long-term monitoring in areas that will be intensively managed.
2	2	2.6.1.1	A	Encourage HDOA to modify import lists to exclude reptiles and amphibians from commercial sale	1 year	*HDOA, *APHIS, USFWS, DLNR	0.1	0.1				
2	1	2.6.1.2	A	Encourage HDOA to modify import lists to decrease the numbers of vertebrate species allowed into the state	1 year	*HDOA, *APHIS, USFWS, DLNR	0.1	0.1				
2	1	2.6.1.3	A	Assist HDOA obtain an enforcement branch to pursue smuggling and release violations	4 years	*HDOA, *APHIS, USFWS, DLNR	20.0	5.0	5.0	5.0	5.0	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	2.6.1.4	A	Encourage USFWS to adopt state injurious species lists as part of federal injurious wildlife list under the Lacey Act	1 year	*USFWS, DLNR	0.1	0.1				
2	2	2.6.1.5	A	Encourage HDOA, DLNR, USFWS, and county police departments to develop a task force to pursue smuggling and release violations	1 year	*HDOA, APHIS, *USFWS, *DLNR, *County Police Departments	5.0	5.0				
2	2	2.6.1.6	A	Provide single point-of-exit at airports	Unknown	*FAA, *County Airports, HDOA, APHIS, USFWS, DLNR	100.0					
2	2	2.6.1.7	A	Increase the numbers of HDOA and USDA inspectors to better cover nursery cargo and passenger baggage/hand-carry	Unknown	County Airports, *HDOA, *USDA	20.0					
2	1	2.6.1.8	A	Secure congressional approval of USDA quarantine of mainland	Unknown	*USDA, APHIS, USFWS, DLNR	10.0					

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	2.6.1.9	A	Prevent inter-island expansion of established vertebrates of restricted range, including brown treesnake	Ongoing	*HDOA, *APHIS, USFWS, DLNR	600.0	20.0	20.0	20.0	20.0	
1	2	2.6.2	A	Eradicate all incipient populations of new nonnative vertebrates	4 years	*APHIS, USFWS, DLNR	80.0	20.0	20.0	20.0	20.0	
1	2	2.6.2.1	A	Prevent spread of *Eleutherodactylus* frogs to new areas	4 years	*APHIS, USFWS, DLNR	80.0	20.0	20.0	20.0	20.0	
1	3	2.6.2.2	A	Eradicate/control populations of *Eleutherodactylus* where possible	4 years	*APHIS, USFWS, DLNR	80.0	20.0	20.0	20.0	20.0	
2	1	2.6.3	A	Reduce or eliminate the detrimental effects of *vespulid* wasps (yellow jackets) on forest birds within forest ecosystems	Ongoing	*USFWS, DLNR, NPS	75.0	2.5	2.5	2.5	2.5	
1	1-3	3	E	Develop captive propagation, translocation and related recovery strategies	Ongoing	*ZSSD, *USFWS, USGS, *DOFAW, HFBRT	600.0	20.0	20.0	20.0	20.0	Annual and total costs for captive propagation program, which would implement all related recovery strategies.

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	2	3.1	E	Periodically evaluate and identify the target species that will require captive propagation for recovery and the appropriate strategy to be used	Ongoing	*ZSSD, *USFWS, USGS, *DOFAW, HFBRT	TBD[4]					
1	2	3.2	E	Develop captive propagation programs for target species, including both endangered and surrogate species	Ongoing	*ZSSD, *USFWS, USGS, *DOFAW, HFBRT	TBD[4]					
1	1	3.2.1	E	For species considered nearly extinct, efforts should be made to collect eggs for incubation and captive rearing to establish captive breeding flocks whose progeny will be used for reintroduction into native, managed habitat in the future	Ongoing	*ZSSD, *USFWS, USGS, *NPS, *DOFAW, HFBRT	TBD[4]					\`ō\`ū, Maui nukupu\`u, Maui \`ākepa, oloma\`o, O\`ahu creeper, kāma\`o, Kaua\`i nukupu\`u, \`akialoa, and Kaua\`i \`ō\`ō.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	3.2.2	E	Continue habitat management, attempt to promote pairing and reproduction, in captivity if necessary, and collect eggs for captive propagation and reintroduction into managed habitat	Ongoing	*ZSSD, *USFWS, USGS, *NPS, *DOFAW, HFBRT	TBD[4]					Po`ouli.
2	1	3.2.3	E	Maintain a captive breeding flock of whose progeny will be used for reintroduction into managed habitat	Ongoing	*ZSSD, USFWS, USGS, DOFAW, HFBRT	TBD[4]					Puaiohi.
2	2	3.2.4	E	Collect eggs for incubation and captive rearing to establish a captive breeding flock whose progeny will be used for reintroduction into managed habitat	Ongoing	*ZSSD, *USFWS, *USGS, *NPS, DOFAW, HFBRT	TBD[4]					`Akiapōlā`au.
2	1	3.2.5.1	E	Collect the eggs of Maui parrotbill and maintain a captive breeding flock whose progeny will be used for reintroduction into managed habitat in the future	Ongoing	*ZSSD, USFWS, USGS, *NPS, *DOFAW, HFBRT	TBD[4]					Maui parrotbill.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	3.2.5.2	E	Develop rear and release methods for managed native habitat on leeward Haleakalā (Kahikinui), West Maui or Moloka`i, when disease is no longer known to be a threat	Ongoing	*ZSSD, USFWS, USGS, DOFAW, HFBRT	TBD[4]					Maui parrotbill.
2	3	3.2.6.1	E	Continue program to use translocation to West Maui or Moloka`i as recovery strategy	Ongoing	ZSSD, USFWS, USGS, NPS, *DOFAW, HFBRT	TBD[4]					`Ākohekohe.
3	1	3.2.6.2	E	Collect eggs for incubation and captive rearing. If translocations fail, use "rear and release" technology for birds reared from wild eggs or establish captive breeding flock whose progeny will be used for reintroduction into managed habitat	Ongoing	*ZSSD, USFWS, USGS, *DOFAW, HFBRT	TBD[4]					`Ākohekohe.
2	2	3.2.7.1	E	Collect eggs for incubation and captive rearing	Ongoing	*ZSSD, USFWS, USGS, NPS, *DOFAW, HFBRT	TBD[4]					Palila.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	3.2.7.2	E	If the genetic diversity of palila in the captive flock drops below acceptable levels (defined as <90%); collect wild eggs	Ongoing	*ZSSD, USFWS, *USGS, DOFAW, HFBRT	TBD[4]					Palila.
2	1	3.2.7.3	E	Maintain a captive breeding flock whose progeny will be used for reintroduction into managed habitat	Ongoing	*ZSSD, USFWS, USGS, DOFAW, HFBRT	TBD[4]					Palila.
3	3	3.2.8.1	E	Collect eggs for incubation and captive rearing	Ongoing	*ZSSD, *USFWS, *USGS, DOFAW, HFBRT	TBD[4]					Hawai`i `ākepa and Hawai`i creeper.
3	2	3.2.8.2	E	Maintain captive flocks of Hawai`i `ākepa and Hawai`i creeper whose progeny will be used for reintroduction into managed habitat in the future, or rear and release in managed habitat	Ongoing	*ZSSD, USFWS, USGS, DOFAW, HFBRT	TBD[4]					Hawai`i `ākepa and Hawai`i creeper.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	1	3.2.9	E	Collect the eggs of Hawai`i `elepaio to serve as a surrogate to develop the techniques to breed, incubate, rear and release the endangered O`ahu subspecies.	Ongoing	*ZSSD, USFWS, USGS, DOFAW, HFBRT	TBD[4]					O`ahu `elepaio.
2	1	3.3.1	E	Develop methods of evaluating, selecting, and preparing sites for release of endangered birds to ensure long-term persistence of birds reintroduced to West Maui and Moloka`i	Ongoing	*ZSSD, *USFWS, USGS, *NPS, *DOFAW, *HFBRT	TBD[4]					Maui forest birds.
2	1	3.3.2	E	Develop methods of evaluating, selecting, and preparing sites for release of endangered birds to ensure long-term persistence of palila reintroduced to upland dry forest on Mauna Kea and Mauna Loa	Ongoing	*ZSSD, *USFWS, *USGS, *NPS, *DOFAW, HFBRT	TBD[4]					Palila.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	3.3.3	E	Develop methods of evaluating, selecting, and preparing sites for release of endangered birds to ensure long-term persistence of reintroduced puaiohi populations	Ongoing	*ZSSD, *USFWS, USGS, *NPS, *DOFAW, HFBRT	TBD[4]					Puaiohi.
2	1	3.3.4	E	Develop methods of evaluating, selecting, and preparing sites for release of endangered birds to ensure long-term persistence of \`akiapōlā\`au reintroduced to South Kona, Kapāpala/Ka\`ū, and upland forests of Mauna Kea	Ongoing	*ZSSD, *USFWS, *USGS, *NPS, *DOFAW, HFBRT	TBD[4]					\`Akiapōlā\`au.
1	1	3.4	E	Acquire funding to build additional facilities to maintain, propagate, incubate and rear endangered species and if necessary, surrogate species	Ongoing	*Private sector funding, ZSSD, USFWS, DOFAW, HFBRT	TBD[4]					

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
1	1	3.5	E	Identify wild populations and/or individuals with potential natural disease resistance on a species by species basis	Ongoing	USFWS, *USGS, DOFAW	TBD[4]					
1	2	3.6.1	E	Develop and refine techniques for the release of captive-reared birds into managed habitat: Monitor dispersal, survival, and mortality of released birds to refine propagation and release techniques	Ongoing	*ZSSD, *USFWS, *USGS, *DOFAW	TBD[4]					
2	1	3.6.2	E	Develop and refine techniques for the release of captive-reared birds into managed habitat: Develop and refine release (hacking) procedures	Ongoing	*ZSSD, USFWS, USGS, DOFAW	TBD[4]					

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	3.7	E	For each of the species identified as candidates for captive propagation, it is important to establish demographic goals for captive propagation program, i.e. how many birds to produce using which demographic strategy over what period of time and released into how many sites	Ongoing	*ZSSD, *USFWS, *USGS, *NPS, *DOFAW	TBD[4]					
2	3	3.8	E	Develop species specific reintroduction guidelines based on risk assessments that consider the behavioral, disease, demographic and genetic needs of the species	Ongoing	*ZSSD, *USFWS, *USGS, *NPS, *DOFAW	TBD[4]					
2	3	3.9	E	Provide biological material from captive held birds to an agreed holding location or locations determined on a species by species basis	Unknown	*ZSSD, USFWS, USGS, DOFAW	TBD[4]					

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	3.10	E	If egg collections fail, develop methods by which to bring nestling birds, juveniles, and/or adults into captivity with concomitant quarantine procedures	Unknown	*ZSSD, *USFWS, USGS, *DOFAW	TBD[4]					
1	3	3.11.1	E	Establish a cryogenic cell culture of germplasm of the endangered Hawaiian avifauna at two partner institutions willing to hold the cell line in perpetuity: In the case of the rarest species in the event of death, or if population is below 300 individuals	Unknown	*ZSSD, ADWG, VC, *USFWS, USGS, DOFAW	5.0					
2	2	3.11.2	E	Establish a cryogenic cell culture of germplasm of the endangered Hawaiian avifauna at two partner institutions willing to hold the cell line in perpetuity: Obtain and hold cryogenic germplasm for all other endangered forest birds	Unknown	*ZSSD, ADWG, VC, *USFWS, USGS, DOFAW	5.0					

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	3.12.1	E	Evaluate the Honolulu Zoo or other qualified institutions as repositories for those endangered species and/or individuals that are not contributing to the captive propagation program	1 year	*ZSSD, *HZ, *USFWS, DOFAW, VC	0.1	0.1				
2	1	4.1.1	E	Identify species-specific niche requirements and the role of habitat degradation and competition in reducing carrying capacity	4 years	*Research Institutions, *UH, USFWS, *USGS, *NPS, DOFAW	21.0	6.0	6.0	6.0	3.0	
1	1	4.2.1.1	C	Continue efforts to register hand and aerial broadcast methods for dispersing diphacinone toxicants for controlling predators	4 years (ongoing)	Research Institutions, UH, *USFWS, USGS, NPS, *DOFAW	6.0	1.5	1.5	1.5	1.5	
2	1	4.2.1.2	C	Evaluate the efficacy of other toxicants than diphacinone for controlling mammalian predators and take the steps needed for their registration	4 years	*Research Institutions, *UH, *USFWS, USGS, NPS, *DOFAW	10.0	2.5	2.5	2.5	2.5	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	4.2.1.3	C	Develop and evaluate improved methods for controlling predators such as more efficient traps, contraceptives, and predator-proof fences for critical areas	4 years (ongoing)	*Research Institutions, *UH, *USFWS, USGS, NPS, *DOFAW	10.0	2.5	2.5	2.5	2.5	
1	1	4.2.2	C	Rat study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	10.0	2.5	2.5	2.5	2.5	
1	2	4.2.3	C	Feral cat study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	6.0	1.5	1.5	1.5	1.5	
1	3	4.2.4	C	Mongoose study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, DOFAW	6.0	1.5	1.5	1.5	1.5	
1	2	4.2.5	C	Mosquito study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, DOFAW	10.0	2.5	2.5	2.5	2.5	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	4.2.6	A	Ungulate exclusion and control study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	12.0	3.0	3.0	3.0	3.0	Experimental tests are needed of alternative methods for controlling and/or excluding feral pigs, goats, sheep, mouflon, and axis deer.
2	1	4.2.7	E	Weed study/control	Ongoing	*Research Institutions, *UH, USFWS, USGS, NPS, *DOFAW	TBD[3]					
2	1	4.2.8	E	Yellow jacket wasp study	4 years (ongoing)	*Research Institutions, *UH, USFWS, USGS, NPS, *DOFAW	4.0	1.0	1.0	1.0	1.0	
2	3	4.2.9	C	Barn owl and pueo study	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	1.5	0.5	0.5	0.5		
2	3	4.2.10	E	Avian competitor study	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	8.0	2.0	2.0	2.0	2.0	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	4.2.10.1	E	Investigate red-billed leiothrix as competitor and reservoir for disease for po`ouli and Maui parrotbill	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	3.0	1.0	1.0	1.0		
2	1	4.2.10.2	E	Investigate competition for food and space, and disease relations, between O`ahu `elepaio and introduced birds	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	3.0	1.0	1.0	1.0		
2	1	4.2.10.3	E	Investigate role of Japanese White-eye and newly appeared Japanese Bush-warbler as competitors and reservoirs of disease for Hawai`i `ākepa, Hawai`i creeper, and `akiapōlā`au	3 years (ongoing)	*Research Institutions, *UH, USFWS, USGS, NPS, *DOFAW	3.0	1.0	1.0	1.0		
2	1	4.2.11	A	Determine best ways of conducting reforestation efforts	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, *DOFAW	4.0	1.0	1.0	1.0	1.0	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	4.2.12	A, C, E	Investigate nonnative invertebrates in forest habitats to determine distribution, direct and indirect interactions with native invertebrates, role as a prey base for nonnative birds and mammals, and effects on flora.	10 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, DOFAW	10.0	1.0	1.0	1.0	1.0	
2	1	4.3.1	A, C	Examine response of populations to habitat restoration, including the provisioning of food, foraging substrates, nest-sites, and roost sites, as well as the effects of habitat restoration on threats such as mosquitoes, predators, and competitors	Ongoing	*Research Institutions, *UH, USFWS, *USGS, NPS, *DOFAW	40.0					
1	1	4.4.1	C	Address public health concerns regarding aerial broadcast of rodenticide and its effects on both game and non-game non-target species, and its persistence in watershed and sediments	3 years	Research Institutions, UH, *USFWS, USGS, NPS, *DOFAW	6.0	2.0	2.0	2.0		

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10		
2	3	4.5.1.1	C	Determine if sleeping habits may reduce exposure to mosquitoes and predators	1 year	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	0.5	0.5					
2	3	4.5.1.2	C, E	Determine if nest structure and location may provide protection from high winds, rain and cold, and predators	3 years	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	3.0	1.0	1.0	1.0			
1	1	4.5.2.1	C	Develop molecular methods for identifying individuals who are more likely to survive pox and malaria infections or to resist them	4 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	8.0	2.0	2.0	2.0	2.0		
1	2	4.5.2.2	C	Refine diagnostic methods for identifying individuals who have survived acute disease and who have acquired immunity to reinfection	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0			
2	3	4.6.1	E	Investigate ways to enhance resource availability for particular species within existing habitat.	Ongoing	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	10.0						

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	4.6.1.1.1	E	Determine if experimental artificial cavities increase the density of breeding pairs of Hawai`i `ākepa or expand the range of the birds through colonization of habitat without natural cavities	4 years (ongoing)	Research Institutions, *UH, USFWS, USGS, DOFAW	2.0	0.5	0.5	0.5	0.5	
2	1	4.6.1.1.2	C	Test the design and efficacy of rat-proof artificial nest structures for puaiohi on Kaua`i	Ongoing (ongoing)	Research Institutions, UH, USFWS, USGS, *DOFAW	1.5	0.5	0.5	0.5		
2	3	4.6.1.2	A	Determine if application of fertilizer to host plants increases growth, and productivity of flowers and arthropods	Complete	*Research Institutions, *UH, USFWS, USGS, *NPS, DOFAW	10.0					
2	1	4.6.1.3	A	Develop effective techniques for restoration of degraded and deforested lands	4 years	*Research Institutions, *UH, *USFWS, *USGS, *NPS, *DOFAW	8.0	2.0	2.0	2.0	2.0	

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds													
Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	4.6.2.1	E	Develop a comprehensive library of microsatellite loci	3 years	*Research Institutions, ZSSD, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	3	4.6.2.2	E	Document genetic population structure of species with single populations	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	2	4.6.2.3	E	Document source/sink metapopulation structure along gradients in density, particularly elevational gradients	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, DOFAW	6.0	2.0	2.0	2.0		
2	3	4.6.2.4	E	Document genetic relationships among individuals in isolated populations such as may be found on different volcanoes or in different areas of a fragmented population	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	3	4.6.2.5	E	Determine patterns of dispersal by age and sex	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	6.0	2.0	2.0	2.0		

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	3	4.6.2.6	E	Determine seasonal patterns of movement by age and sex	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	6.0	2.0	2.0	2.0		
2	1	4.6.3	E	Conduct population and metapopulation viability analyses	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			
2	1	4.6.3.1	E	Conduct trend analysis using count data	2 years (ongoing)	*Research Institutions, UH, USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			
2	1	4.6.3.2	E	Use demographic data for estimating lambda	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			
2	1	4.6.4	A, E	Investigate naturally occurring and alien species induced native plant species die-back phenomena affecting forest bird habitats	10 years (ongoing)	*Research Institutions, UH, USFWS, *USGS, *NPS, DOFAW	10.0	1.0	1.0	1.0	1.0	

Table 19. Implementation Schedule for the Revised Recovery Plan for Hawaiian Forest Birds

Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	4.7.1	C	Evaluate effectiveness of translocations of both disease survivors and disease resistant forest birds for restoration of populations in areas with active disease transmission	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	8.0	2.0	2.0	2.0	2.0	
2	1	4.7.2	E	Determine optimal parameters for translocation efforts	3 years (ongoing)	*Research Institutions, UH, *USFWS, *USGS, NPS, *DOFAW	3.0	1.0	1.0	1.0		
3	2	4.7.3	E	Evaluate the relative costs of habitat suitability analysis vs. experimental translocation or reintroduction	3 years (ongoing)	*Research Institutions, UH, *USFWS, *USGS, *DOFAW	3.0	1.0	1.0	1.0		
2	1	4.8.1	C	Special research considerations for disease and parasitism: Determine the effects of land use changes on disease transmission	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	4.8.2	C	Special research considerations for disease and parasitism: Determine effects of long-term climate change on disease transmission	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			
2	1	4.8.3	C	Conduct research on the feasibility of vaccines for avian pox and malaria, methods for their delivery, and possible effects on host-parasite coevolutionary adaptations	3 years	*Research Institutions, ZSSD, *UH, USFWS, *USGS, DOFAW	4.5	1.5	1.5	1.5		
2	2	4.8.4	C	Conduct research on genetic variability, virulence, and interactions between avian pox virus and malarial parasites and how these variants interact with susceptible and resistant host genotypes	3 years	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	4.5	1.5	1.5	1.5		
2	3	4.8.4.1	C	Use molecular methods to identify specific markers that correlate with phenotypic differences in virulence	3 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	4.5	1.5	1.5	1.5		

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	4.8.4.2	C	Determine whether concomitant infections with pox and malaria affect virulence and transmissibility	3 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	4.5	1.5	1.5	1.5		
1	2	4.8.5	C	Determine dispersal distances of adult mosquitoes from point sources outside of recovery area.	4 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	1.5	1.5	1.5	1.5	
2	1	4.8.6	C	Determine the feasibility of decreasing malarial transmission through genetic manipulation of vector populations	3 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		
2	3	4.8.7	C	Determine the role that ectoparasites play in transmission of avian pox, particularly during the nesting cycle when adults may pass infections to offspring	3 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		
2	3	4.8.8	C	Determine the role that endoparasites such as Coccidea play in demography of birds	3 years	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	4.8.9	C	Monitor long-term changes in the prevalence and transmission of avian diseases in recovery forest bird habitats	Unknown	*Research Institutions, *UH, USFWS, *USGS, NPS, DOFAW	4.0	1.0	1.0	1.0	1.0	
2	1	4.9	E	Develop and test improved survey and monitoring techniques in recovery area for extremely rare species and species difficult to monitor using standard methods	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, *DOFAW	1.0	0.5	0.5			
2	1	4.10.1	E	Determine the basis for variation in population density and termination of range	3 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, DOFAW	3.0	1.0	1.0	1.0		Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	3	4.10.2	E	Determine the basis for low nesting success documented at Honohina Tract (wet habitat) using cameras on nests while documenting rainfall	2 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			Hawai`i; Hakalau Forest NWR, Honohina Tract. Species: Hawai`i creeper

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	4.10.3	E	Determine the role of food in timing of breeding, attempts to breed, and breeding success	3 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, DOFAW	3.0	1.0	1.0	1.0		Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	1	4.10.4	E	Determine why these birds are limited to high elevations	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	3.0	1.0	1.0	1.0		Maui. Species: `ākohekohe, Maui parrotbill
2	1	4.10.5	E	Examine factors that determine abundance and distribution, including elevational range	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, NPS, *DOFAW	2.0	1.0	1.0			Kaua`i; Alaka`i Wilderness area. Species: Kaua`i creeper, Puaiohi
2	2	4.10.6	E	Determine the role of food as the basis for different densities of the bird in continuous habitat	2 years	*Research Institutions, *UH, USFWS, *USGS, NPS, *DOFAW	2.0	1.0	1.0			Kaua`i; Alaka`i Wilderness area. Species: Kaua`i creeper
2	1	4.10.7	C	Determine population response of palila to predator control efforts	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, NPS, DOFAW	2.0	1.0	1.0			Hawai`i; Mauna Kea and Mauna Loa. Species: palila

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	2	4.10.8	C	Determine population response of endangered Maui forest birds to predator control efforts	2 years (ongoing)	*Research Institutions, *UH, USFWS, USGS, *NPS, *DOFAW	2.0	1.0	1.0			Maui. Species: \`ākohekohe, Maui parrotbill, po\`ouli
2	1	4.10.9	C	Determine the effect of predator control on survival of female O\`ahu \`elepaio	Complete	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	0.0					O\`ahu. Species: O\`ahu \`elepaio
1	2	4.10.10	C	Measure effect of experimental test of broad-scale predator control on nest success, adult and post-fledging survival, and population trends	3 years	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	4.5	1.5	1.5	1.5		Kaua\`i; Alaka\`i Wilderness area. Species: Kaua\`i creeper, Puaiohi
2	2	4.10.11	A	Determine population response of palila to forest regeneration and restoration efforts	3 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	4.5	1.5	1.5	1.5		Hawai\`i; Mauna Kea and Mauna Loa. Species: palila
2	2	4.10.12	A	Determine use of regenerating/restored canopy trees as substrates for feeding	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, DOFAW	2.0	1.0	1.0			Hawai\`i. Species: Hawai\`i \`ākepa, Hawai\`i creeper, \`akiapōlā\`au

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	4.10.13	A	Determine population response of endangered Maui forest birds to forest regeneration and habitat restoration efforts	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	2.0	1.0	1.0			Maui. Species: \`ākohekohe, Maui parrotbill
2	2	4.10.14	A	Determine population response to experimental control of weeds (e.g., ginger)	2 years (ongoing)	*Research Institutions, *UH, USFWS, USGS, NPS, *DOFAW	2.0	1.0	1.0			Kaua\`i. Species: Kaua\`i creeper, Puaiohi
1	3	4.10.15	C	Determine if tolerance or resistance to malaria and pox virus is evolving at the lower portion of the elevational range of these birds	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.5	1.5			Hawai\`i. Species: Hawai\`i \`ākepa, Hawai\`i creeper, \`akiapōlā\`au
2	1	4.10.16	C	Determine if tolerance or resistance to malaria and pox virus is evolving in any of the fragmented populations	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	3.0	1.5	1.5			O\`ahu. Species: O\`ahu \`elepaio
2	3	4.10.17	E	Document genetic population structure of species with single populations	2 years (ongoing)	*Research Institutions, *UH, USFWS, *USGS, *NPS, *DOFAW	2.0	1.0	1.0			Maui. Species: po\`ouli, Maui parrotbill, \`ākohekohe

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	4.10.18	E	Document source/sink metapopulation structure and dispersal characteristics in populations along lateral and elevational gradients of density	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, DOFAW	2.0	1.0	1.0			Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	3	4.10.19	E	Document the basis of variation in size of home range in areas of different density of the bird and in areas with different forest structure	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, *DOFAW	2.0	1.0	1.0			Hawai`i. Species: `akiapōlā`au
2	3	4.10.20	E	Determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations.	2 years (ongoing)	*Research Institutions, *UH, *USFWS, *USGS, *NPS, DOFAW	4.0	2.0	2.0			Hawai`i; Mauna Kea and Hualālai. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	3	4.10.21	E	Determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations.	2 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, *DOFAW	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio
2	3	4.10.22	E	Determine patterns of dispersal by age and sex	2 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, *DOFAW	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	4.10.23	E	Document dispersal and survival of juveniles	2 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, *DOFAW	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio
2	3	4.10.24	E	Conduct population and metapopulation viability analyses and calculate lambda in populations in different portions of the recovery area	4 years	*Research Institutions, *UH, *USFWS, *USGS, *NPS, *DOFAW	4.0	1.0	1.0	1.0	1.0	Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	1	4.10.25	E	Conduct development and testing of improved survey and monitoring techniques	3 years	*Research Institutions, *UH, *USFWS, *USGS, NPS, *DOFAW	3.0	1.0	1.0	1.0		Kaua`i. Species: Kaua`i creeper, Puaiohi
1	1	5.1	E	Conduct systematic surveys of all forest bird habitat on Kaua`i, O`ahu, Moloka`i, Lāna`i, Maui, and Hawai`i at least once every five years to determine changes in distribution and population size of all native and nonnative forest birds	Ongoing	UH, *USFWS, *USGS, *NPS, *DOFAW	36.0	1.2	1.2	1.2	1.2	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	5.2.1	E	Conduct systematic surveys of māmane forest on Mauna Kea, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, *USGS, DOFAW	6.0	0.2	0.2	0.2	0.2	Annual survey.
2	1	5.2.2	E	Conduct systematic surveys of Hakalau Forest NWR, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	UH, *USFWS, USGS	6.0	0.2	0.2	0.2	0.2	Annual survey.
2	1	5.2.3	E	Conduct systematic surveys of Kona Unit, Hakalau Forest NWR, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, USGS	3.0	0.1	0.1	0.1	0.1	Annual survey.
2	1	5.2.4	E	Conduct systematic surveys of Ka`ū Forest, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, *USGS, *DOFAW	7.5	0.5	0	0.5	0	Every 2 years.

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	5.2.5	E	Conduct systematic surveys of Pu`u Wa`awa`a Forest Bird Sanctuary, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, *USGS, *DOFAW	3.0	0.2	0	0.2	0	Every 2 years.
2	1	5.2.6	E	Conduct systematic surveys of Kūlani, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, *USGS, DOFAW, NPS	3.0	0.1	0.1	0.1	0.1	Annual survey.
2	1	5.2.7	E	Conduct systematic surveys of Keauhou Ranch/Kīlauea Forest, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*KS, *USFWS, *USGS, DOFAW	3.0	0.1	0.1	0.1	0.1	Annual survey. Total cost based on annual cost for 30 years.
2	2	5.2.8	E	Conduct systematic surveys of Mauna Loa Strip, Hawai`i, to determine annual and seasonal changes in distribution and population size	Ongoing	USFWS, *USGS, DOFAW, *NPS	3.0	0.1	0.1	0.1	0.1	Annually/biannually. Total cost based on annual cost for 30 years.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	5.2.9	E	Conduct systematic surveys of Hanawī NAR, Maui, to determine annual and seasonal changes in distribution and population size	Ongoing	USFWS, USGS, *DOFAW	7.5	0.25	0.25	0.25	0.25	Annual survey. Total cost based on annual cost for 30 years.
2	1	5.2.10	E	Conduct systematic surveys of Waikamoi Preserve, Maui, to determine annual and seasonal changes in distribution and population size	Ongoing	USFWS, USGS, *DOFAW, *TNCH	3.0	0.1	0.1	0.1	0.1	Annual survey. Total cost based on annual cost for 30 years.
2	1	5.2.11	E	Conduct systematic surveys of Kīpahulu Valley, Maui, to determine annual and seasonal changes in distribution and population size	Ongoing	USFWS, *USGS, DOFAW, *NPS	3.0	0.1	0.1	0.1	0.1	Annual survey. Total cost based on annual cost for 30 years.
2	1	5.2.12	E	Conduct systematic surveys of Wailupe Valley, O`ahu, to determine annual and seasonal changes in distribution and population size and to monitor efficacy of predator control	Ongoing	*USFWS, USGS, *DOFAW	1.6	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle. Total cost based on annual cost for 30 years.

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	5.2.13	E	Conduct systematic surveys of Pia Valley, O`ahu, to determine annual and seasonal changes in distribution and population size and to monitor efficacy of predator control	Ongoing	*USFWS, USGS, *DOFAW	1.6	0.2	0.2	0.2	0	Annual for 3 years, Total cost based on annual cost for 30 years integrated with 5-year cycle.
2	2	5.2.14	E	Conduct systematic surveys of Honouliuli Preserve, O`ahu, to determine annual and seasonal changes in distribution and population size and to monitor efficacy of predator control	Ongoing	*USFWS, USGS, DOFAW, *TNCH	1.6	0.2	0.2	0.2	0	Annual for 3 years, Total cost based on annual cost for 30 years, integrated with 5-year cycle.
2	3	5.2.15	E	Conduct systematic surveys of Schofield Barracks West Range, O`ahu, to determine annual and seasonal changes in distribution and population size and to monitor efficacy of predator control	Ongoing	*USFWS, USGS, DOFAW, *U.S. Army	1.6	0.2	0.2	0.2	0	Annual for 3 years, Total cost based on annual cost for 30 years, integrated with 5-year cycle.

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	5.2.16	E	Conduct systematic surveys of any other areas on O`ahu where active management is undertaken to determine annual and seasonal changes in distribution and efficacy of actions	Ongoing	*USFWS, USGS, *DOFAW	1.6	0.2	0.2	0.2	0	Annual for 3 years. Total cost based on annual cost for 30 years, integrated with 5-year cycle.
2	1	5.2.17	E	Conduct systematic surveys of "core" puaiohi habitat in Alaka`i Wilderness Preserve, Kaua`i, to determine annual and seasonal changes in distribution and population size	Ongoing	*USFWS, *USGS, *DOFAW	6.0	0.2	0.2	0.2	0.2	Annual survey.
1	1	5.3	E	Establish and support an interagency Forest Bird Monitoring Coordinator position to coordinate monitoring and provide regular reports on the status and trend of forest bird populations	Ongoing	*USFWS, USGS, NPS, *DOFAW	21.0	0.7	0.7	0.7	0.7	

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#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	1	6.1.1.1	E	Develop scenic overlook and trail with interpretive displays depicting native forest birds at Saddle Road 21 mile marker, Hawai`i	2 years	*DLNR	2.0	1.0	1.0			
3	3	6.1.1.2	E	Improve parking area and interpretive displays at Pu`u `Ō`ō Trail, Saddle Road, Hawai`i	2 years	*DLNR	1.0	0.5	0.5			
3	1	6.1.1.3	E	Develop several short loop trails at Mauna Loa Strip Road, Hawai`i Volcanoes National Park	2 years	*NPS	2.0	1.0	1.0			
2	2	6.1.1.4	E	Expand visitor use with a loop trail and interpretive displays at Hakalau Forest NWR, Hawai`i	2 years	*USFWS	2.0	1.0	1.0			
2	3	6.1.1.5	E	Establish a loop trail in palila habitat and provide interpretive signs at Pu`u Lā`au, Mauna Kea, Hawai`i	2 years	*DLNR, *USGS	2.0	1.0	1.0			
3	3	6.1.1.6	E	Work with Nā Ala Hele to add material on birds to their interpretive displays and brochure at Ainapō Trail, Hawai`i	2 years	*DLNR, *NPS	2.0	1.0	1.0			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	6.1.1.7	E	Develop a system of trails with interpretive displays at Pu`u Wa`awa`a Forest Bird Sanctuary, Hawai`i	2 years	*DLNR	2.0	1.0	1.0			
3	3	6.1.1.8	E	Develop a system of trails with interpretive displays at Pu`u Maka`ala, Laupāhoehoe, Kīpāhoehoe, Manukā, and Pu`u O`umi NARs, Hawai`i	2 years	*DLNR	3.0	1.5	1.5			
3	2	6.1.1.9	E	Develop interpretive signs for the nature trail at Hosmer Grove Haleakalā National Park, Maui	2 years	*NPS	2.0	1.0	1.0			
3	2	6.1.1.10	E	Develop interpretive kiosk in parking area and brochures and signs for the Waiakoa Loop Trail at Polipoli State Park, Maui	2 years	*DLNR	1.0	0.5	0.5			
3	3	6.1.1.11	E	Develop access, trails, and interpretive displays at Pu`u Kukui, Maui	2 years	*Maui Land and Pineapple Co.	2.0	1.0	1.0			
3	3	6.1.1.12	E	Develop an interpretive display at Waihe`e Ridge Trail, Maui	2 years	*DLNR	2.0	1.0	1.0			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	3	6.1.1.13	E	Develop an interpretive display at Kahakuloa NAR, Maui	2 years	*DLNR	1.0	0.5	0.5			
3	3	6.1.1.14	E	Develop an interpretive trail to the rim of Pēpē`ōpae Bog at Hanalilolilo Trail, Moloka`i	2 years	*DLNR	1.0	0.5	0.5			
3	3	6.1.1.15	E	Develop scenic overlook and interpretive displays at Pu`u Ali`i NAR, Moloka`i	2 years	*DLNR	1.0	0.5	0.5			
2	3	6.1.1.16	E	Develop interpretive signs and brochures at Kuli`ou`ou Trail and `Aiea Loop Trail, O`ahu	2 years	*DLNR, *USFWS	2.0	1.0	1.0			
2	2	6.1.1.17	E	Develop interpretive kiosks and signs at Kalalau and Pu`u O Kila lookouts, Kōke`e State Park, Kaua`i	2 years	*DLNR	2.0	1.0	1.0			
3	2	6.1.2.1	E	Promote increased access and interpretation programs on lands where native species are found: Hawai`i, Hakalau Forest NWR, Hakalau and Kona Forest Units	Ongoing	*USFWS	3.0	0.1	0.1	0.1	0.1	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	6.1.2.2	E	Promote increased access and interpretation programs on lands where native species are found: Hawai`i, Pu`u Wa`awa`a Forest Bird Sanctuary	Ongoing	*DLNR, *DOFAW	3.0	0.1	0.1	0.1	0.1	
3	2	6.1.2.3	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Waikamoi Preserve, The Nature Conservancy	Ongoing	* TNCH	3.0	0.1	0.1	0.1	0.1	
3	3	6.1.2.4	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Makawao Forest Reserve	Ongoing	*DLNR, *DOFAW	3.0	0.1	0.1	0.1	0.1	
3	2	6.1.2.5	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Hanawī NAR	Ongoing	*NAR	3.0	0.1	0.1	0.1	0.1	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
3	2	6.1.2.6	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Haleakalā National Park	Ongoing	*NPS	3.0	0.1	0.1	0.1	0.1	
3	3	6.1.2.7	E	Promote increased access and interpretation programs on lands where native species are found: Moloka`i, Kamakou Preserve, The Nature Conservancy	Ongoing	*TNCH	3.0	0.1	0.1	0.1	0.1	
3	2	6.1.2.8	E	Promote increased access and interpretation programs on lands where native species are found: O`ahu, Barber's Point	Ongoing	*DLNR, *DOFAW	3.0	0.1	0.1	0.1	0.1	
2	1	6.1.2.9	E	Promote increased access and interpretation programs on lands where native species are found: Honouliuli Preserve, The Nature Conservancy	Ongoing	*DLNR, *DOFAW	3.0	0.1	0.1	0.1	0.1	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	6.1.3.1	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public services interpretive programs: Hawai`i, Hakalau Forest NWR	Ongoing	*USFWS	34.0	10.0	10.0	0.5	0.5	
2	3	6.1.3.2	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public services interpretive programs: Maui, Haleakalā National Park	Ongoing	*NPS	34.0	10.0	10.0	0.5	0.5	
2	3	6.1.3.3	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public services interpretive programs: O`ahu, Honolulu Zoo	Ongoing	*HZ	34.0	10.0	10.0	0.5	0.5	
2	3	6.1.4	E	Promote the opening of State Forest reserve trails to the general public for nature walks and birding on all islands	Ongoing	*DLNR, *DOFAW	30.0	1.0	1.0	1.0	1.0	
3	2	6.1.5	E	Support the Nā Ala Hele Trail System	Ongoing	*DLNR, *DOFAW	30.0	1.0	1.0	1.0	1.0	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
2	1	6.2.1.1	E	Institute core curriculum programs at the university level emphasizing Hawaii's native species for elementary and high school education programs	Ongoing	*UH	60.0	2.0	2.0	2.0	2.0	
2	1	6.2.1.2	E	Develop an interpretation internship program for university students specializing in the field of forest bird information and education	Ongoing	*UH	60.0	2.0	2.0	2.0	2.0	
2	1	6.2.1.3	E	Provide permanent funding for programs such as Imi Pono No Ka Aina, an Environmental Educator program at Hawai`i Volcanoes National Park that educates teachers through accredited workshops in environmental and native species issues	Ongoing	TBD	60.0	2.0	2.0	2.0	2.0	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	6.2.1.4.1	E	Fund the development and distribution of educational materials: Develop forest bird posters for schools, emphasizing each of the native forest birds and keyed to each islands endemic species	2 years	TBD	2.0	1.0	1.0			
3	2	6.2.1.4.2	E	Fund the development and distribution of educational materials: Keauhou Ranch/Kīlauea Forest Reserve. Assist Kamehameha Schools with ongoing development of environmental learning opportunities	2 years	KS*, USFWS	0.5	0.25	0.25			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	1	6.2.2.1	E	Fund and support programs for school children on each island that provide a "hands on" approach to learning about Hawaii's native species: Keokeolani Outdoor Education Program on the Big Island; Maui Outdoor Education Center on Maui; Hawai`i Nature Center on O`ahu; The Discovery Outdoor Education Center on Kaua`i; and funding for the establishment of a Moloka`i Outdoor Education Center	Ongoing	*Hawai`i Outdoor Education Centers	90.0	3.0	3.0	3.0	3.0	
2	2	6.2.2.2	E	Fund and support organizations such as `Ōhi`a Productions and Keauhou Bird Conservation Center that provide environmental educational programs to Hawaii's school children	Ongoing	TBD	30.0	1.0	1.0	1.0	1.0	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	6.2.2.2.1	E	Provide funding for \`Ōhi\`a Productions to perform on other islands and to produce videos of previous performances for distribution to schools throughout Hawai\`i	Ongoing	*\`Ōhi\`a Productions	6.0	0.2	0.2	0.2	0.2	
2	3	6.2.2.3	E	Develop and support programs such as Mālama Hawai\`i, that encourage widespread awareness of conservation goals through a diverse coalition of traditional and non-traditional partnerships	Ongoing	TBD	6.0	0.2	0.2	0.2	0.2	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	6.2.3.1	E	Fund, create and support continuous maintenance of an informational website focused on native species, their habitats, as well as alien species and their effects on native species, and provide up to date information that can be utilized and copied onto other web sites to spread the information	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	
3	3	6.2.3.1.1	E	Obtain funding from Gates Foundation for remote digital broadcast from O`ahu `elepaio “nest cam” to local schools through a web site	4 years	TBD	4.0	1.0	1.0	1.0	1.0	
1	1	6.2.4.1	E	Initiate and fund public outreach and information about the effect of rats and cats as vectors for human disease, agricultural pests, and their threats to native species as predators	4 years	*USFWS, *HDPH	6.0	2.0	2.0	1.0	1.0	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
1	1	6.2.4.2	E	Initiate public outreach efforts to inform the public about potential human and animal diseases transmitted by mosquitoes and how source reduction can reduce those threats	4 years	*USFWS, *HDPH	6.0	2.0	2.0	1.0	1.0	
2	1	6.2.4.3	E	Inform the public as to the value of feral ungulate and weed control in native forests by providing film and video footage of the harmful effects of alien weeds and ungulates on native species and agriculture	4 years	*USFWS, *HDPH	6.0	2.0	2.0	1.0	1.0	
2	3	6.3.1	E	Conduct market research on the public's knowledge of native species and attitudes towards conservation, to provide the information to develop the most direct ways to educate the public and gain support for native species	2 years	TBD	4.0	2.0	2.0			

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	3	6.3.2.1	E	Assist in the development of public service announcements about native species by providing local television stations with footage of native species with natural sounds and suggest their use as background visuals or sounds during credits for local or other programming	Ongoing	TBD	6.0	0.2	0.2	0.2	0.2	
2	3	6.3.2.2	E	Use local "heroes", entertainers, sports figures, or other role models, to promote local pride in common native and endangered species	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	
3	3	6.3.2.3	E	Promote the use of prize-winning contests, with sponsors, on local radio, television stations and newspapers to promote native species awareness	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	

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Priority #	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 07	FY 08	FY 09	FY 10	Comments/Notes
3	2	6.3.2.3.1	E	Sponsor and support contests such as: Forest bird website contest among high school students, forest bird essay contest in Hawaii's schools with prizes for different grade levels, forest bird photo contest, or a song writing contest with the song to be used for a theme song for a locally produced nature program	Ongoing	*HDOE	1.5	0.05	0.05	0.05	0.05	
3	2	6.3.2.4.1	E	Develop a weekly column provided to all newspapers in Hawai`i providing information on native species and ecosystem issues, with the writing shared by conservation organizations throughout the state	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	6.3.2.4.2	E	Develop a weekly program for radio stations on all islands providing information on native species and ecosystem issues, with the writing shared by conservation organizations throughout the State.	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	
3	2	6.3.2.4.3	E	Develop a half hour weekly or monthly television nature program about Hawaii's native species and their habitat	Ongoing	TBD	12.0	0.4	0.4	0.4	0.4	
3	2	6.3.3.1	E	Promote the use of the \`i\`iwi or a caricature of \`i\`iwi as the "Poster Child" for native species in advertising and in education	4 years	TBD	1.2	0.3	0.3	0.3	0.3	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	6.3.3.2	E	Provide native species images and promote the use of these images in advertising by advertising agencies, local and national fast food corporations for use in advertising on tray-liners, milk cartons, and other heavily used advertising media	Ongoing	TBD	1.5	0.05	0.05	0.05	0.05	
3	2	6.3.4.1	E	Promote the hosting of special events in cooperation with major local hotels and corporations as partners for funding, and to champion native species and ecosystem awareness	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	
2	2	6.4.1.1	E	Support conservation outreach organizations to promote conservation at a "grass roots" level	Ongoing	TBD	15.0	0.5	0.5	0.5	0.5	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
3	2	6.4.1.2	E	Develop a "mentor" program, where natural science based professionals provide field opportunities for young people in learning about Hawaii's native species	Unknown	*UH, *USFWS, *USGS, *DLNR, *DOFAW	6.0	0.2	0.2	0.2	0.2	
2	2	6.4.1.3	E	Support the use of volunteers in projects on State, Federal and private lands that will contribute to the enhancement of native habitat and increase the level of awareness and pride in native species within the local populace	Ongoing	*USFWS, *USGS, *DLNR, *DOFAW, *NAR, *NPS	12.0	0.4	0.4	0.4	0.4	
3	2	6.4.1.4	E	Support the development of a volunteer "clearinghouse" to provide volunteers for resource management, education, and outreach	Ongoing	TBD	3.0	0.1	0.1	0.1	0.1	

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Priority		Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
#	Tier						Total	FY 07	FY 08	FY 09	FY 10	
2	2	6.4.2.1	E	Develop and maintain partnerships with Kamehameha Schools, The Nature Conservancy of Hawai`i, Hawai`i Audubon Society, Pig Hunters of Hawai`i, Hawai`i Conservation Association and other NGO’s to promote environmental awareness and broaden the spectrum of a local environmentally educated populace	Ongoing	TBD	15.0	0.5	0.5	0.5	0.5	
TOTAL							24,774	947	895	806	755	

[1]Costs to secure recovery area cannot be determined at this time because numerous methods are available (conservation easement, partnership agreement, safe harbor agreement, change in land use designation, change of jurisdiction, lease, or purchase from willing seller) that vary widely in their potential cost, and it is not possible to speculate which method might be most appropriate or effective in the future. Many land parcels in question are owned by State or local governments or private interests, and the most appropriate method of securing habitat will depend on the disposition and willingness of the landowner.

[2]Costs to reduce or eliminate detrimental effects of ungulates on vegetation are approximations because locations and extent of strategic fencing are not known at this time, and/or total acreage to be fenced has not been determined.

[3]Costs to reduce or eliminate the detrimental effects of exotic plants through mechanical, chemical, or biological means and research can not be determined at this time because the distributions of exotic plants are only partly known, and in many cases the most effective means for their control have yet to be determined.

[4]Costs for this captive propagation, translocation, or related recovery action are included under recovery action number 3, and are part of the continuing captive propagation program for Hawaiian forest birds.

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VII. APPENDICES

APPENDIX A.

Land Parcels in Recovery Areas and Recovery Actions by Parcel for Protection, Reforestation, Fencing and Ungulate Control, and Predator Control

After each recovery action number is the priority number in parentheses. Refer to the recovery action narrative for a complete description of recovery actions. The general recovery action numbers are:

1.3. = Parcels in recovery areas in need of protection;
2.1. = Parcels in recovery areas needing reforestation;
2.2. = Parcels in recovery areas needing fencing and ungulate control; and
2.4.1. = Parcels in recovery areas where predator control is needed.

Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Landowner acronyms: DLNR = Hawai`i Department of Land and Natural Resources, DHHL = Department of Hawaiian Home Lands, DOFAW = Hawai`i Division of Forestry and Wildlife, NARS = Natural Area Reserve System, HVNP = Hawai`i Volcanoes National Park. TMK = Tax Map Key.

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Northeastern slopes of Mauna Kea, portions of 344014002 344014003 343010002 343010008	Hawai`i DLNR, State Land Division.	1.3.1 (2); 2.1.1 (2); 2.2.1 (2); 2.4.1.1 (2)
H	Kanakaleonui Corridor, 338001009	Hawai`i DHHL.	1.3.2 (1); 2.1.2 (1); 2.2.2 (1); 2.4.1.2 (2)
H	Hilo Forest Reserve, Laupāhoehoe Section, 337001004	Hawai`i DLNR. Currently the Laupāhoehoe Game Management Area.	1.3.3 (2); 2.1.3 (3)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Hilo Forest Reserve, Pīhā Section, 333001004	Hawai`i DLNR. Currently the Pīhā Game Management Area.	1.3.4 (2); 2.1.4 (3)
H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001004 333001004	Hawai`i DLNR. Currently the Laupāhoehoe and Pīhā Game Management Areas.	2.2.3 (2)
H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001002 333001004	Hawai`i DLNR. Currently the Laupāhoehoe and Pīhā Game Management Areas.	2.4.1.3 (2)
H	Hakalau Forest NWR, 337001010 329005005 333001007 329005003	U.S. Fish and Wildlife Service.	2.1.5 (1); 2.2.4 (1); 2.4.1.4 (1)
H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	Hawai`i DHHL. Leased by DOFAW and currently under annual lease.	1.3.5 (2); 2.1.6 (3); 2.2.7 (2); 2.4.1.7 (2)
H	Humu`ula, 338001002	Hawai`i DHHL.	1.3.6 (1); 2.1.7 (2)
H	Humu`ula, Portions of 338001007	Hawai`i DHHL. Parker Ranch, leased for grazing.	1.3.7 (2); 2.1.8 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Lama`ia Section and Portions of 326018002	Hawai`i DHHL. Adjacent to Hakalau Forest National Wildlife Refuge.	1.3.8 (1); 2.1.9 (2) 2.2.5 (2); 2.4.1.5 (2)
H	Pu`u `Ō`ō Ranch, 326018001	Hawai`i DLNR, State Land Division. Pu`u `Ō`ō Ranch leased for cattle grazing.	1.3.9 (1); 2.1.10 (2) 2.2.6 (2); 2.4.1.6 (2)
H	Ka`ohe Lease, 344015002	Hawai`i DLNR, State Land Division. Currently leased for cattle grazing to various lessees.	1.3.10 (1); 2.1.11 (2); 2.2.8 (2); 2.4.1.8 (2)
H	Mauna Kea Forest Reserve, 344015001	Hawai`i DLNR.	2.1.12 (1);
H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	Hawai`i DLNR.	2.2.9 (1); 2.4.1.9 (1)
H	Waiākea Forest Reserve, Upper Portion, 324008001	Hawai`i DLNR.	2.2.10 (1); 2.4.1.10 (2)
H	Waiākea Forest Reserve, Lower Portion, 324008001	Hawai`i DLNR.	2.2.11 (1); 2.4.1.11 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	\`Ōla\`a/Kīlauea Partnership, 324008009 399001007 399001004 324008025 319001001 319001007	Kamehameha Schools, Keauhou Ranch. Kūlani Correctional Facility, Pu\`u Maka\`ala Natural Area Reserve, Hawai\`i Volcanoes National Park.	2.2.12 (1); 2.4.1.12 (1)
H	Keauhou Ranch, 399001004	Kamehameha Schools.	1.3.11 (2); 2.1.13 (3)
H	Hawai\`i Volcanoes National Park, 399001002	Hawai\`i Volcanoes National Park.	2.1.14 (3)
H	Kapāpala Ranch, Portions of 398001010	Hawai\`i DLNR, State Land Division. Kapāpala Ranch, currently leased for cattle grazing.	1.3.12 (2)
H	Kapāpala Ranch, Portions of 398001004	Hawai\`i DLNR, State Land Division. Kapāpala Ranch, currently leased for cattle grazing.	2.1.15 (2)
H	Kapāpala Forest Reserve, Portions of 398001004	Hawai\`i DLNR, State Land Division.	2.2.13 (2); 2.4.1.13 (2)
H	Ka\`ū Forest Reserve, 397001001	Hawai\`i DLNR.	2.2.14 (1); 2.4.1.14 (1)
H	Ka\`ū Forest Reserve, 397001007	Mauna Kea Agribusiness.	1.3.13 (2); 2.1.16 (3)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Ka`ū Forest Reserve, Portions of 397001006 397001005	Kamehameha Schools.	1.3.14 (2); 2.1.17 (2)
H	Kahuku Ranch, Portions of 392001002	Samuel M. Damon Trust.	1.3.15 (1); 2.1.18 (2); 2.2.15 (1); 2.4.1.15 (2)
H	Manukā NAR, Upper portions of 391001002	Hawai`i DLNR.	2.2.16 (2); 2.4.1.16 (2)
H	Honomalino, 389006004 389006029	Scott C. Rolles Trust.	1.3.16 (2); 2.1.19 (3)
H	Pāpā, 388001001	Koa Aina Ventures.	1.3.17 (2); 2.1.20 (3)
H	TNCH, Honomalino, 389001001	The Nature Conservancy of Hawai`i.	2.1.21 (3); 2.2.17 (3); 2.4.1.17 (2)
H	Honomalino Forest Reserve, 389001002	Hawai`i State.	2.1.22 (2)
H	Yee Hop Ranch, Portions of 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011 387001004	Yee Hop Ranch Ltd.	1.3.18 (2); 2.1.23 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Yee Hop Ranch, 392001005	Yee Hop Ranch Ltd.	2.2.18 (3); 2.4.1.18 (2)
H	Kona Forest NWR, 386001001	U.S. Fish and Wildlife Service.	2.1.24 (1); 2.2.19 (2); 2.4.1.19 (1)
H	`Alae Ranch, Portions of 387001014	Hawai`i DLNR, State Land Division. Currently leased for cattle grazing.	1.3.19 (3); 2.1.25 (3)
H	McCandless Ranch, Portions of 392001003 386001001	McCandless Ranch.	1.3.20 (2)
H	McCandless Ranch and E. Stack *et al.*, Portions of 392001003 386001001 385001002	McCandless Ranch and E. Stack *et al.*	2.1.26 (2); 2.2.20 (2); 2.4.1.20 (2)
H	Waiea Tract, 386001003	Hawai`i DLNR, State Land Division.	1.3.21 (2); 2.1.27 (2); 2.2.21 (2); 2.4.1.21 (2)
H	Keālia Ranch, 385001001	Kamehameha Schools.	1.3.22 (2)
H	Keālia Ranch, 385001001 and Portions of 384001001 383001001	Kamehameha Schools.	2.1.28 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Hōnaunau Forest, 384001001 384001002 383001001 383001002	Kamehameha Schools.	1.3.23 (2); 2.2.22 (2); 2.4.1.22 (2)
H	Keālia Ranch, Portions of 385001002	Elizabeth Stack *et al.*	1.3.24 (2)
H	Kealakekua Development Corp., Portions of 382001001	Kealakekua Development Corp.	1.3.25 (3); 2.1.29 (3)
H	Pu`u Lehua, Portions of 378001003 378001007 372002001 378001001	Kamehameha Schools.	1.3.26 (2); 2.1.30 (2)
H	Pu`u Lehua, Portion of 378001003	Kamehameha Schools.	2.2.23 (2); 2.4.1.23 (2)
H	Pu`u Wa`awa`a, 371001001 371001006	Hawai`i DLNR.	2.1.31 (2); 2.4.1.24 (2)
H	Hualālai Ranch, 372002001	Kamehameha Schools.	2.1.32 (2)
MA	Haleakalā National Park, 218001007	National Park Service.	2.1.33 (1); 2.4.1.29 (1)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	Haleakalā National Park, 213001003 216001002 216001001 216001003 217004016 216010001	National Park Service.	2.2.28 (1); 2.4.1.29 (1)
MA	Ko`olau Forest Reserve, 224016003 224016004 228008001 228008007	Alexander and Baldwin, East Maui Irrigation.	1.3.27 (1); 2.2.24 (1); 2.4.1.25 (1)
MA	Ko`olau Forest Reserve, 211002002 212004005 229014001 211001050 211001044	Hawai`i DLNR.	2.2.25 (1); 2.4.1.26 (1)
MA	Hanawī NAR and Ko`olau Forest Reserve, 212004007	Hawai`i DLNR.	2.2.26 (1); 2.4.1.27 (1)
MA	Hāna Forest Reserve, 210001001 214001001 215001001	Hawai`i DLNR.	2.2.27 (1); 2.4.1.28 (1)
MA	Kīpahulu Forest Reserve, Kukui`ula, 216001007	J. Haili.	1.3.28 (3); 2.2.29 (3)
MA	Kīpahulu Forest Reserve, Kukui`ula, 216001006	Kalalau, Cleveland.	1.3.29 (3); 2.2.30 (3)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006 218001007	Hawai`i DLNR.	1.3.30 (1)
MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006	Hawai`i DLNR.	2.2.31 (1); 2.4.1.30 (2)
MA	Kīpahulu Forest Reserve, 217004006	Hawai`i DLNR.	2.1.34 (2)
MA	Kīpahulu Forest Reserve, 217001032	A. Kaapana *et al.* Small parcel at lower edge of recovery area.	1.3.31 (3); 2.2.32 (3)
MA	Kīpahulu Forest Reserve, 217001024	Kaupō Ranch Ltd. Small parcel at lower edge of recovery area.	1.3.32 (2); 2.2.33 (2)
MA	Nu`u, 218001001	Kaupō Ranch Ltd.	1.3.33 (3); 2.1.35 (3); 2.2.34 (3)
MA	Nu`u, 218001002	James Campbell Est.	1.3.34 (3); 2.1.36 (3); 2.2.35 (3);
MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	Hawai`i DLNR.	1.3.35 (1); 2.1.37 (1); 2.2.36 (1); 2.4.1.31 (2)
MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	Hawai`i DHHL.	1.3.36 (1); 2.1.38 (1); 2.2.37 (1); 2.4.1.32 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	Upper Auwahi, 219001006 221009001 222001001 222001034	`Ulupalakua Ranch Inc.	1.3.37 (2); 2.1.39 (2); 2.2.38 (1)
MA	Kula Forest Reserve, 222007001	Hawai`i DLNR.	1.3.38 (2); 2.1.40 (2); 2.2.39 (2); 2.4.1.33 (3)
MA	Kēōkea, 222004033	James Campbell Est.	1.3.39 (2); 2.1.41 (2); 2.2.40 (2)
MA	Waiohuli, 222005052	James Campbell Est.	1.3.40 (2); 2.1.42 (2); 2.2.41 (2)
MA	Ka`ono`ulu, 222007002 222006009 222006032 222007010	Ka`ono`ulu Ranch Co. Ltd.	1.3.41 (2); 2.1.43 (3); 2.2.42 (2)
MA	Waiakoa, 222008001	Lucky Shoji USA Inc. *et al.*	1.3.42 (2); 2.1.44 (3); 2.2.43 (2)
MA	Kamehame Nui/Kealahou, 223005002	John Zwaanstra.	1.3.43 (2); 2.1.45 (3); 2.2.44 (2);
MA	Haleakalā Ranch (Pūlehu Nui/Kalialinui), 223005003	Haleakalā Ranch Co.	1.3.44 (1); 2.1.46 (1); 2.2.45 (2); 2.4.1.34 (3)
MA	Waikamoi Preserve, 223005004	Haleakalā Ranch Co., The Nature Conservancy of Hawai`i.	1.3.45 (1); 2.1.47 (1); 2.2.46 (1); 2.4.1.35 (1)
MA	Makawao Forest Reserve, 224016001 224016002	Hawai`i DLNR.	2.1.48 (2); 2.2.47 (1); 2.4.1.36 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	West Maui NAR, Kahakuloa, 2231006001	Hawai`i DLNR.	2.1.49 (2); 2.2.48 (2); 2.4.1.37 (2)
MA	West Maui Forest Reserve, Waihe`e, 232014001	Maui Board of Water Supply.	2.2.49 (2)
MA	West Maui Forest Reserve, Kou, 232014002	Hawai`i DLNR.	2.2.50 (2)
MA	West Maui Forest Reserve, Wailuku, 233003003 235003001 236003001	Wailuku Agriculture.	1.3.46 (2); 2.2.51 (2)
MA	West Maui Forest Reserve, `Īao, 233003004,	Hawai`i DLNR.	2.2.52 (2)
MA	West Maui Forest Reserve, Kealaloloa, 236001014	Hawai`i DLNR.	2.2.53 (2)
MA	West Maui Forest Reserve, Manawainui Plant Reserve, 236001052 248001010	Hawai`i DLNR.	2.2.54 (2)
MA	West Maui Forest Reserve, Kaheawa, 248001001	Hawai`i DLNR.	2.1.50 (2); 2.2.55 (2)
MA	West Maui Forest Reserve, Ukumehame/Olowalu, West Maui NAR, Līhau, 248001002	Hawai`i DLNR.	2.1.51 (2); 2.2.56 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	West Maui NAR, Līhau, 248001002	Hawai`i DLNR.	2.4.1.38 (3)
MA	West Maui Forest Reserve, Launiupoko, 247001002	American Factors (Amfac)/JMB Hawai`i Co.	1.3.47 (2); 2.2.57 (2)
MA	West Maui Forest Reserve, Pūehuehu, 247001004	Hawai`i DLNR.	2.2.58 (2)
MA	West Maui Forest Reserve, Kaua`ula, 246025001	American Factors (Amfac)/JMB Hawai`i Co.	1.3.48 (2); 2.2.59 (2)
MA	West Maui Forest Reserve, Pana`ewa, 246025002	Hawai`i DLNR.	2.2.60 (2); 2.4.1.39 (3)
MA	West Maui Forest Reserve, Kahoma, 245022001	Kamehameha Schools.	1.3.49 (2); 2.2.61 (2)
MA	West Maui Forest Reserve, Kahoma, 245022005	Hawai`i DLNR.	2.2.62 (2)
MA	West Maui Forest Reserve, Pu`u Kī/Haakea, 245022002 245022004	American Factors (Amfac)/JMB Hawai`i Co.	1.3.50 (2); 2.2.63 (2)
MA	West Maui Forest Reserve, Wahikuli, 245022003	Hawai`i DLNR.	2.2.64 (2)
MA	Kapunakea Preserve, Amfac/JMB, The Nature Conservancy of Hawai`i, 244007001	American Factors (Amfac)/JMB Hawai`i Co., The Nature Conservancy of Hawai`i.	1.3.51 (2); 2.2.65 (2); 2.4.1.40 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	West Maui Forest Reserve, Kapāloa, 244007007	Unknown.	1.3.52 (2); 2.2.66 (2)
MA	West Maui NAR, Honokōwai, 244007004	Hawai`i DLNR.	2.2.67 (2); 2.4.1.41 (2)
MA	Pu`u Kukui Watershed Management Area, 242001001 241001017	Maui Land and Pineapple.	1.3.53 (2); 2.2.68 (2); 2.4.1.42 (2)
MA	Pu`u Kukui Watershed Management Area, 241001017	Maui Land and Pineapple.	2.1.52 (2)
MA	Moloka`i Forest Reserve, Pu`u Ali`i NAR and Waikolu, 261001002	Hawai`i DLNR.	2.4.1.43 (2)
MO	Moloka`i Forest Reserve, Kalamāula, 252014003	Hawai`i DLNR.	2.1.53 (2); 2.2.69 (2)
MO	Moloka`i Forest Reserve, Kahanui, 252014001	R. W. Myer Ltd., *et al.*	1.3.54 (2); 2.1.54 (2); 2.2.70 (2)
MO	Moloka`i Forest Reserve, Kahanui, 261001004	Hawai`i DLNR.	2.1.55 (2); 2.2.71 (2)
MO	Moloka`i Forest Reserve, Waikolu, 261001002	Hawai`i DLNR.	2.2.72 (2)
MO	Moloka`i Forest Reserve, Pelekunu Valley, 259006011	The Nature Conservancy of Hawai`i.	1.3.55 (2); 2.2.73 (2)
MO	Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, 259008017	Wm. Hitchcock *et al.*	1.3.56 (2); 2.2.74 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MO	Moloka`i Forest Reserve, Pelekunu Valley, 254003032	The Nature Conservancy of Hawai`i.	1.3.57 (2); 2.2.75 (2)
MO	Oloku`i NAR, Moloka`i Forest Reserve, Wailau Valley, 259006002	Hawai`i DLNR.	2.2.76 (2); 2.4.1.44 (2)
MO	Moloka`i Forest Reserve, Wailau Valley and Oloku`i, 259006004	G. Brown III *et al.*	1.3.58 (2); 2.2.77 (2)
MO	Moloka`i Forest Reserve, Laeokapuna, 257005027	P. Hodgins.	1.3.59 (2); 2.2.78 (2)
MO	Moloka`i Forest Reserve, Keanakoholua, 257005001	M. Hustice Trust.	1.3.60 (2); 2.2.79 (2)
MO	Moloka`i Forest Reserve, `Uala`pue, 256006026	Hawai`i DLNR, DOFAW.	2.2.80 (2)
MO	Moloka`i Forest Reserve, Kahananui, 256006014	Hawai`i DLNR.	2.2.81 (2)
MO	Moloka`i Forest Reserve, Manawai, 256006013	P. Petro Trust.	1.3.61 (2); 2.2.82 (2)
MO	Moloka`i Forest Reserve, eastern `Ōhi`a Gulch, 256006011	Hawai`i DLNR.	2.2.83 (2)
MO	Moloka`i Forest Reserve, West `Ōhi`a Gulch, 256006010	E. Wond Trust.	1.3.62 (2); 2.2.84 (2)
MO	Moloka`i Forest Reserve, Keawa Nui, 256006007	Kamehameha Schools.	1.3.63 (2); 2.2.85 (2)
MO	Moloka`i Forest Reserve, Pua`ahala, 256006002	K&H Horizons Hawai`i.	1.3.64 (2); 2.2.86 (2)
MO	Moloka`i Forest Reserve, Kumu`eli, 256006001	D. Fairbanks III Trust.	1.3.65 (2); 2.2.87 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MO	Moloka`i Forest Reserve, Kamalō, 255001016 255001006 255001017	Kamehameha Schools.	1.3.66 (2); 2.1.56 (2); 2.2.88 (2);
MO	Moloka`i Forest Reserve, Mākolelau, 255001015	Ashton Pitts Jr. Trust.	1.3.67 (2); 2.1.57 (3); 2.2.89 (2)
MO	Kamakou Preserve, Kawela, 2540003026	Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i.	1.3.68 (2); 2.1.58 (2); 2.2.90 (2); 2.4.1.45 (2)
MO	Moloka`i Forest Reserve, Kawela, 254003001	Kawela Plantation Homes Association.	2.2.91 (2)
MO	Moloka`i Forest Reserve, Kawela, 254003001 254003028	Kawela Plantation Homes Association.	1.3.69 (2)
MO	Moloka`i Forest Reserve, Kawela, 254003001	Kawela Plantation Homes Association.	2.1.59 (3)
MO	Moloka`i Forest Reserve, Kamiloloa, Makakupaīa, 254003025	Hawai`i DLNR.	2.1.60 (2); 2.2.92 (2)
MO	Moloka`i Forest Reserve, Kaunakakai, 253003005	Moloka`i Ranch Ltd.	1.3.70 (2); 2.1.61 (3); 2.2.93 (2)
O	Honouliuli Preserve, 92005013	James Campbell Estate. Managed by The Nature Conservancy of Hawai`i.	2.2.94 (1); 2.4.1.46 (1)
O	Lualualei Naval Magazine, 88001001	U.S. Navy.	2.2.95 (2); 2.4.1.47 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
O	Schofield Barracks West Range, 77001001	U.S. Army.	2.2.96 (1); 2.4.1.48 (1)
O	Kahana Valley State Park, 52001001 52002001	Hawai`i State.	2.4.1.53 (1)
O	Mākaha Valley, 84002014 84002001	City and County of Honolulu.	2.4.1.54 (1)
O	Pahole NAR, 68001002	Hawai`i DLNR.	2.2.97 (2); 2.4.1.55 (2)
O	Kahanahāiki Valley, 81001012	U.S. Army.	2.2.98 (2); 2.4.1.56 (2)
O	O`ahu Forest NWR, 95004001 76001001	U.S. Fish and Wildlife Service.	2.2.99 (3); 2.4.1.57 (2)
O	Lower Ka`ala NAR, 67003025	Hawai`i DLNR.	2.2.100 (3); 2.4.1.58 (3)
O	Pia Valley, 37003073 37003033	Benjamin Cassiday, James Pflueger	1.3.71 (1)
O	Honolulu Watershed Forest Reserve (Wailupe), 36004004	Hawai`i State.	2.4.1.49 (1)
O	Lower Wailupe Valley, 36004001	City and County of Honolulu	1.3.72 (1)
O	Kūpaua Valley, 37004001 37004002	Hawai`i Humane Society.	1.3.73 (1)
O	Kuli`ou`ou Valley, 38013001	Joseph Paiko Trust.	1.3.74 (1)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
O	Ka`alākei Valley, 39009001	Hawai`i Kai Development Co.	1.3.75 (2)
O	Kapālama, 14015009	Julius Chung Trust.	1.3.76 (3)
O	Moanalua Valley, 11013001	Damon Estate.	1.3.77 (1)
O	Moanalua Valley, 11013001 11013002	Damon Estate.	2.4.1.51 (1)
O	North Hālawa Valley, 99011002	Kamehameha Schools.	2.4.1.50 (1)
O	South Hālawa Valley, Tripler Ridge, 99011001	Queen's Medical Center.	1.3.78 (1)
O	Waikāne Valley, 48014005	SMF Enterprises.	1.3.79 (1); 2.4.1.52 (1)
O	Waianu Valley, 48014003 48013014	Waiāhole Irrigation Co. Ltd.	1.3.80 (2)
O	Mākua Military Reservation	U.S. Army.	2.1.62 (3)
K	Halehaha, Halepā`ākai and Koai`e drainages, Alaka`i Wilderness Preserve, 414001003	Hawai`i DLNR.	2.2.101 (1); 2.4.1.59 (1)
K	Upper Mōhihi and upper Waiakoali drainages, Alaka`i Wilderness Preserve, 414001003	Hawai`i DLNR.	2.2.102 (2); 2.4.1.60 (2)
K	Alaka`i Wilderness Preserve, 4414001003	Hawai`i DLNR.	2.2.103 (2)

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
K	Upper Kawaikōī, Alaka`i Wilderness Preserve, 459001001	Hawai`i DLNR.	2.4.1.61 (2)
K	Kōke`e State Park, 414001013 459001016 414001020 414001014 414001002 and numerous small parcels within	Hawai`i State Parks Division.	2.1.63 (3)
K	Southern Alaka`i Plateau, Portions of 417001001	Robinson Family Partners	1.3.81 (1); 2.2.104 (2); 2.4.1.62 (2)
K	Upper Wainiha Pali, Portion of 458001001	Alexander and Baldwin Hawai`i Inc.	1.3.82 (2)

APPENDIX B.
Captive Propagation Program Strategies for the Hawaiian Endangered Bird Conservation Program, Keauhou Bird Conservation Center/Maui Bird Conservation Center, and Zoological Society of San Diego

A. PROCEDURES FOR RANKING SPECIES

1. Evaluate Hawaiian avifauna recovery priority and select target species based on the following criteria:

    - Taxonomic uniqueness
    - Urgency/degree of threat
    - Cause of decline in the wild
    - Available knowledge of species' natural history
    - Status of current research/habitat management efforts in the field and potential for collaboration
    - Practical considerations (availability of funding and expertise/labor)
    - Population size
    - Population distribution (fragmentation)
    - Avicultural history/difficulty
    - Release history/difficulty
    - Availability of suitable release sites (healthy forest and habitat management)
    - Private landowner partnership agreements (habitat conservation plans, safe harbors agreements etc.)
    - Species value as basic component of the ecosystem (e.g., significance as a seed disperser or pollinator)
    - Cultural value
    - Educational value
    - Recovery priority

2. Evaluate whether captive propagation/reintroduction is necessary for recovery of the target species:

   - Is a captive propagation/reintroduction program necessary to recover the species or can alternative (more cost-effective) recovery strategies (e.g., translocation or habitat management) restore and/or protect the species in the wild?
   - Does captive propagation/release have a reasonable chance of succeeding?
   - Will the program be part of an integrated landscape level recovery effort incorporating habitat management, research, and environmental education?
   - How much time will be required for habitat research/management/restoration before acceptable, secure release sites are available?

3. Define the recovery goals for the target species:

   - Genetic and demographic stability
   - Density
   - Dispersal
   - Distribution
   - Long-term population trends and "monitoring criteria"
   - Survivorship (adult and juvenile)
   - Reproductive success (causes of failure)
   - Habitat requirements (pre-release "site preparation criteria")

4. Identify, select, evaluate, prepare, and maintain quality release sites. Develop a systematic process to establish pre-release "site preparation criteria" for target species:

   - Identify and select the release site. The goal is to select/restore habitat that fulfills year-round requirements for the species to ensure that birds remain in managed habitat (e.g., sufficient seasonal food resources, nesting and roosting sites). Preliminary site selection should include the evaluation of:

- Species natural history information (habitat requirements for foraging, nesting and roosting, home range, presence/absence of conspecifics, ecosystem type etc.).
- Vegetative analysis.
- Physical qualities (size, elevation, elevational gradient, topography, edaphics, prevailing weather patterns, corridor potential, and proximity to other populations).
- Biological limiting factors (e.g., mosquito/disease prevalence, feral ungulates, predators, alien bird species, etc.).
- Human-made threats/hazards (e.g., land use in adjacent areas, presence of housing developments, hunting levels, etc.).
- Current level of habitat management (e.g., predator control, alien plant control, etc.).
- Landowner partnership agreements (e.g., habitat conservation plans, safe harbor agreements, etc.).

• Increase the involvement of stakeholders in the negotiations necessary for designing successful land management programs in selected release sites. Inform the public regarding proposed conservation activities through policy documents, conservation education programs, public relation activities, etc. Discuss and finalize partnership agreements with landowners for potential release sites (e.g., habitat conservation plans, safe harbor agreements, etc.).
• Evaluate the release site and fund landscape level research to develop habitat management techniques necessary to decrease limiting factors. Develop pre-release "site preparation criteria" that must be met before reintroduction begins.
• Fund, implement, and continue habitat management programs in accordance with pre-release "site preparation criteria."

5. Select the programmatic strategy necessary to recover targeted species (see Section B, below, for detailed definitions of these strategies):

- No captive propagation/reintroduction program necessary
- Translocation
- Rear and release
- Captive-breeding (immediate release)

- Captive-breeding (self-sustaining population)
- Captive-breeding (production for restoration)
- Emergency search and rescue
- Technology development

6. Develop programmatic techniques (if necessary).

7. Begin programmatic activity best suited to recover the target species.

8. Define recovery "monitoring criteria" for target species:

   - Survivorship (adult and juvenile)
   - Dispersal and distribution
   - Reproductive success (causes of failure)
   - Long-term population trends

9. Evaluate results.

B. DEFINITION OF PROGRAM STRATEGIES

Hawaiian Endangered Bird Conservation Program strategies are designed to contribute to recovery efforts by providing captive birds for reintroduction to reinforce or re-establish populations in the wild. Reinforcement of wild populations using captive propagation requires the development of cost-effective management programs that are designed to maintain population genetic diversity and demographic security considering the resources available. All endangered bird programs are managed following the American Association of Zoological Parks and Aquariums (AZA) – Small Population Management Advisory Group and International Union for the Conservation of Nature (IUCN) – Captive Breeding Specialist Group Guidelines (Appendix 6.2 in Foose and Ballou 1988). Captive-breeding programs need to be established before species are reduced to critically low numbers if they are to have a reasonable chance of preventing a species' extinction.

Founder Requirements for Wild Population Genetic Diversity

1 founder = 50 percent
2 founders = 75 percent
3 founders = 90 percent
10 founders = 95 percent

1. **No Captive Propagation/Reintroduction Program Necessary.**

   Captive propagation/reintroduction is an expensive recovery strategy that is not always necessary to restore or protect endangered species. If habitat preservation, protection and/or restoration will ensure species recovery, those strategies are preferable to captive propagation and reintroduction.

2. **Translocation and/or Cross Fostering**.

   This option requires moving wild eggs/birds from one field site to another. In general, cross- fostering/translocation is more cost-effective than a captive propagation program and should be considered as a recovery strategy prior to implementing captive-breeding. However, recovery strategies involving translocation/cross-fostering require: a) founder populations large enough to support collection of wild adults or eggs, b) the availability of surrogate foster species (e.g., Chatham Island Tits were used as fosters for robins), and c) site fidelity of translocated individuals to the new release area (Serena 1995). For some species, although suitable habitat may be available for translocation, some or all translocated birds may return to their site of origin, especially if the site is on the same island, as in the case of the palila (Fancy *et al.* 1997).

   Example Program: \`Ōma\`o

   In 1995, an experimental program was undertaken by the U.S. Geological Survey to evaluate translocation of wild birds vs. reintroduction of captive-reared birds as potential recovery options for endangered thrushes. The results of this study with \`ōma\`o demonstrated similar survival rates for both groups of birds, but fidelity to the release site was higher for captive-reared birds than translocated birds (Fancy *et al.* 2001).

3. **Rear and Release**.

Collection of wild eggs for artificial incubation/hand-rearing and immediate release of juveniles to the wild requires easily located, accessible, wild nests and secure habitat for reintroduction. "Rear and release" is not always more cost-effective than captive-breeding because nest search crews, helicopter time, and the establishment and staffing of temporary incubation facilities are expensive, especially if the program continues for several years. If the target species breeds readily in captivity, it is more cost-effective to develop a short-term "captive-breeding (immediate release)" program (approximately 50 percent less cost). If nests are easily accessible, the species does not breed readily in captivity, and enough birds can be hand-reared to provide an acceptable release cohort, "rear and release" is a preferable strategy.

<u>Example Program: Hawai`i `Amakihi</u>

20 viable wild eggs collected (hatchability = 85 percent; survivability of hand-reared chicks = 94 percent)
20 eggs × 85 percent hatchability = 17 chicks hatched
17 chicks × 94 percent survivability = 16 chicks hand-reared
16 birds released
(Kuehler *et al.* 1996).

4. **Captive-breeding (Immediate Release).**

Collection of wild eggs to establish a <u>small</u> captive flock that encompasses <u>some</u> of the genetic diversity of the wild population, and immediate release of juveniles to the wild, requires a breeding flock with enough founders to establish enough genetic diversity in captivity to produce birds for release. Juveniles produced are immediately released to the wild. Each year a few offspring would be retained in captivity to maintain the necessary genetic/demographic stability of a captive flock designed to produce birds for immediate release. This option requires maintaining fewer captive animals than a self-sustaining population.

Example Program: Puaiohi (1996 to 1999)

43 viable wild and captive eggs collected (hatchability =91 percent; survivability of hand-reared chicks = 93 percent)
43 eggs × 91 percent hatchability = 39 chicks hatched
39 chicks × 92 percent survivability = 36 chicks hand-reared
14 birds released in 1999; 5 birds due for release in 2000.

5. Captive-breeding (Self-sustaining Population).

This option should be considered as a hedge against future species bankruptcy. Birds would be maintained in captivity but not reintroduced until secure habitat was available. Management of self-sustaining captive populations would protect the genetic and demographic health of the species for many generations (e.g., target = 90 percent genetic diversity for 100 years) if further recruitment from the wild is not an option (stable population).

Example Program: Bali Mynahs

There are approximately 691 birds in over 100 institutions; no release program exists at this time. Releases failed because limiting factors were not controlled (poaching).

6. Captive-breeding (Production for Restoration).

This can be considered the "factory" option of captive propagation/release (hatch rate greatly exceeds mortality). After the avicultural questions have been answered, facilities built, personnel trained, and habitat for reintroduction is available, full-scale production of birds can be implemented to produce many birds for release into areas that are in need of support. This option would only be considered for critically endangered species (extinct in the wild) that would justify the expense of many cages and maximum labor for production of as many birds as possible.

Example Program: California Condors

There are 118 captive birds; an ongoing reintroduction program exists.

7. Emergency Search and Rescue.

The search and rescue, or last-ditch, strategy should only be considered if extinction is imminent and the strategy of captive propagation has a greater probability of recovering the species than translocation or habitat management. Although we may be saving the last few eggs/individuals by removing them from their natural habitat, we are losing an opportunity to study and protect the species in the wild. There are no guarantees that captive propagation will be successful and that production will ever outstrip mortality. This strategy is high risk, but may be the only option remaining for a few species. Ideally, captive-breeding programs need to be established before species are reduced to critically low numbers if they are to have a reasonable chance of saving a species from extinction.

<u>Example Program: Micronesian Kingfishers</u>

Twenty-nine birds were brought into captivity. For 16 years the size of the captive population has fluctuated while husbandry techniques were being developed. It currently numbers approximately 60 birds.

8. Technology Development Program.

The purpose of this strategy is to develop captive propagation and release expertise. Many of the artificial incubation and hand-rearing techniques for Hawaiian forest birds have already been developed. In the future, this strategy would be chosen primarily for those species that still require development of captive-breeding or release techniques.

<u>Example Program: \`Ōma\`o as a surrogate for Puaiohi</u>

Non-endangered \`ōma\`o eggs were collected from the wild to develop artificial incubation, hand-rearing, and release techniques for Hawaiian thrushes - prior to the implementation of a reintroduction program for puaiohi. Twenty-five chicks were hand-reared and released into Pu\`u Wa\`awa\`a Forest Bird Sanctuary.

29 viable wild eggs collected (hatchability =93 percent; survivability of hand-reared chicks = 93 percent)
29 eggs × 93 percent hatchability = 27 chicks hatched
27 chicks × 93 percent survivability = 25 chicks hand-reared
25 birds released (Fancy *et al.* 2001, Kuehler *et al.* 2001).

APPENDIX C.

Endangered and Threatened Species Recovery Priority Numbers
(adapted from Federal Register 48:51985, 15 November 1983)

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

APPENDIX D.

U.S. Fish and Wildlife Service Listing Priority System

(adapted from Federal Register 48:43098-43105, 21 September 1983)

<table>
<tr><th colspan="2">Threat</th><th rowspan="2">Taxonomy</th><th rowspan="2">Priority</th></tr>
<tr><th>Magnitude</th><th>Immediacy</th></tr>
<tr><td rowspan="6">High</td><td rowspan="3">Imminent</td><td>Monotypic genus</td><td>1</td></tr>
<tr><td>Species</td><td>2</td></tr>
<tr><td>Subspecies</td><td>3</td></tr>
<tr><td rowspan="3">Non-imminent</td><td>Monotypic genus</td><td>4</td></tr>
<tr><td>Species</td><td>5</td></tr>
<tr><td>Subspecies</td><td>6</td></tr>
<tr><td rowspan="6">Low to Moderate</td><td rowspan="3">Imminent</td><td>Monotypic genus</td><td>7</td></tr>
<tr><td>Species</td><td>8</td></tr>
<tr><td>Subspecies</td><td>9</td></tr>
<tr><td rowspan="3">Non-imminent</td><td>Monotypic genus</td><td>10</td></tr>
<tr><td>Species</td><td>11</td></tr>
<tr><td>Subspecies</td><td>12</td></tr>
</table>

APPENDIX E.
Summary of Comments Received on the Draft Revised Recovery Plan for Hawaiian Forest Birds

In October 2003, the U.S. Fish and Wildlife Service (Service) released the Draft Revised Recovery Plan for Hawaiian Forest Birds for review and comment by Federal agencies, State and local governments, and members of the public. The public comment period was announced in the Federal Register (68 FR 70527) on October 16, 2003 and closed on December 15, 2003. Over 250 copies of the draft plan were sent out to interested parties for review during the comment period, and it was also made available online. Six peer reviewers were contacted and agreed to provide comments on the draft plan; comments were received from the following four scientific peer reviewers:

Cathleen Natividad Bailey, Haleakalā National Park
Dr. Kirsty Swinnerton, Maui Forest Bird Recovery Project
Ron Walker, Hawai`i Division of Forestry and Wildlife (retired)
Sharon Reilly, Ducks Unlimited

We received 15 comment letters during the comment period, and some additional comments, information, and updates after the comment period ended. We carefully considered all comments received in finalizing this recovery plan. Many comments suggested additions or changes for clarification. A few comments suggested additional recovery actions. We thank all the commenters and peer reviewers for their time and interest in this recovery plan, and we feel the final Revised Recovery Plan for Hawaiian Forest Birds has been significantly improved by the comments we received.

Summary of Comments and Service Responses

Issue 1: Recovery Habitat and Critical Habitat

Comment: One commenter was concerned that inclusion of their private land in recovery habitat might eventually require a greater expenditure of time and money to implement recovery actions and that this would result in personal financial hardship. The commenter felt the inclusion of their private land in recovery habitat was unacceptable.

Response: We recognize that the term "recovery habitat" was similar to the term "critical habitat" and that this may have caused confusion. In the final plan we have used the term "recovery area" instead of "recovery habitat" to make it more clear that identification of certain areas as important for recovery of forest birds is different from designation of critical habitat. Identification of land as "recovery area" does not create or imply any legal requirement of the property owner to implement recovery actions, nor does it impose any limitation on the types of activities that the landowner may choose to engage in. Lands named here as recovery areas are those that from a purely biological standpoint have the greatest potential to provide habitats important to the recovery of the forest birds. The identification of land as recovery area should not be confused with designation of land as critical habitat, which is a separate process usually conducted during the listing of a species as threatened or endangered. Designation of land as critical habitat does not require the landowner to implement recovery actions or to manage the land in a certain way, but it does require the landowner to consult with the Service if they undertake projects that entail Federal funding or permitting. This requirement does not apply to what we have identified here as recovery areas.

Comment: One commenter felt that enough protected areas are already available for recovery, and that recovery actions should be focused on areas that are already managed by the U.S. Fish and Wildlife Service, the National Park Service, the State of Hawai`i, the Hawai`i counties, The Nature Conservancy, and other conservation agencies or groups.

Response: We believe the recovery areas described in this plan are necessary to recover the species addressed in this plan. We agree that there is much work still to do on lands that are managed principally for the benefit of native species. However, we feel that to recover all the species described here, recovery actions will be needed throughout recovery areas, including some lands that are privately owned.

Comment: One commenter said that a portion of a privately owned land parcel included in a recovery area is very remote, zoned for conservation, pristine in nature, and does not require fencing, greater effort to remove ungulates, or predator control. The commenter felt the parcel should be excluded from recovery area because the area is well managed already, additional management is expensive, and some types of management suggested could harm the land.

Response: We are glad to hear that the section of the land parcel described is well managed and that the owner intends to continue to maintain its pristine condition. However, it is likely that fencing and ungulate removal and predator control would further enhance and protect this and other recovery areas for the benefit of listed species. Although expensive, recovery actions described in this plan will contribute significantly to species recovery and can be conducted in a manner to minimize damage caused to habitat areas, at the same time maximizing habitat benefits. As noted above, these actions are recommendations and we believe they are necessary to achieve recovery of the forest birds, but they are not required. In addition, we recognize that conditions vary from site to site, and the actions recommended here are of necessity relatively broad in nature. If there is any question as to whether the management actions we have suggested would possibly harm the land under some circumstance, or if the landowner would like to explore possible alternative approaches to management for the suggested habitat conditions, we recommend that the landowner seek advice specific to their particular situation from either the Service or the Hawai`i Department of Land and Natural Resources.

Comment: One commenter felt it should be made clear why critical habitat is designated for O`ahu `elepaio and palila and not for the other 19 species in the plan.

Response: We clarified on page 3-7 that listing of all species in the plan except the O`ahu `elepaio (listed in 2000), palila (listed in 1977) and Hawai`i creeper and po`ouli (listed in 1975) preceded the legal requirement in the Endangered Species Act of 1973 to consider the designation of critical habitat at the time of species' listing.

Issue 2: Criteria for Downlisting and Delisting

Comment: One commenter felt that the process for delisting because of extinction should be described.

Response: We have added a description of the types of information needed to consider delisting because of extinction to the plan in the Recovery Criteria section on page 3-4. This issue is also addressed in Section 3-i of the Rare Bird Discovery Protocol on page 3-18.

Comment: One commenter felt that search effort should be considered as a factor when determining the designation "potentially extinct" in the Rare Bird Search Protocol section of the plan.

Response: We agree and have included search effort as a factor when determining the designation "potentially extinct" in the Rare Bird Search Protocol.

Comment: One commenter thought it was not clear how the 15- and 30-year criteria were established, respectively, for downlisting and delisting.

Response: We have tried to clarify in the Recovery section of the plan the reasons for the time frames chosen, which are based on biological time-frames over which population trends data can be analyzed meaningfully, and on our ability to survey forest birds on the five main Hawaiian islands on a rotating basis.

Comment: One commenter suggested the recovery criteria for downlisting and delisting include amount of habitat area occupied.

Response: Although we would have liked to be able to describe more precisely the geographic extent and specific habitat areas occupied by species for downlisting and delisting, this was not possible, in part because our current understanding is limited as to the numbers of individuals that can be supported by different habitat types and the areas of habitat needed for viable populations. Therefore the approach we have taken in the plan is to base recovery criteria both on measurable population and on demographic parameters, such as the numbers of individuals, population trends, population stability, and intrinsic growth rate, as well as metapopulation, habitat, and criteria for threats removal and threats reduction.

Comment: One commenter felt the term "viable" in the Recovery Criteria section needed to be defined more explicitly. The commenter suggested that modeling results should show the taxon to be viable as defined in terms of its ability to sustain itself numerically and with no loss of genetic variability for a period of 1,000 years.

Response: We feel that the definition of viability in the plan, in terms of the taxon's population characteristics as stable or increasing, by population trend analysis and/or stable or increasing intrinsic growth rate over a 15- and 30-year period, is adequate for downlisting and delisting, respectively, in conjunction with other metapopulation, habitat, and threats reduction downlisting and delisting criteria.

Comment: One commenter suggested defining recovery accomplishments in terms of stabilization and the prevention of species extinction, because successes may be better measured in these terms for some species.

Response: Unless and until a formal redefinition of recovery is approved, in order to legally downlist or delist a species we must create the biological conditions under which a listed species is no longer vulnerable to extinction or threatened with becoming vulnerable to extinction (in other words, in which the species no longer meets the definition of threatened or endangered according to the Endangered Species Act). Recovery actions needed to stabilize a species or prevent extinction are of key importance to achieving the conditions where species can be downlisted or delisted.

Issue 3: Recovery Plan Utility

Comment: One commenter felt that the plan would be more useful if accompanied by short-range plans for each species describing immediate actions that have a reasonable chance for completion given current funding limitations and which can be used as an easy guide for resource managers.

Response: During completion of the Draft Revised Recovery Plan for Hawaiian Forest Birds in 2002, the Hawaiian Forest Bird Recovery Team recommended that key near-term recovery actions for each species be described in "Five-Year Recovery Work Plans." Several of these work plans have been completed and appear at the back of this plan as Appendices F through L. Each work plan lists 10 to 15 key recovery actions that can be completed in the next 5 years. These work plans are available from the Pacific Islands Fish and Wildlife Office in Honolulu, Hawai`i, or from the following website maintained by the Hawai`i Division of Forestry and Wildlife: http://www.dofaw.net/fbrp/projects.php. We anticipate that work plans for additional species will be completed in the near future.

Comment: One commenter felt that the plan would be more useful if it highlighted actions that benefit several species simultaneously.

Response: Tables 7, 8, 9, 11, and 14 list individual species benefiting from recovery actions. In many cases the actions described in these tables are directed at more than one species. Also benefiting multiple species are recovery actions for avian disease research and monitoring, measures to prevent the introduction of new avian diseases to Hawai`i, and actions to prevent the introduction of invasive plant and animal species to Hawai`i, among others.

Comment: In addition to threat, population status, and other biological factors, one commenter suggested that the captive propagation recovery priority rankings in Appendix B should be based on the probabilities of successfully recovering the species, with consideration of geopolitical and social and financial realities.

Response: Although social, financial, and geopolitical factors will likely affect the success of recovery actions, we have based our captive propagation recovery rankings on biological factors. This is because we consider all the listed species in this plan to be recoverable and we are required by law to develop recovery strategies for all listed species based on their biological needs.

Comment: One commenter suggested it would be helpful to provide a step-down outline before the recovery action narrative.

Response: We have added a simplified Step-down Outline, or overview of the major recovery action categories, before the Step-down Narrative to assist users of this plan.

Comment: One commenter felt the Recovery Actions Narrative section was too general and failed to describe specific recovery actions.

Response: Tables 7, 8, 9, 11, and 14 describe recovery actions to be carried out on specific land parcels and specifically identifies which species they are designed to benefit. In some cases a specific recommendation was not made for how to conduct the action and several possible implementation methods are mentioned. We feel this is appropriate because it is important to allow land managers and others who will implement recovery actions the latitude to use the most effective methods and approaches for individual conditions, which may be difficult to determine based on available information and may change over time.

Comment: One commenter felt the link between research results and management actions could be improved.

Response: We have modified the introduction to the research actions section of the Step-down Narrative to make clear that research results need to be translated into on-the-ground management.

Issue 4: Feral Ungulate Control

Comment: One commenter felt that the plan would benefit from a more complete discussion of methods to control feral ungulates, and that the plan should address conflicts between sustained yield game management approaches versus complete removal of ungulates from fenced areas, and the relative effectiveness of the two approaches for habitat recovery.

Response: A complete treatment of the approaches and methods of feral ungulate control in Hawai`i would be very lengthy and is beyond the scope of this plan. There are several approaches to management of feral ungulates, ranging from sustained yield game management to complete eradication, and several methods of removing ungulates from areas, including fencing, public hunting, drives, and snaring. The plan identifies land parcels where control of feral ungulates is needed, but does not attempt to provide a complete discussion of the advantages and disadvantages of the various methods available for doing this. In general, and as described under Recovery Action 2.2, we feel the most effective approach for protecting and restoring habitat for native forest birds is fencing and removal of all feral ungulates. However, the most appropriate strategy and methods also may depend on land ownership and other factors.

Comment: One commenter felt that costs to maintain ungulate fencing and to remove ungulates if a breach in an exclosure fence occurs should be included with the costs for fencing and ungulate removal.

Response: We agree that there will be costs to maintaining fences to ensure that areas remain ungulate-free. These costs are discussed in the Implementation Schedule and are included in costs for fencing and ungulate removal.

Issue 5: New Threats Information

Comment: One commenter recommended recent information be included in the plan concerning "die-back" of over 60 percent of the koa (*Acacia koa*) tree canopy in Kīpahulu Valley, Maui. The commenter thought the die-back was likely caused by the native moth, *Scotorythra paludicola* and the wilt-causing fungus, *Fusarium oxysporum f.sp koae*.

Response: We have included this recent information in the section for research needs in Recovery Action 4.6.4 on page 4-106.

Comment: One commenter felt that the description in the plan was inadequate for the potential impacts of alien bird species on native forest birds; the commenter provided some new information regarding these impacts.

Response: We have included in the Executive Summary a description of the possible impacts of alien birds on native forest birds. Recovery Action 4.2.10 on page 4-99 also addresses the need for research into the potential impacts of alien birds.

Comment: One commenter felt the small Indian mongoose (*Herpestes auropunctatus*) is a greater threat to forest birds than was indicated in the draft plan.

Response: Mongooses are often assumed to be a lesser threat to forest birds than feral cats or rats because of their limited climbing ability. We agree, however, that the small Indian mongoose may be more of a threat to forest birds in certain areas than was indicated in the draft plan. We have revised Recovery Action 2.4 on page 4-52, which deals with control of alien mammalian predators, to reflect this.

Comment: Two commenters noted that recent research on global warming has documented shifts in distribution patterns of flora and fauna to higher latitudes and elevations to "escape" increasing temperatures, and suggested that a recovery action should be included to address global warming and local climate change, which threaten Hawaiian forest birds by reducing the amount of high elevation habitat area free of mosquito vectors.

Response: Global warming and local climate change are a significant threat to avian species in Hawai`i, as noted in the plan. A complete discussion of global warming and local climate changes is beyond the scope of this recovery plan, but we have added a recovery action to the plan (Action 2.5.1.4) calling for active participation to curb global warming and climate change.

Comment: One commenter felt the priority numbers for Recovery Actions 4.6.3 - Conduct population and metapopulation viability analyses, 4.6.3.1 - Conduct trend analysis using count data, and 4.6.3.2 - Use demographic data for estimating lambda; should be elevated from priority 2 to priority 1, because these actions measure population trends, and ultimately, the effectiveness of management actions.

Response: We agree. In the plan the priority numbers for these recovery actions have been elevated from priority 2 to priority 1.

Comment: One commenter was concerned that direct transmission of disease by bird-to-bird contact and handling of multiple birds by researchers is not adequately addressed in the plan.

Response: Researchers follow protocols adequate to prevent transmission of avian disease, such as washing hands and disinfecting mist-nets and measuring tools, which are required for permits issued for research activities. Currently there is no method of preventing possible transmission of avian disease through bird-to-bird contact in the wild.

Issue 6: Captive Propagation and Reintroduction

Comment: One commenter recommended that a thorough habitat assessment be made at release sites, including food availability and disease potential, and examination of the reasons for a species not occurring at sites, including historical habitat modification and the cultural practices of pre-contact Hawaiians, before captive introductions are attempted. The commenter also suggested establishing species in areas outside the historical range to increase forest bird populations.

Response: Recovery Action 3.3 in the plan calls for the development of methods for evaluating, selecting, and preparing sites for releases and/or translocation of endangered birds. We have revised this action to include consideration of habitat modification by historical land uses and practices of pre-contact Hawaiians. Although it is preferred that species be introduced into their historical range it is possible that habitat outside known historical range could be suitable or preferable. We have clarified Recovery Action 3.3 to reflect that habitat outside historical range will be considered when evaluating sites for releases and/or translocations, if necessary.

Comment: One commenter suggested pursuing the establishment of captive propagation programs of nearly extinct species by means other than collecting eggs from the wild, particularly when no wild breeding pairs are known to exist.

Response: We agree that methods of establishing captive propagation programs under circumstances where egg collection from the wild is not an option should be included in the plan, and we have revised Recovery Action 3.2.1 to include creating pairs in the wild through translocation and bringing wild birds into captivity.

Comment: One commenter felt captive propagation of the po`ouli is the only remaining option to save this species from extinction.

Response: We agree that bringing the remaining po`ouli into captivity for captive propagation is the most effective approach for recovering the po`ouli at this time, since field efforts to form a wild breeding pair through translocation recently failed. We have updated Recovery Action 3.2.2 accordingly.

Comment: One commenter suggested that the captive propagation program be expanded and that it should include non-listed native Hawaiian forest birds that may be declining. The commenter also thought greater support should be provided to species in Table 13 that are assigned lower captive breeding priority rankings. The commenter felt this greater emphasis on captive propagation is necessary given the magnitude of the threats Hawaiian forest birds face, the low numbers of some species, and patterns of rapid species declines in Hawai`i.

Response: We would like to expand the captive propagation program to include additional species, especially for all species listed in Table 13 with breeding priorities rankings of 1 and 2. Unfortunately, such expansion is not possible at this time due to limited funding. As stated in Recovery Action 3.1, we periodically evaluate and identify species that will require captive propagation for recovery.

Comment: One commenter suggested when doing translocations that young of the year should be used instead of adult pairs with established territories, because young of the year have a higher mortality rate generally, are the typical dispersers in bird populations, and are less likely to return to the locations from which they are taken.

Response: We agree that these factors are likely true, however, there may be some instances where a combination of young birds and non-breeding adults can create a more normal social dynamic or where because of logistical constraints some non-breeding adults may need to be translocated.

Issue 7: Partners Participation in Recovery Planning and Implementation

Comment: One commenter felt that the National Park Service's responsibilities and accomplishments were not adequately credited in the plan.

Response: We agree that the National Park Service plays a key role in conservation of endangered species and has made significant achievements in the recovery of Hawaiian forest birds. We have attempted to make this more clear by revising the Implementation

Schedule to reflect the interest, planning involvement, achievements, and implementation responsibility the National Park Service has had and will continue to have for recovery of many of the species in this plan.

Comment: One commenter suggested consideration should be given to providing incentives for private landowners to participate in forest bird habitat protection and enhancement, such as tax breaks, partnership financial rewards, and planting assistance.

Response: We agree those types of incentives can enhance habitat protection, and have included these suggestions in the plan under Recovery Action 1.3 (secure recovery area) and other recovery action categories where these approaches would be useful.

Comment: One commenter felt the plan suggested governmental agencies might exercise control over lands the commenter owns and uses and the plan intrudes on private property and landowners' rights.

Response: As discussed above in response to the first comment, the identification of land as "recovery area" is intended as a biological assessment of those lands that have the potential to contribute high quality habitat for the recovery of Hawaiian forest birds, and implies no legal obligation of the landowner to participate in any recovery actions, and does not indicate a desire by the government to control the land or impinge upon the landowners' rights. As discussed under Recovery Action 1.3, agreements for access to private lands and the implementation of recovery actions are with willing partners only, as are any potential acquisitions. We have added to the Introduction to the Implementation Schedule a statement further describing our wish to work with all willing partners towards species recovery.

Comment: One commenter suggested the Service should more actively discuss with the State of Hawai`i Department of Land and Natural Resources, Land Division, changes in land use designations as a way to provide greater protection to recovery areas.

Response: Already included in the plan is consideration of change in land use designation for parcels owned by the State of Hawai`i as an option to secure recovery areas.

Issue 8: Cost Estimates

Comment: One commenter felt that the cost for recovery was excessive and taxpayers' dollars should be spent instead on social programs directly benefiting the public well-being. A second commenter felt that the costs in the plan to protect and/or restore Hawaiian birds were excessive considering the many other public needs on which money could be spent.

Response: The estimated minimum time for delisting any of the species addressed in this plan is 30 years, so we revised the estimated total cost for recovery to encompass this time-frame, which resulted in a reduction in the estimated total cost to $2,477,395,000. As described in the Introduction to the Implementation Schedule on page 5-4, it is difficult to estimate the eventual cost of certain actions, such as ungulate removal and predator control, because the actual area of each parcel in which the action must be conducted cannot be determined at this time, and because we anticipate that improved and more cost-effective methods will become available in the future. Therefore, the actual costs for many of these actions may be lower than the estimates provided in this plan. Although substantial, we feel these costs are necessary and reasonable over the 30-year time period required to recover the species addressed in this plan.

Comment: One commenter felt that the plan lacked the focus and direction needed to justify the planned budget. The commenter suggested that the plan should focus on the most cost-effective recovery actions and those that will be most beneficial in the near-term.

Response: The priority ranking system provided in the Implementation Schedule is intended to help focus efforts on the most urgent and most beneficial actions. One of the criteria for ranking an action as high priority was benefit to multiple species and cost-effectiveness. We have attempted to clarify the explanation of the priority ranking system in the Executive Summary. The Five-year Recovery Work Plans, provided as Appendices F through L of this plan, provide key recovery actions to focus on in the near-term.

Comment: One commenter was concerned that because the plan presents a total dollar figure for recovery, for all species, including all recovery actions, the public and legislative response will be negative to the high total recovery cost. The commenter suggested it would be better to perform a cost/benefit analysis for recovery actions and to focus only on the most cost effective and highest priority recovery actions.

Response: In the Executive Summary we broke costs down by priority to allow the reader to see the costs to implement all priority 1 recovery actions. Many of these recovery actions benefit multiple species, particularly habitat based actions. In Tables 7, 8, 9, and 11 of the plan, all the species benefiting from habitat-based recovery actions are listed. In general, most recovery actions that benefit all or most of the species in this plan received a priority 1 ranking. Therefore, the plan is focused generally on the most cost effective actions. However, as required, we also have presented in the plan all other recovery actions. We have taken a combined approach focusing on those recovery actions that are most cost-effective and that will benefit most species, and that need to be taken immediately to prevent the extinction or the irreversible decline of the species.

APPENDIX F.

O`AHU `ELEPAIO FIVE-YEAR RECOVERY WORK PLAN

Prepared by O`ahu `Elepaio Working Group and Hawaiian Forest Bird Recovery Team

Male O`ahu `Elepaio. Photo © Eric VanderWerf

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the O`ahu `elepaio are provided in the Hawaiian Forest Bird Recovery Plan, which covers 21 species (USFWS 2005). The purpose of this five-year work plan is to identify interim recovery objectives for the O`ahu `elepaio that can be realized within five years, and to describe succinctly the actions needed to reach those interim objectives. Identification of interim recovery objectives and actions will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, facilitate efficient use of limited recovery resources, and provide milestones that can be used to track and evaluate progress toward recovery. Realization of these milestones will measure progress toward eventual recovery. Failure in realizing these milestones may indicate that additional resources are needed, or that the current recovery strategy is not effective.

Species Summary. The O`ahu `elepaio (*Chasiempis sandwichensis ibidis*) is a monarch flycatcher endemic to O`ahu. Other `elepaio subspecies occur on Kaua`i and Hawai`i but are not endangered. `Elepaio are nonmigratory, and pairs defend year-round territories averaging 1.2-2.0 hectares (3.0-4.9 acres) in size, depending on habitat structure (Conant 1977, VanderWerf and Smith 2002, VanderWerf 2003). O`ahu `elepaio are adaptable and occur in a variety of forest types, but they are most common in valleys with tall riparian forest and a dense understory (VanderWerf *et al.* 1997). Forest structure is more important to `elepaio than species composition, and `elepaio forage and nest in a variety of trees, including many alien species. `Elepaio are versatile foragers and prey on a variety of invertebrates, including nonnative taxa such as mosquitoes and fruit flies. The nest is a freestanding cup placed in a fork or on a horizontal branch 2-24 meters above the ground (VanderWerf 1998). Clutch size is 1-3, usually 2, and eggs hatch in 18 days. The parents share incubation during the day, but only the female incubates at night and develops a brood patch. The chicks are fed by both parents and fledge in 16 days. Juveniles are fed by their parents for another 1-2 months after leaving the nest, and remain on the natal territory for up to 9 months. Usually only one chick is fledged, but in good years more pairs fledge two chicks and a few pairs may raise two broods (VanderWerf and Smith 2002). The nesting season usually extends from February to May, but active nests have been found from November to July (VanderWerf 1998).

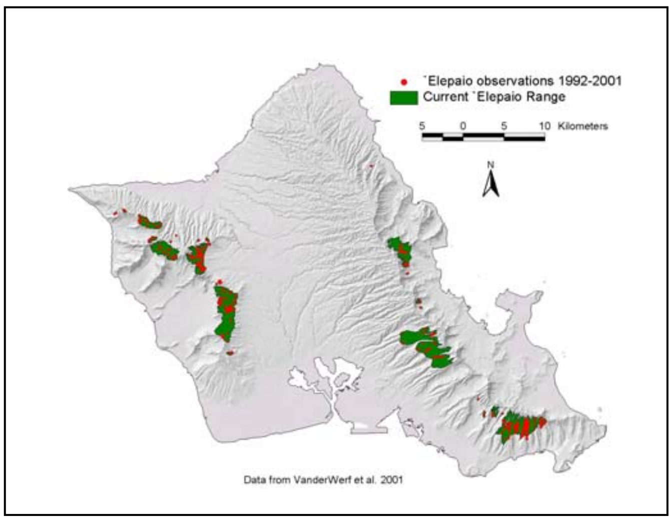

Table 1. Sizes of `Elepaio core populations.

Population	Total Birds	Breed-ing birds	Occupied Area (ha)
Southern Ko`olau	493	450	1132
Central Ko`olau	226	207	1396
Waikāne-Kahana	265	242	523
Southern Wai`anae	464	423	1231
Schofield West Range	342	312	538
Mākaha-Wai`anae Kai	123	113	459
All other populations	95	54	518
Total	2008	1801	5797

`Elepaio were once the most abundant forest bird on O`ahu and probably occupied much of the 127,000 hectares of forest that existed on the island before humans arrived. By 1975 the range of O`ahu `elepaio had declined to 20,900 hectares, and `elepaio currently occupy only 5800 hectares, or less than 4% of their original range (Shallenberger 1977, VanderWerf *et al.* 2001). The total current population is approximately 2000 birds, but the breeding population is only about 1800 birds due to a male-biased sex ratio (VanderWerf *et al.* 2001). The majority of remaining birds is distributed in six large subpopulations of 100-500 birds each (Table 1), with the remainder in numerous small fragments, some of which contain only males. The current distribution superficially appears to constitute a metapopulation, but the amount of dispersal among subpopulations and the genetic population structure are unknown. Natal dispersal distances in `elepaio are usually less than one kilometer (0.62 miles) and adults have high site fidelity (VanderWerf 2003). There may be some exchange among subpopulations within each mountain range, but dispersal across the extensive urban and agricultural lands that separate the Wai`anae and Ko`olau mountains seems unlikely, and most subpopulations probably are isolated.

Primary Threats. Much of the historical decline in distribution of the `elepaio was caused by clearing of forest for human development and agriculture, but most areas currently occupied by `elepaio are zoned conservation, and today habitat loss is a threat only in certain locations, such as at Schofield Barracks through fires caused by military training.

`Elepaio have continued to decline even in areas of intact forest due to a combination of poor reproduction and low adult survival. The primary causes of nest failure and adult mortality are introduced nest predators and diseases carried by the introduced southern house mosquito (*Culex quinquefasciatus*), particularly avian pox virus (*Poxvirus avium*) and possibly avian malaria (*Plasmodium relictum*). Both predation and disease are serious threats, but predation has a larger negative effect on `elepaio populations than disease and is a more serious threat (Table 2). Cameras placed at artificial nests showed that black rats (*Rattus rattus*) are the most important nest predator in `elepaio habitat (VanderWerf 2001). From 1996-2000 ground-based rodent control, using snap traps and diphacinone bait stations resulted in average increases in `elepaio reproduction of 112% and in survival of female `elepaio of 66% (VanderWerf and Smith 2002). Predation is greater on females because only females attend the nest at night, when rats are most active. Rodent control has been conducted by the Hawai`i State Division of Forestry and Wildlife in the Honolulu Watershed Forest Reserve since 1997, by the U.S. Army Environmental Division at Schofield Barracks West Range and Mākua Military Reservation since 1998, by The Nature Conservancy of Hawai`i at Honouliuli Preserve since 2000, and by the U.S. Navy in Lualualei since 2002. These programs have been successful on a small scale, but are labor intensive and expensive. Recovery of the O`ahu `elepaio will require rodent control on a larger scale, and this can

Table 2. `Elepaio population growth with and without predation and disease. Lambda >1.0 indicates growth. (from VanderWerf 2002).

Predator control?	Disease removed?	Growth rate (lambda)
Yes	Yes	1.04
Yes	No	0.98 ± 0.05
No	Yes	0.83
No	No	0.76 ± 0.04

be achieved more efficiently through aerial broadcast methods. Registration of aerial broadcast of diphacinone for rodent control with the U.S. Environmental Protection Agency should be actively pursued and supported, and public outreach and education about the importance and benefits of controlling rodents and the safety of diphacinone is needed before aerial broadcast can be applied. Reproduction of `elepaio with active pox virus infections birds is 69% lower than reproduction of healthy birds, and survival of infected birds is 24% lower than survival of healthy birds, but the prevalence of pox varies among years, and on average 14% of birds have active infections each year (VanderWerf 2002). Avian malaria is a serious threat to many Hawaiian forest birds, but its effect on `elepaio has not been investigated. Currently there is no environmentally safe and effective and method of controlling mosquitoes in forested areas, and it is not practical to vaccinate wild bird populations because any immunity would not be heritable. Controlling rodents also may lessen the threat from disease by providing birds that have greater natural immunity a greater chance of reproducing (VanderWerf and Smith 2002).

Recovery Strategy. The ultimate recovery goal for O`ahu `elepaio is to restore viable populations or metapopulations on both the windward and leeward sides of the Ko`olau and Wai`anae Mountains (USFWS 2005). The number of birds remaining is sufficiently large that *in situ* habitat management of wild birds currently is the most cost-effective recovery strategy. Rodent control is the most effective method of stabilizing `elepaio populations. Recovery efforts should focus first on protecting and managing the six large "core" populations, because management in these areas will benefit the largest number of birds. These core populations are distributed throughout most of the original historical range, have the greatest chance of long-term persistence because their larger sizes make them less susceptible to stochastic events, and they probably have lost less genetic diversity than smaller populations. All six core populations should be conserved to preserve as much genetic, morphological, and behavioral (vocal) variation as possible. Smaller populations should be addressed next if there are sufficient resources or interested parties. If management actions are effective, the core populations eventually may serve as sources of dispersing individuals that can help support smaller populations or recolonize areas where `elepaio have disappeared. If habitat management alone proves insufficient to allow recovery, captive propagation and/or rear and release of O`ahu `elepaio may become necessary, and would be especially valuable if genetically disease-resistant birds can be identified for use as breeding stock.

Interim Recovery Objectives. In order to meet the long-term recovery goals for the O`ahu `elepaio, the following short-term goals should be accomplished first:

- Stabilize numbers of birds in the six remaining core populations through rodent control.
- Prevent any further loss of forest habitat supporting the six remaining core populations.

If these objectives are met within five years, then new interim recovery objectives will be identified to continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy will be developed and new actions identified.

Five-year Recovery Actions (2004-2008). In order to realize the interim recovery objectives described above, the following actions are necessary:

- Ensure/encourage continued support for ongoing rodent control programs and expand these programs.
    - Honolulu Watershed State Forest Reserve in Wailupe Valley (Hawai`i DOFAW)
    - Honouliuli Preserve (The Nature Conservancy of Hawaii)
    - U.S. Army Schofield Barracks West Range (U.S. Army)
    - Lualualei Naval Magazine (U.S. Navy)

- Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone.
- Conduct large-scale rodent control by aerial broadcast of diphacinone in at least one site and compare efficacy and cost with ground-based methods. Possible sites include Honouliuli Preserve, Schofield Barracks West Range, and Mākua Military Reservation.
- Contact landowners and initiate rodent control in unmanaged areas within core populations, through safe harbor agreements, partnerships, technical support, and collaboration.
  - Moanalua Valley (Damon Estate)
  - North Hālawa Valley (Kamehameha Schools)
  - South Hālawa Valley (Queen Emma Foundation)
  - Wiliwilinui Gulch (Kamehameha Schools)
  - Waikāne Valley (SMF Enterprises)
  - Pia Valley (Hawaii Humane Society and J. Pflueger)
  - Mākaha Valley (City and County of Honolulu)
- Complete an effective fire management plan at Schofield Barracks West Range, ensure that Army provides adequate resources to implement that plan and responds to fires in a timely manner (U.S. Army).
- Ensure access to Honouliuli Preserve for management by The Nature Conservancy of Hawaii. May require coordination with U.S. Army over condemnation of lands in northern portion of Preserve, and negotiation of lease or conservation easement with a new owner if land comprising the remainder of the Preserve is sold by Campbell Estate.

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APPENDIX G.

PUAIOHI FIVE-YEAR RECOVERY WORK PLAN

Prepared by Puaiohi Working Group and Hawaiian Forest Bird Recovery Team

Captive Puaiohi with chicks. Photo © Jack Jeffrey.

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the Puaiohi are provided in the Final Revised Recovery Plan for Hawaiian Forest Bird, which covers 21 species (USFWS 2005). The purpose of this five-year work plan is to identify interim recovery objectives for the puaiohi that can be realized within five years, and to describe succinctly the actions needed to reach those interim objectives. Identification of interim recovery objectives and actions will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, facilitate efficient use of limited recovery resources, and provide milestones that can be used to track and evaluate progress toward recovery. Realization of these milestones will measure progress toward eventual recovery. Failure in realizing these milestones may indicate that additional resources are needed, or that the current recovery strategy is not effective.

Species Summary. The puaiohi, or small Kauai thrush (*Myadestes palmeri*), is a medium-sized thrush endemic to the island of Kauai. Adult puaiohi are olive-brown above, gray below, with a white-eye-ring and pinkish legs. Juveniles have distinctive spots and scalloping on the breast and wings. Puaiohi feed on insects and the fruit of several native plants, particularly `ōlapa (*Cheirodendron trigynum*), lapalapa (*C. platyphyllum*), `ōhi`a ha (*Syzygium sandwicensis*), kanawao (*Broussaisia arguta*), `ōhelo (*Vaccinium* spp.), pa`iniu (*Astelia* spp.), pūkiawe (*Styphelia tameiameiae*), kāwa`u (*Ilex anomala*), and pilo (*Coprosma* spp.). Puaiohi nest in cavities or ledges concealed by mosses and ferns on cliff faces, or more rarely in secondary cavities formed in trees (Snetsinger *et al.* in prep.). Nesting occurs from March to mid-September, with a peak from April to June (Snetsinger *et al.* in prep). The female alone builds the nest, and incubates and broods the young. Clutch size is almost always two. Eggs hatch after 13 to 15 days. Both parents share responsibility for provisioning the chicks, but after fledging the male assumes primary responsibility for feeding chicks while the female frequently initiates another nesting attempt. Occasionally (8 percent of nests), second-year and hatch-year birds assist in nest defense and feeding of nestlings and fledglings. Recently fledged young often remain within 2 meters of the ground for 2 to 4 days after fledging, where they may be particularly vulnerable to predation by introduced mammalian predators. A breeding season of up to 132 days and high nest success rates of up to 90% result in productivity in some years of up to 4.9 fledglings/pair. El Niño conditions can shorten the breeding season to 51 days and lower nest success to 42 percent,

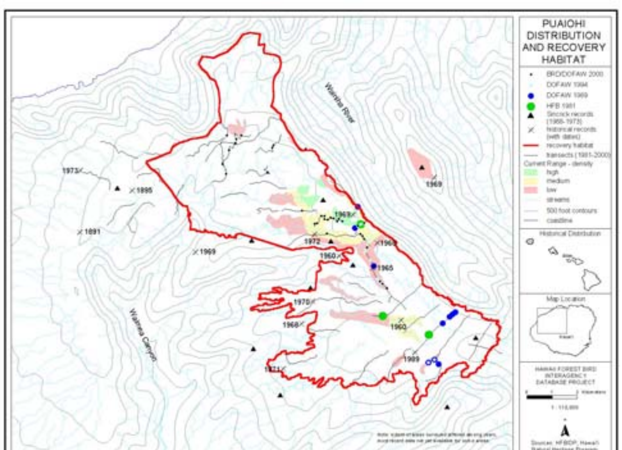

Figure 1. Puaiohi Distribution and Recovery Area.

leading to productivity of only 0.4 young per pair per year. Dispersal frequency and distances appear to be small but are poorly known. Adult survival is estimated at 74% and juvenile survival at 25% (T. Snetsinger pers. comm.).

The total population of puaiohi is estimated to be 300-400 birds, which occur in wet (>6,000 mm rain/year) montane forest in stream valleys and associated ridges above 1,050 meters (3,450 feet) elevation on the southern and central plateau of the Alaka`i Wilderness Preserve (Scott *et al.* 1986, Snetsinger *et al.* 1999, USGS and DOFAW unpubl. data). The breeding population is restricted to an area of < 20 square km, and 75 percent of the breeding population occurs in only 10 square kilometers (Figure 1). The puaiohi exists in high densities (up to 11 breeding pairs per linear kilometer of stream) in three adjacent drainages; the Upper Mōhihi, Upper Waiakoali, and the northeastern upper Kawaikōī (the "core" or "Mōhihi/Waiakoali" population; Table 1). Densities decline with elevation about 1,050 meters (3,450 feet) in these drainages (T. Snetsinger pers. comm.). The upper reaches of the Halehaha and Halepā`ākai drainages contain a medium-density population of approximately 5 pairs per linear km, and low-density populations exist in the lower Waia`alae/unnamed drainage (1.25 pairs/km; Pratt *et al.* 2002) and lower Kawaikōī/Kauaikinanā (0.5 pairs/linear km). Two small, low-density populations were detected during State forest bird surveys in 1994 on private lands along the Halekua and Waiau streams at the southern edge of the species' range, but neither population was detected during surveys in March 2000 (T. Telfer pers. comm.). Surveys in March 2000 confirmed the existence of a small population along the upper reaches of a tributary to the Koai`e Stream, although its size and extent remain to be documented (J. Foster/USGS unpubl. data).

A captive propagation and release program has been implemented for the puaiohi, and a total of 77 birds have been released in 2 sites since 1999 (Kuehler *et al.* 2000; The Peregrine Fund 1999; The Peregrine Fund and ZSSD 2000; ZSSD 2001, 2002, 2003; ZSSD unpubl. data). Captive-bred released puaiohi readily paired with both captive and wild birds, and bred in the wild in the first season following their release. For releases conducted from 1999-2002, thirty-six of forty-two (85.7%) released birds survived to 30 days post-release, and survival during the subsequent 40-50 day post-independence period ranged from 67% in 1999 to 71% in 2001 and 83% in 2002. However, only 20-43% of released birds established breeding territories in the target drainage each year, and the majority of released birds dispersed several km away, frequently in the direction of high-density populations (Tweed *et al.* 1999, Monahan *et al.* 2001, Pratt *et al.* 2002). Although released birds have survived well and reproduced, the efficacy of captive releases at establishing new, disjunct populations has yet to be demonstrated.

Table 1. Densities of Puaiohi populations in drainages of the Alaka`i region of Kauai.

Drainage	Density (pairs/km)
Mōhihi	High
Waiakoali	High
Kawaikōī	High
Halehaha	Medium
Halepā`ākai	Medium
Kawaikōī/Kauaikinanā	Low
Waia`alae/unnamed	Low

Primary Threats. Predation by alien rats (*Rattus* spp.) may be a serious limiting factor on puaiohi populations. Although their habit of nesting on steep cliff faces may provide some protection from nest predation, data from 1998 and 1999 showed that 14 percent and 22 percent of nests, respectively, failed due to rat predation. Eggs, nestlings, and incubating females all have been depredated by rats. Snetsinger *et al.* (in prep.) demonstrated that nests protected by rat bait stations fledged significantly more birds than untreated nests. In addition, the tendency of young puaiohi to remain close to the ground for several days after fledging probably makes them particularly vulnerable to predation by feral cats.

Only five wild puaiohi have been tested for disease, of which one had antibodies to malaria but none had active infections, suggesting that at least some puaiohi may survive malaria infection (Atkinson *et al.* 2001). However, disease likely limits puaiohi from inhabiting the lower reaches of stream drainages with suitable nesting cliffs.

The disruption of seedling regeneration of beneficial plants, the invasion of nonnative weeds, and soil erosion are some of the many forest management problems within the remaining puaiohi range. Feral pigs and goats have had long-term damaging effects upon native forests by opening space for weeds and transporting weed seeds into the forest. Hurricanes in 1982 and 1992 also severely disturbed areas of native forest and made space for the germination and expansion of alien plants. Habitat degradation resulting from the invasion of many nonnative weeds has drastically changed the forest structure and integrity.

The population size of 300 to 400 birds in several subpopulations falls below the effective population size of 500 individuals recommended for long-term maintenance of genetic diversity (Soulé 1987).

Recovery Strategy. Several tools exist that can be used to manage puaiohi populations, including captive propagation and release, predator control, use of rat-resistant artificial nest boxes, and fencing and ungulate control. All of these tools are likely to be important components of the long-term recovery strategy for puaiohi, but knowing which tool is most effective will allow more efficient short-term use of limited conservation resources. In addition, the most appropriate conservation strategy and the most urgent management needs of the puaiohi depend on the size, distribution, and trend of the population, and these parameters are only partly known. If the population is relatively large and stable, then management of wild birds may be most effective and releases of small numbers of captive-bred birds are not needed. On the other hand, if unoccupied areas of suitable habitat can be identified that are isolated from the existing population, then it may be preferable to decrease the threat from local catastrophes by creating additional disjunct populations through release of captive birds. If the population is stable, then there is time to investigate the efficacy of different tools; if it is declining, then it may be necessary to augment simultaneously the population through release of captive birds. Until this information is known, it is prudent to continue existing management programs that have shown some degree of success, such as captive propagation and release (Kuehler *et al.* 2001), and ground-based predator control around nest sites (Snetsinger *et al.* 1999).

Interim Recovery Objectives. In order to meet the long-term recovery goals for the puaiohi, the following short-term goals should be accomplished first:

- Investigate management tools for stabilizing/increasing the puaiohi population and determine which is most effective.
- Determine the total current population size and distribution.
- Determine the puaiohi population trend.

If these objectives are met within five years, then new interim recovery objectives will be identified to continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy will be developed.

Five-year Recovery Actions (2004-2008). In order to realize the interim recovery objectives described above, the following actions are necessary:

- Compile and summarize existing survey data (USGS).
    - Complete surveys in additional areas (State DLNR field crew)
- Identify a new release site that fulfills the criteria of providing high quality habitat, zero or low density of wild puaiohi, sites for the erection of release towers, and helicopter access (State DLNR field crew).
- If a release site is identified, relocate the release infrastructure (towers, cages, weatherport, etc.) to new release site (ZSSD/USFWS/DOFAW).
- Use landsat images and geographic and biological data to model puaiohi habitat with GIS and identify additional potential habitat (USGS).
- Conduct large-scale rodent control by aerial broadcast of diphacinone. Possible treatment sites include upper Mōhihi, and Halepā`ākai. Treatment of both a high-density site and

a medium-density site might provide valuable comparison. In order to implement and fully evaluate the efficacy of an aerial broadcast, the following actions also are needed:
  - Collect baseline data on survival and reproduction of puaiohi for comparison, from a spatial control, a temporal control, or both.
  - Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone.
  - Collect before and after data on water quality and possible contamination of game species if these are deemed necessary to obtain public support.
- Evaluate efficacy of rat-resistant artificial nest boxes at reducing predation.
  - Test different designs of nest boxes, with wild birds, captive birds, or both (graduate student and ZSSD).
  - Compare nest success and female survival in natural nests vs. artificial nest boxes (graduate student).
  - Fledge captive birds from artificial nest boxes so they recognize and use artificial nest boxes after release (ZSSD).
- Measure survival and dispersal of adult and juvenile puaiohi, through mist-netting, banding, resighting, and radio tracking, for use in demographic modeling and determination of population trend (graduate student).
- Model puaiohi population to determine whether it is stable and the effect of management tools (graduate student).

Annual Workplan - 2005. The following tasks are planned for 2005:

- Release 12 captive-bred hatch year birds at the Halepā`ākai hack site and 6 captive-bred hatch year birds at a newly established hack site near Koai`e stream. The release at the Koai`e stream is planned to test survival and dispersal of captive-bred birds released into suitable habitat in which there are few wild resident birds.
- Document dispersal and survival of all released birds for the life of the transmitters using ground based or helicopter access as needed.
- Conduct systematic surveys in drainages not yet surveyed using methodology described in Pratt *et al.* 2002.
- Begin demography studies and prepare for predator control actions by banding as many birds as possible in two drainages and monitoring as many nests in the two drainages as possible.
- Perform basic statistical analyses on release data compiled from 1999-2004.
- Puaiohi Working Group meet in June to discuss results of releases at the two hack sites and future hack site locations.
- Report due 30 September 2005.

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APPENDIX H.

PALILA FIVE-YEAR RECOVERY WORK PLAN

Prepared by Palila Working Group and Hawaiian Forest Bird Recovery Team

Male Palila. Photo © Jack Jeffrey

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the Palila are provided in the Hawaiian Forest Bird Recovery Plan, which covers 21 species (USFWS 2005). The purpose of this five-year work plan is to identify interim recovery objectives for the Palila that can be realized within five years, and to describe succinctly the actions needed to reach those interim objectives. Identification of interim recovery objectives will help ensure that initial conservation efforts by different agencies or groups are directed toward the same ultimate goals, encourage efficient use of limited recovery resources, and provide milestones that can be used to track and evaluate progress toward recovery. Realization of these milestones will provide evidence that progress is being made toward eventual recovery. Failure in realizing these milestones may indicate that additional effort and funding are needed, or that the current recovery strategy is not effective.

Species Summary. The palila (*Loxioides bailleui*) is a finch-billed Hawaiian honeycreeper (subfamily: Drepanidinae) from the island of Hawai`i, and is one of the larger Hawaiian honeycreepers with an overall length of 15.0 to 16.5 centimeters (6.0 to 6.5 inches) and an adult weight of 38 to 40 grams (1.3 to 1.4 ounces). Adult palila have a yellow head and breast, greenish wings and tail, and are gray dorsally and white ventrally (Jeffrey *et al.* 1993). Fossil remains of palila have been found at sea level on O`ahu (Olson and James 1982a, b), suggesting that the species once occurred over a much larger range pre-historically.
Historically, the palila is known only from the island of Hawai`i, were it occurred in māmane (*Sophora chrysophylla*)/naio (*Myoporum sandwicense*) forests on the upper slopes of Mauna Kea, the northwestern slope of Mauna Loa, and probably the southern and eastern slopes of Hualālai Volcanoes (Figure 1). In the 1890s, Perkins (1903) found the palila to be "extremely numerous" in the māmane belt of the Kona region between 1,210 and 1,830 meters (4,000 to 6,000 feet) elevation. Palila were still locally common in the 1940's between 2,360 and 2,530 meters (7,800 to 8,350 feet) on the western and northeastern slopes of Mauna Kea (Richards and Baldwin 1953). However, the range of palila apparently shrank relatively quickly in the early 1900s to the current small area on the upper slopes of Mauna Kea, and Munro (1944) determined that the species was in danger

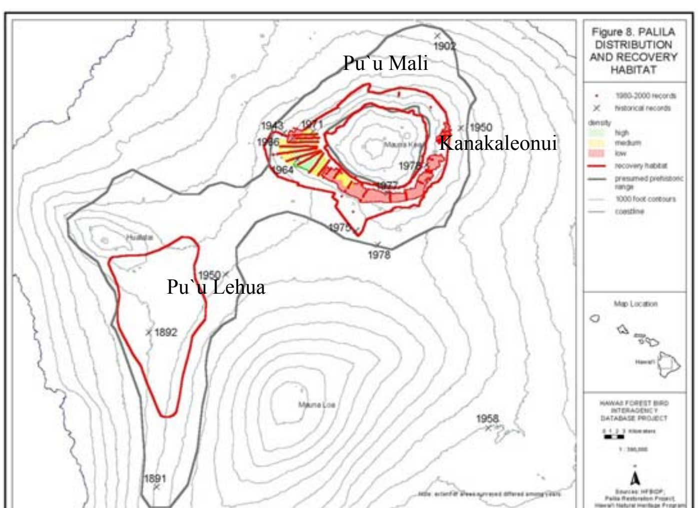

Figure 1. Palila Distribution and Recovery Area

of extinction. Palila numbers have varied over the last 25 years from approximately 1000 to 5000 birds (Figure 2), 96% of which population occurs on the southwestern slope of Mauna Kea, where the elevation range of the forest and habitat quality is greatest (Scott *et al.* 1984, 1986; Jacobi *et al.* 1996; Banko *et al.* 1998; Gray *et al.* 1999). Highest densities of palila occur in areas of greater crown cover, taller trees, and higher proportion of native shrubs near 2,300 meters (7,550 feet) elevation (Scott *et al.* 1984, 1986). Recent releases of captive-reared palila near Pu`u Mali on the north slope of Mauna Kea in 2003, and translocation of palila from the western slope to near Pu`u Mali in 2004 appear to have resulted in some increase in the numbers of resident palila on the north slope of Mauna Kea (ZSSD and USGS unpubl. data).

The palila is a food specialist, preferring māmane seeds in green pods, but also will eat māmane flowers, buds, and leaves, and naio berries, especially when other foods are in short supply. Annual and seasonal density of birds is strongly related to māmane pod availability (Scott *et al.* 1984, 1986; Hess *et al.* 2001). Most nesting occurs in māmane trees (Pletschet and Kelly 1990), while naio is more frequently selected for roosting (USGS unpubl. data). The elevation range of forest was the most important variable in an analysis by Scott *et al.* (1984) of response of palila to available habitat. A wide elevational range of māmane forest results in more consistent availability of seeds within the range of daily movements typically made by palila, especially during the breeding season.

Peak nesting usually occurs in May or June, but may begin in March and May and continue through August or mid-September (van Riper 1980, Pletschet and Kelly 1990, Pratt *et al.* 1997, USGS unpubl. data), while the number of nesting attempts each year is strongly influenced by the availability of green māmane pods. Mean length of the egg-laying season is 113 ± 25.1 days (range = 53–205; USGS unpubl. data). Nesting density varies with habitat composition, averaging 6 ± 2 nests/100 hectares in māmane-dominated forest, and 4 ± 1 nests/100 hectares in mixed naio/māmane forest (USGS unpubl. data). Preferred nest sites are in forks near the ends of higher branches in medium to large māmane trees. Modal clutch size is 2 eggs (range 1 to 3). Eggs require 16 to 17 days to hatch, and nestlings fledge at 25 days (Pletschet and Kelley 1990). Palila may re-nest after failure, and some palila are able to successfully raise two broods during the same year. Palila are monogamous, but other adult males often help the pair by feeding the female and chicks (Pratt *et al.* 1997; Miller 1998).

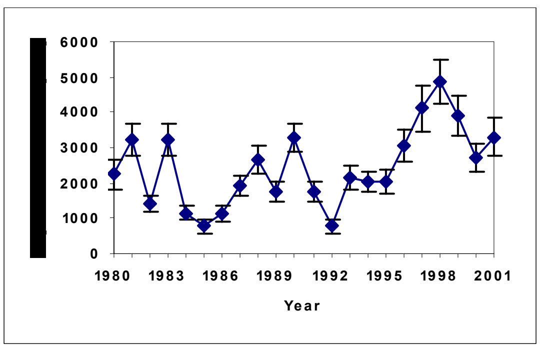

Figure 2. Palila Population Trend. Data from Paul Banko.

Primary Threats. Habitat loss and modification, avian disease, and predation by introduced mammals are thought to have caused the palila population to become endangered, and these factors continue to limit the palila population today (Scott *et al.* 1984, 1986; Jacobi *et al.* 1996, Pratt *et al.* 1997). Heavy browsing by feral sheep during the first decades of the 1900s effectively lowered tree line and reduced tree density in some areas on Mauna Kea (Bryan 1937, Scowcroft and Giffin 1983, Scott *et al.* 1984), and although the substantial populations of feral sheep were greatly reduced, ungulate browsing by feral sheep, goats, mouflon sheep (*Ovis musimon*), and browsing and rooting by feral pigs on Mauna Kea continues to negatively impact māmane trees and saplings and reduce habitat quality (USFWS 2005). Habitat modification by introduced nonnative plants and grasses and increased fire threat and introduced nonnative invertebrate species that eat native insects used as food by palila are also significant threats.

Recovery Strategy: The recovery strategy for the palila is to better understand and optimize management of threats, provide habitat protection within the entire current range, restore habitat, and increase the species' range by establishing additional viable populations on Mauna Kea and

Mauna Loa. The tools available for this work are population research, predator control using broad-scale methods, fencing and ungulate control, and captive propagation and release and translocation to reintroduce palila into areas of former range.

Interim Recovery Objectives. In order to meet the long-range recovery goals for palila, the following short-term goals should be accomplished first:

- Prevent any habitat loss in the core palila population on the southwest slope of Mauna Kea, and restore māmane/naio forest in adjacent areas on Mauna Kea and on Mauna Loa to allow expansion of the core population.
- Reduce the risk of catastrophic fire to the core population.
- Establish a second population in a disjunct area on Mauna Kea to decrease the risk from catastrophes.

If these objectives are met within five years, then new interim recovery objectives should be identified that will continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be examined and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is not considered effective, then a new strategy should be developed.

Recovery Actions. In order to realize the interim recovery objectives described above, the following actions are necessary:

- Protect Existing Habitat
  - Develop a comprehensive ungulate management plan for Mauna Kea including fencing and ungulate removal from palila critical habitat (DLNR/USFWS).
  - Continue/complete removal of feral ungulates from palila critical habitat on Mauna Kea (DLNR).
  - Fence and remove ungulates from māmane/naio forest (>6,000 acres) at Pu`u Lehua, North Kona (KS/USFWS).
  - Protect and restore māname/naio forest at Kanakaleonui on the east slope of Mauna Kea (DHHL/DLNR/USFWS).
  - Design and implement an effective fire-management plan for the Mauna Kea/Saddle Road area (USGS/DLNR/DOD)
  - Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone and importance of feral cat control (USGS/DLNR/USFWS).
  - Conduct large-scale rodent control by aerial broadcast of diphacinone in at least one site and monitor population and individual-level responses. Possible sites include Pu`u Mali and Pu`u Lehua (KS/USFWS/DLNR)
- Continue Research to Document Distribution, Threats, and Habitat Needs.
  - Continue basic research on palila biology and māmane/naio forest ecology (USGS).
  - Continue māmane phenology on Mauna Kea (USGS) and Pu`u Lehua area, North Kona (KS/USGS).
- Restore New Habitat.
  - Begin long-term restoration and management at Pu`u Mali (>5,000 acres) on the north slope of Mauna Kea for palila habitat (USGS/USFWS/DOFAW/FHWA).
- Continue to Develop Captive Propagation and Translocation Reintroduction Programs
  - Investigate best methods to re-establish wild palila populations by release of captive-raised birds and/or translocation (USGS/ZSSD).
  - Release captive bred or translocated birds into restored habitat. Continue releases of captive bred and translocated birds at Pu`u Mali and begin at least one additional release at Pu`u Lehua or Kanakaleonui if habitat is ready (USGS/ZSSD/USFWS/DLNR).

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APPENDIX I.

MAUI PARROTBILL FIVE-YEAR RECOVERY WORK PLAN

Prepared by Maui Parrotbill Working Group and Hawaiian Forest Bird Recovery Team

Male Maui Parrotbill. Photo © Eric VanderWerf

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the Maui parrotbill are provided in the Hawaiian Forest Bird Recovery Plan, which covers 21 species (USFWS 2005). The purpose of this five-year work plan is to identify interim recovery objectives for the Maui parrotbill that can be realized within five years, and to describe succinctly the actions needed to reach those interim objectives. Identification of interim recovery objectives will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, encourage efficient use of limited recovery resources, and provide milestones to track and evaluate progress toward recovery. Realization of these milestones will provide evidence of progress being made toward eventual recovery. Failure in realizing these milestones may indicate that additional resources are needed, or that the current recovery strategy is not effective.

Species Summary. The Maui parrotbill is an insectivorous Hawaiian honeycreeper that uses its massive hooked bill to dig, tear, crack, crush, and chisel the bark and wood on a variety of native shrubs and small to medium-sized trees, especially `ākala (*Rubus hawaiensis*), kanawao (*Broussaisia arguta*), and `ōhi`a (*Metrosideros polymorpha*). Parrotbills also pluck and bite open fruit in search of insects, particularly kanawao. Especially preferred are larvae and pupae of various beetles and moths (Perkins 1903, Mountainspring 1987, Simon *et al.* 1997). Maui parrotbills are socially monogamous, non-migratory, and defend year-round territories averaging 2.3 hectares (5.7 acres) in size (Pratt *et al.* 2001). However, the Maui Forest Bird Recovery Project recently found at least 18 individuals in a 12 hectare area and have documented dispersal over 1.5 km, suggesting there may be more movement and variation in sociobiology than currently realized (MFBRP unpubl. data). Parrotbills frequently occur in family groups, due to the prolonged dependency of fledglings on their parents (Simon *et al.* 1997).

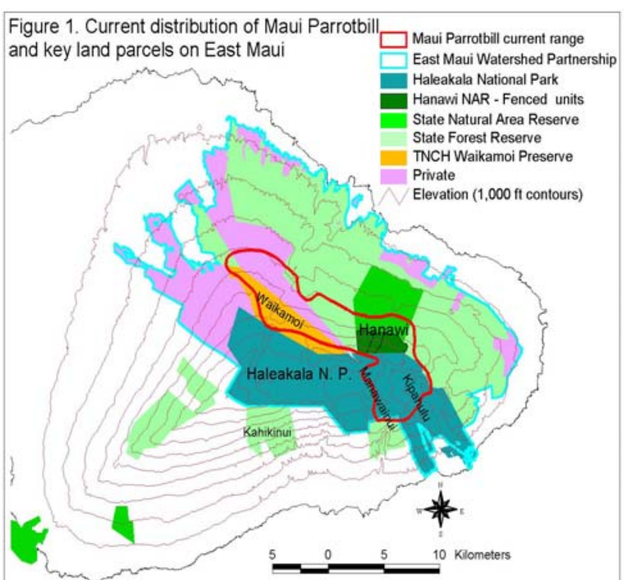

Figure 1. Current distribution of Maui Parrotbill and key land Parcels on East Maui.

The ecology of the Maui parrotbill has been little studied, but recently Lockwood *et al.* (1994) and Simon *et al.* (1997) investigated aspects of reproductive biology. The open cup nest is built by the female an average of 12 meters (40 feet) above the ground in a forked branch just inside the outer canopy foliage. Simon *et al.* (1997)

reported only single egg clutches, but there are reports of two-chick broods. Re-nesting occurs only after nest failures, and pairs will not raise more than one brood in a season. Development of the large bill and specialized feeding techniques proceed slowly, and fledgling dependency on parental care lasts 5 to 8 months.

Currently the Maui parrotbill is found only on Haleakalā Volcano in East Maui, in 50 square kilometers (19 square miles) of wet montane forests from 1,200 to 2,350 meters elevation (4,000 to 7,700 feet; Scott *et al.* 1986, Mountainspring 1987, Simon *et al.* 1997). The current range forms an arc from the Waikamoi Drainage west of Ko`olau gap to Haleakalā National Park lands in Kīpahulu Valley and the Manawainui Drainage (Figure 1). The current geographic range is much restricted compared to the known prehistoric range, which included dry leeward forests and low elevations (200 to 300 meters, 660 to 1,000 feet) on East Maui as well as Moloka`i, based on collections of subfossil bones (James and Olson 1991). Distribution and densities in the Waikamoi and Manawainui range edges are not well documented.

The number of Maui parrotbills was estimated to be 500 ± 230 (95 percent CI) birds at an average density of 10 birds per square kilometer (0.39 square miles) in 1980 by the Hawai`i Forest Bird Survey (Scott *et al.* 1986). Repeat surveys of the same transects conducted in 1992 (Hawai`i Department of Land and Natural Resources 1995) and limited surveys conducted from 1995 to 1997 by U.S. Geological Survey biologists indicated approximately the same densities of birds, but with perhaps some range constriction at lower elevations.

A captive propagation program has successfully bred, hatched and reared Maui parrotbill, both from wild collected eggs and from pairs established in captivity, and anticipates producing enough offspring to provide the cohorts necessary for pilot releases (The Peregrine Fund and ZSSD 2000; Kuehler, *et al.* 2001; ZSSD 2002, 2003).

Primary Threats. Maui parrotbill are restricted to higher elevation forests due to the presence of mosquito-borne diseases at lower elevations, and are restricted at upper elevations due to destruction of forest habitat. Within their present range, the factors that limit densities are not well known. Feral cats (*Felis catus*) and Barn Owls (*Tyto alba)* are known to prey on birds at Hanawī (Kowalsky *et al.* 2002), and black (*Rattus rattus*) and Polynesian (*R. exulans*) rats, both of which are serious predators on adults and nests of other Hawaiian forest birds, are abundant in parrotbill habitat (Malcolm *et al.* 2002), but direct evidence of predation on parrotbills is lacking and recent work suggests that predation rates may be low (Sparklin *et al.* in prep.) and that the population may be limited by food availability (Simon *et al.* 2000). Maui parrotbills were reported to strongly favor koa for foraging (Perkins 1903). Widespread habitat destruction from logging and ranching has greatly reduced parrotbill range, and has been particularly severe in more mesic areas that formerly supported high densities of koa. The current range is restricted to wet forest areas in which koa densities are relatively low. Habitat within the current range thus may be suboptimal compared to portions of the former range. Within its current range, habitat damage by feral pigs to the understory vegetation may be a significant factor contributing to reduced food availability, large territories, and low reproduction. Similar impacts in unoccupied potential habitat may make those areas unsuitable for reestablishment of parrotbill. Habitat degradation and marginal suitability may exacerbate the negative effects of severe weather events such as rainstorms, which are common in East Maui and have been linked to failure of parrotbill nests (Mountainspring 1987, Simon *et al.* 2000).

Recovery Strategy. The recovery strategy for the Maui parrotbill is to better understand and optimize management of threats to population stability, to provide habitat protection within the entire current range, and to increase its range and establish a second viable population. The tools available for this work are population research, predator control using broad-scale methods, fencing and ungulate control, and captive propagation and reintroduction.

Interim Recovery Objectives. In order to meet the long-range recovery goals for the Maui parrotbill the following short-term goals should be accomplished first.

- Maintain Existing Stable Population.
- Increase Distribution and Abundance of Existing Population.

- Begin habitat protection and restoration work to secure >1200 acres of koa forest habitat at Kahikinui (see map above).

If these objectives are met within five years, then new interim recovery objectives will be identified to continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy will be developed and new actions identified.

Five-year Recovery Actions (2004-2008). In order to realize the interim recovery objectives described above, the following actions are necessary:

- Protect Existing Habitat
  - Maintain existing fences in Hanawī NAR, Waikamoi, and Haleakalā National Park (NPS, USFWS, TNC, and DOFAW).
  - Complete fencing of lower Hanawī NAR (EMWP).
  - Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone (USFWS/DOFAW).
  - Conduct large-scale rodent control by aerial broadcast of diphacinone in at least one site and monitor population and individual-level responses. Possible sites include Hanawī and Kīpahulu Valley.
- Continue research to document distribution, ecology, threats, and habitat and management needs.
  - Complete long-term population trend analysis and habitat suitability modeling (Interagency Database Project, USFWS, NPS, DOFAW, and BRD).
  - Investigate movement patterns of adults and dispersal of juveniles through mist-netting, resighting, and radio tracking.
  - Document and publish response of Maui parrotbill distribution to habitat protection in Kīpahulu Valley.
  - Complete surveys in the Waikamoi and Manawainui areas (MFBRP/USFWS/DOFAW/NPS).
  - Carry out habitat use research in the Manawainui area (NPS).
  - Complete pilot nest predation study in Hanawī NAR (MFBRP/USFWS/DOFAW).
- Restore New Habitat
  - Complete fencing and ungulate eradication of DOFAW Kahikinui parcel TMK# 218001009 and portions of DHHL parcels TMKs 219001011, 219001007, and 219001003 west of Kahikinui (see Fig. 1). Begin outplanting of koa and understory species in select areas. The community group LIFE holds a 20-year lease on the DHHL parcel and is currently fencing portions of the parcel for the purpose of restoration. Once restored, these parcels will together provide approximately 1200 acres of protected koa forest habitat. DOFAW and USFWS are currently funding this work.
  - Support the formation of a Leeward Maui Watershed Partnership.
- Develop a Captive Propagation and Reintroduction Program.
  - Continue captive propagation and optimization of methods.
  - Assess suitability of potential release sites in Waikamoi and Manawainui.
  - Conduct two years of experimental releases into suitable habitat to develop and optimize reintroduction methods.

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APPENDIX J.

`AKIAPŌLĀ`AU FIVE-YEAR RECOVERY WORK PLAN

Prepared by Akiapōlā`au Working Group and Hawaiian Forest Bird Recovery Team

Male `Akiapōlā`au. Photo © Eric VanderWerf

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for `akiapōlā`au are provided in the Final Revised Recovery Plan for Hawaiian Forest Birds, which covers 21 species (USFWS 2005). The purpose of this five-year work plan is to identify interim recovery objectives for `akiapōlā`au, that can be realized within five years, and to succinctly describe the actions needed to reach those interim objectives. Identification of interim recovery objectives will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, encourage efficient use of limited recovery resources, and provide milestones to track and evaluate progress toward recovery. Realization of these milestones will provide evidence that progress is being made toward eventual recovery. Failure in realizing these milestones may indicate that additional effort and funding are needed, or that the current recovery strategy is not effective.

Species Summary. The `akiapōlā`au is a specialized insectivorous Hawaiian honeycreeper that uses its unusual dimorphic bill as two tools deployed separately or together to extract insect larvae and spiders from crevices or insect borings (Pratt *et al.* 2001). Moth larvae are the most common food item in `akiapōlā`au fecal samples, followed by spiders and long-horned beetle larvae (Ralph and Fancy 1996). Lichen-covered and dead branches are preferred as foraging substrates. Tree species preferred for foraging include koa (*Acacia koa*), kōlea (*Myrsine* spp.), māmane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*), while `ōhi`a (*Metrosideros polymorpha*) is not favored. This species also takes sap from small wells it drills in the bark of `ōhi`a trees. It is not clear how these sap trees are selected, and the prevalence of this behavior and the importance of this nutritional source are not known. `Akiapōlā`au often join mixed species foraging flocks. Home range size varies from approximately 5 to 40 hectares (12 to 100 acres). The factors that influence the range in territory size, and therefore population size, are unknown. Recently, `akiapōlā`au have been observed foraging and nesting in young koa plantations (L. Pejchar, unpubl. data), suggesting that this species may not be restricted to old growth as previously assumed. `Akiapōlā`au also inhabited wet montane forest dominated by `ōhi`a, with no koa. Some birds are still found in that habitat at middle elevations in Hāmākua. `Akiapōlā`au are found in

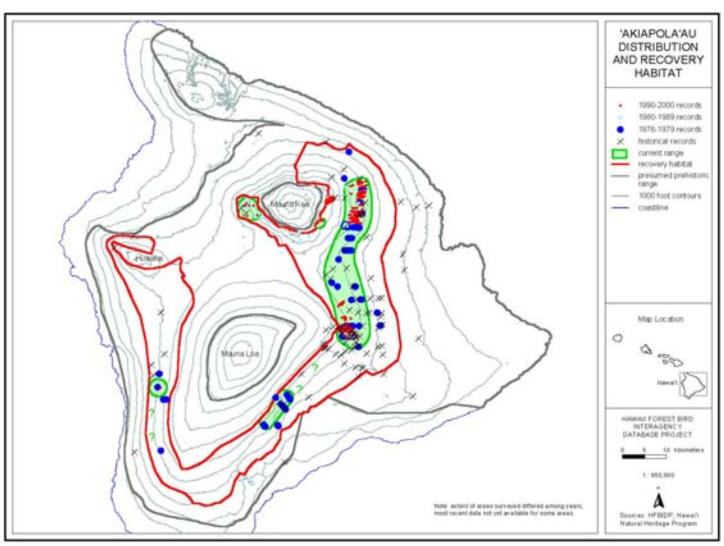

Figure 1. `Akiapōlā`au Distribution and Recovery Area

four disjunct populations inhabiting koa-dominated montane forests (Hāmākua south across the upper Waiākea kīpuka to Kūlani and Keauhou, in Ka`ū and Kapāpala, in southern Kona, and in central Kona; Figure 1). Until recently, a fifth population occupied subalpine dry forest on Mauna Kea. Originally these populations were all connected, but they have been isolated mainly because of loss of forest habitat due to the grazing. The current population estimate, based on surveys in 1990 to 1995, is 1,163 birds, with a 90 percent confidence interval of 1,109 to 1,217 birds (Fancy *et al.* 1995).

Primary Threats. `Akiapōlā`au are apparently restricted to higher elevation forests due to the presence of mosquito-borne diseases at lower elevations (van Riper *et al.* 1986, Atkinson *et al.* 1995), and are restricted at upper elevations due to destruction and degradation of forest habitat (Scott *et al.* 1986). Habitat fragmentation may isolate the remaining populations, decrease the effective population size, and hinder recolonization of areas that were formerly inhabited. Within their present range, the factors that limit densities are not well known. Predation by introduced mammals and owls may play a role, but direct evidence for this is scarce. Recent surveys indicate rat densities are high at Hakalau Forest National Wildlife Refuge, which contains a significant portion of the largest remaining `akiapōlā`au population (Lindsey *et al.* 1999). Juvenile `akiapōlā`au may be especially vulnerable to predators during the post-fledging period because their loud, persistent begging call makes them easy to locate. Predation may impact `akiapōlā`au more than other native birds because of their low reproductive rate (Ralph and Fancy 1996). Habitat degradation and food availability also may limit populations within their current range. Habitat within most of the current range of `akiapōlā`au has experienced significant degradation of canopy and understory structure.

Recovery Strategy. The recovery strategy for the `akiapōlā`au is to better understand its habitat use and needs in order to optimize habitat and threat management, to provide habitat protection within the entire current range, and to increase its range. The tools available for this work are population research, predator control using broad-scale methods, fencing and ungulate control, and captive propagation and reintroduction.

Interim Recovery Objectives. In order to meet the long-range recovery goals for `akiapōlā`au the following short-term goals should be accomplished first.

- Maintain Stable Existing Populations
- Increase Distribution and Abundance of Existing Populations
- Establish New Population(s)

If these actions are met within five years, then new interim recovery objectives will be identified to guide progress toward full recovery. If these actions are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy should be developed and new actions identified.

Five-year Recovery Actions (2004-2008). In order to realize the interim recovery objectives described above, the following actions are necessary:

- Protect Existing Habitat
  - Maintain existing fences and ungulate control in Hakalau Forest National Wildlife Refuge, Keauhou, and Kapāpala.
  - Repair fences and maintain ungulate control at Pu`u Wa`awa`a (currently funded by USFWS and DOFAW).
  - Fence additional areas and remove ungulates in Waiākea kīpuka to Kūlani and Keauhou, Ka`ū and Kapāpala, and southern and central Kona.
  - Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone.

- Conduct large-scale rodent control by aerial broadcast of diphacinone in at least one site and monitor population and individual-level responses. Possible sites include Hakalau, Keauhou, and Kapāpala.
- Continue research to document distribution, threats, and habitat needs.
  - Complete habitat use research at Hakalau, Keauhou, and Kapāpala (currently funded by DOFAW and UC Santa Cruz) in old and new growth forests.
  - Begin comparative demography study in forests of different age and structure.
  - Begin food availability study in forests of different age and structure, drawing from results from comparative habitat use study.
  - Complete intensive surveys in the Kapāpala area (currently funded by DOFAW, USFWS, and BRD).
  - Carry out surveys in Pu`u Wa`awa`a and south and central Kona.
  - Complete long-term population trend analysis and habitat suitability modeling (currently funded by USFWS, NPS, DOFAW, and BRD)
- Restore New Habitat
  - Continue reforestation of upper Hakalau and adjacent DHHL lands.
  - Continue reforestation of Kamehameha Schools lands in Keauhou.
  - Begin restoration at Pu`u Mali and Ka`ohe (currently funded by DOFAW and USFWS).
- Develop a Captive Propagation and Reintroduction Program.
  - Begin captive propagation and optimization of methods.
  - Assess suitability and select release sites.
  - Conduct two years of experimental releases into suitable habitat to develop and optimize reintroduction methods.

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APPENDIX K.

PO`OULI FIVE-YEAR RECOVERY WORK PLAN

Prepared by Po`ouli Working Group and Hawaiian Forest Bird Recovery Team

Po`ouli. Photo by Paul Baker, Maui Forest Bird Recovery Project.

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the po`ouli are provided in the Final Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2005), which covers 21 species. The purpose of this five-year work plan is to identify interim recovery objectives for the po`ouli, and to succinctly describe the actions needed in the next five years to reach those interim objectives. Identification of interim recovery objectives will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, encourage efficient use of limited recovery resources, and provide milestones to track and evaluate progress toward recovery. Realization of these milestones will measure progress being made toward eventual recovery. Failure in realizing these milestones may indicate that additional resources are needed, or that the current recovery strategy is not effective.

Species Summary. The po`ouli (*Melamprosops phaeosoma*) is a critically endangered Hawaiian honeycreeper, and is perhaps the rarest bird in the world, with only three known individuals (Baker 2001). It is a stocky, medium-sized (26 g), bird with short wings, a short tail, stout legs, and a short straight bill, and is easily recognized by its gray crown, white cheek patch, and black "lone ranger" mask (Baker 1998). Remarkably, the po`ouli was apparently unknown to the Hawaiians and was first discovered in 1973 (Casey and Jacobi 1974). Morphological and genetic evidence indicates that the po`ouli forms a unique lineage within the Hawaiian honeycreepers, and it comprises its own monotypic genus (Fleischer *et al.* 2001). Only two nests of the po`ouli have ever been found, in March and April 1986, both from the same pair (Kepler *et al.* 1996). The second nest successfully fledged one of the two young, which spent 21 days in the nest. The female alone incubated the eggs and brooded the chicks, but both parents fed the chicks. Both nests were an open cup composed of twigs and mosses and lined with thin fern rootlets (Engilis *et al.* 1996), and were hidden among the foliage 8 meters (26 feet) high in tall `ōhi`a trees (Kepler *et al.* 1996). Po`ouli forage by gleaning, probing, and excavating for small invertebrate prey in moss, lichen, and bark, primarily in the subcanopy and understory. They seem to prefer kanawao (*Broussaisia arguta*), kāwa`u (*Ilex anomala*), and `ōhi`a as foraging

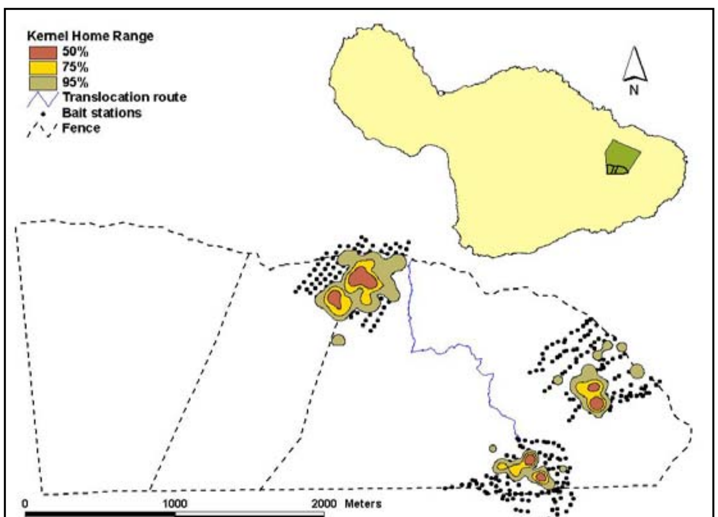

Figure 1. Location of Po`ouli home ranges in Hanawī NAR. Map by Bill Sparklin, Maui Forest Bird Recovery Project.

substrates (Mountainspring *et al.* 1990, Pratt *et al.* 1997). Prey consist mainly of native snails, adult and larval beetles, and Lepidoptera larvae (Baldwin and Casey 1983, Mountainspring *et al.* 1990, Kepler *et al.* 1996). Po`ouli often associate with mixed-species foraging flocks of other insectivorous honeycreepers, especially Maui parrotbills (*Pseudonestor xanthophrys*) and Maui `alauahio (*Paroreomyza montana*). Po`ouli are unusually quiet, and their calls closely resemble parrotbills calls. Female po`ouli have been seen interacting with and even feeding juvenile parrotbills (T. Malcolm pers. obs.).

Historically, po`ouli have been confined to a 1,300 hectare (3,200 acre) area of wet montane forest on the northern and eastern slopes of Haleakalā (Mountainspring *et al.* 1990), but fossil evidence indicates po`ouli once inhabited drier forests at lower elevation on the leeward slope of Haleakalā (James and Olson 1991). The population was estimated at 140 ± 280 (Scott *et al.* 1986), but estimates of population size and density are imprecise because of the species' low density and cryptic behavior. Numbers and range declined from 1976-1985 (Mountainspring *et al.* 1990), and surveys in 1994-1995 found six po`ouli at four locations, while surveys from 1997-2000 located only three birds (Reynolds and Snetsinger 2001). No other po`ouli have been located since these three birds were color-banded in 1997 and 1998 (Hawai`i DLNR, unpubl. data). The last three birds, thought to consist of one male and two females, occur in separate, non-overlapping home ranges between 1,500 meters (5,000 feet) and 1,950 meters (6,500 feet) elevation in Hanawī Natural Area Reserve (Figure 1). There are no known breeding pairs, and the last documented reproduction occurred in 1995 (Reynolds and Snetsinger 2001). Conservation efforts for the po`ouli have included creation of the 3,035 ha (7,500 acre) Hanawī Natural Area Reserve to provide additional protection for lands encompassing the known range; fencing of 800 ha (2000 acres) in the upper portion of Hanawī by 1996 and removal of all ungulates by 1997 (Bill Evanson, Maui DOFAW, pers. comm.); protection of adjacent forest through acquisition and protection of lands by the National Park Service and formation of the East Maui Watershed Partnership; and ground-based predator control in the home ranges of the three known birds (Malcolm *et al.* 2002). Ecological and life-history research was carried out under the direction of the USGS-Biological Resources Discipline during 1994-1996 (Baker 2001).

Primary Threats. The range of the po`ouli coincides with high population densities of other honeycreeper species, a distribution believed to be delimited by suitable habitat and disease-bearing mosquitoes prevalent at elevations below 1,500 meters (5,000 feet; Scott *et al.* 1986). Po`ouli are associated with low levels of disturbance to soil and vegetation by feral pigs, and habitat damage by feral pigs is thought to be an important cause of the decline in po`ouli numbers (Mountainspring *et al.* 1990). Other threats have not been directly linked to the po`ouli, but both black and Polynesian rats are abundant in po`ouli habitat (Malcolm *et al.* 2002), and these animals are known to prey on adults and nests of other Hawaiian forest birds and also on native land snails, which are an important food for the po`ouli (Baldwin and Casey 1983).

Recovery Strategy. Alternative strategies for recovery of the po`ouli were outlined previously in an Environmental Assessment (USFWS and Hawai`i DLNR 1999). Based on that EA and subsequent public comments, it was decided that the best strategy was continued habitat management, including predator control, in conjunction with translocation of a female into the home range of the last male, in hopes that they would form a breeding pair and nest. That translocation was successfully carried out in April of 2002, but the translocated female subsequently returned to her own home range after one day (Groombridge *et al.* 2002, 2003). Although no breeding pair was created by the translocation, the female showed signs of potential positive acclimation to captivity, reacting passively to its holding cage and readily consuming food items including a native *Succinea* snail and several waxworms (Groombridge *et al.* 2002, 2003).

With a known population of only three birds, the last documented breeding of po`ouli in 1995, and no known breeding pairs, the most urgent aspect of the recovery strategy for the po`ouli must be to facilitate pair formation and reproduction among the three known individuals (VanderWerf *et al.* 2003). The various recovery strategies for achieving this goal were revisited in June of 2002 by the Po`ouli Recovery Working Group, which consists of representatives from the USFWS, Hawai`i DOFAW, Hawai`i NARS, Hawaiian Forest Bird Recovery Team, the Zoological Society of San Diego, the Maui Forest Bird Recovery Project, and the University of Hawai`i. It was not possible to arrive at a strategy that was unanimously supported, but two options had broad support; capture of all three birds and removal to captivity, and capture of all three birds and placement in a field aviary. These strategies may be equally viable and both were considered to have advantages and disadvantages, but in November 2002 the USFWS and Hawaii DOFAW decided that removal to captivity was preferable because that option could be implemented more quickly, which is important due to the advanced ages of the birds and their unknown lifespan, and provided greater ability to ensure the safety of the birds from severe weather, predators, and vandals (VanderWerf *et al.* 2003). The ZSSD agreed subsequently with reservations to undertake care and attempt captive propagation of the po`ouli at the Maui Bird Conservation Center (ZSSD 2002). A series of trips from February-April 2003 failed to catch any of the three known birds for removal to captivity. Another series of trips is scheduled for October-December 2003.

The ultimate goal of recovery efforts is to release offspring of the remaining birds back into the wild and restore a self-sustaining wild population. It is therefore extremely important that the species' habitat continue to be protected and managed to ensure that reintroduction to the wild remains an option. Although much of the suitable habitat on east Maui has been surveyed for po`ouli (Reynolds and Snetsinger 2001), it is difficult to say with certainty that no more than three birds exist due to the rugged terrain and cryptic nature of the species. Continued habitat protection and management also may benefit any wild po`ouli that have not been located and are not part of captive propagation efforts. The scale of management should be increased through actions such as additional fencing, ungulate control, and aerial broadcast of diphacinone to control rats. Surveys for additional wild po`ouli should be undertaken in order to provide more options for recovery.

In the event of a death of a po`ouli, various tissues should be collected for cell culture and possible future cloning, and immediately sent to both the Zoological Society of San Diego Center for the Reproduction of Endangered Species and the Audubon Nature Institute Center for Research on Endangered Species.

Interim Recovery Objectives. In order to meet the long-range recovery goals for the po`ouli, the following short-term goals should be accomplished first.

- Facilitate production of at least one young po`ouli.
- Conduct large-scale rodent control at Hanawī NAR by aerial broadcast of diphacinone.
- Complete fencing of lower Hanawī NAR and adjacent areas.
- Locate any additional wild po`ouli through additional surveys.

If these objectives are met within five years, then new interim recovery objectives will be identified to continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy will be developed and new actions identified.

Five-year Recovery Actions (2004-2008). In order to realize the interim recovery objectives described above, the following actions are necessary:

- Facilitate production of at least one young po`ouli.
  - Safely capture remaining birds and transport them to MBCC.
  - Acclimate birds to captivity and get them to eat supplemental food.
  - Use captive breeding techniques to facilitate pair formation and breeding.
  - If reproduction does not occur in captivity after 30 months, consider moving birds to an outdoor aviary in a more natural setting. Possible sites include Waikamoi and Hanawī.
- Protect and Manage Existing Habitat.

- Maintain existing fences in Hanawī NAR, Waikamoi, and Haleakalā National Park (currently funded by NPS, USFWS, TNC, and DLNR).
- Complete fencing of lower Hanawī NAR and adjacent areas (in progress by EMWP).
- Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone.
- Conduct large-scale rodent control by aerial broadcast of diphacinone in Hanawī and monitor population and individual-level responses of the avian community.

- Conduct surveys to locate additional wild po`ouli. Areas to survey include Hanawī, Haleakalā National Park, and State Forest Reserves.
- Collect indeterminate germ cells from all three birds to establish cell cultures for use in possible future cloning.

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APPENDIX L.

`ĀKOHEKOHE FIVE-YEAR RECOVERY WORK PLAN

Prepared by `Ākohekohe Working Group and Hawaiian Forest Bird Recovery Team

Adult `Ākohekohe. Photo © Eric VanderWerf

Purpose. The long-term recovery goals, delisting criteria, recovery strategy, and a comprehensive list of recovery tasks for the `Ākohekohe are provided in the Hawaiian Forest Bird Recovery Plan, which covers 21 species (USFWS 2004). The purpose of this five-year work plan is to identify interim recovery objectives for the `Ākohekohe, and to succinctly describe the actions needed in the next five years to reach those interim objectives. Identification of interim recovery objectives and actions will help ensure that initial conservation efforts by different agencies or groups are focused on the same ultimate goals, facilitate efficient use of limited recovery resources, and provide milestones that can be used to track and evaluate progress toward recovery. Realization of these milestones will provide evidence of progress toward eventual recovery. Failure in realizing these milestones may indicate that additional resources are needed, or that the current recovery strategy is not effective.

Species Summary. The `Ākohekohe, or crested honeycreeper (*Palmeria dolei*), is a primarily nectarivorous Hawaiian honeycreeper that also feeds on caterpillars (Lepidoptera), spiders, and other arthropods (Perkins 1903, Carothers 1986, Berlin and VanGelder 1999). Nectar is primarily sought from flowers of `ōhi`a (*Metrosideros polymorpha*), but also from several subcanopy tree and shrub species (Berlin and VanGelder 1999, Berlin *et al.* 2001). Insects are taken mostly by gleaning `ōhi`a foliage, buds, and flower clusters (Berlin and VanGelder 1999). `Ākohekohe are highly aggressive and dominate resources over other nectarivorous birds (Carothers 1986).

`Ākohekohe defend relatively discrete feeding and nesting territories throughout the year by chasing and calling (VanGelder and Smith 2001, Pratt *et al.* 2001). The species appears to be monogamous for more than one breeding season, with pair formation starting in October, nesting occurring mainly between November and May, and some pairs raising two to three successful broods in a season (VanGelder and Smith 2001). They begin breeding by their second year (Simon *et. al*. 2001). `Ākohekohe nests were an average of 14 meters (46 feet) above ground in the terminal ends of branches below the canopy foliage of `ōhi`a trees (Berlin and VanGelder 1999, VanGelder and Smith 2001). The open cup nest is built by the female, who lays one to two eggs. Incubation by the female lasts 17 days, and the chicks fledge after 3 to 4 weeks. Chicks can forage independently after 10 to 14 days, or longer when the chicks are from the last brood of the season (Berlin and VanGelder 1999). Independent juveniles flock in small groups and disperse to the edge of the species' range (Scott *et al.* 1986). Weather appears to be the most important factor in nest success, which is thus highly variable from year to year (36 - 87 percent success rate) (Simon *et. al*. 2001, VanGelder and Smith 2001). Vocalizations of the `Ākohekohe include various guttural clucking gurgles, raspy croaks, buzzing sounds, and clear upslurred whistles (Perkins 1903, VanGelder 1996, Berlin and VanGelder 1999).

`Ākohekohe currently are found only in 58 square kilometers (22 square miles) of wet and mesic montane forest dominated by `ōhi`a (*Metrosideros polymorpha*) on the northeastern slope of Haleakalā Volcano in east Maui. Their elevational range has been reported to be 1,100 to 2,300 meters elevation (3,600 and 7,550 feet), but nearly all birds occur from 1,500 to 2,100 meters (5,000 to 6,600 feet), with some nonbreeding birds wandering further down slope (Conant 1981, Scott *et al.* 1986, Hawai'i Division of Forestry and Wildlife unpubl. data). `Ākohekohe occur from just west of the Waikamoi Drainage in the Nature Conservancy's Waikamoi Preserve east through the Ko`olau and Hāna Forest Reserves and around to Haleakalā National Park lands in Kīpahulu Valley and southeast of Kuiki to Manawainui Valley. The current geographic range is much restricted compared to the known historical range, which also included native wet forests of the island of Moloka`i (Perkins 1903, Banko 1987). On Moloka`I the species was not known to have survived later than 1907, and was found at 1,200 meters (4,000 feet) on the high forested plateau between Wailau and Pelekunu valleys (Bryan 1908). On Maui, the species was first collected in the 1890's on the western slopes of Kula in mesic koa (*Acacia koa*)/`ōhi`a forest, but by 1920 it was already absent due to deforestation caused by logging and cattle-ranching. `Ākohekohe now inhabit only 5 percent of the estimated historical range of 1,015 square kilometers (385 square miles) on Maui and none of the 262 square kilometers (100 square miles) on Moloka`i Island (Scott *et al.* 1986). Fossil bones found in caves at low elevation on the southwestern slopes of Haleakalā suggest the species once inhabited very different dry forest habitat at much lower elevations (James and Olson 1991).

The total number of `ākohekohe was estimated to be 3,800 ± 700 (95 percent confidence interval) birds in 1980 by the Hawai`i Forest Bird Survey (Scott *et al.* 1986). Surveys of the same transects in 1992 (Hawai'i Department of Land and Natural Resources 1995) and limited surveys 1995 to 1997 by U.S. Geological Survey biologists indicated approximately the same densities of birds within the same range. `Ākohekohe adults show high site tenacity, which may be expected from a behaviorally dominant nectivore (Pratt *et. al.* 2001). In addition, adult survivorship in Hanawi over a three year period was high (95%; Simon *et .al.* 2001).

Primary Threats. `Ākohekohe are restricted to higher elevation forests due to the presence of mosquito-borne diseases at lower elevations, and are restricted at upper elevations in some areas by destruction of forest habitat. `Ākohekohe may be particularly vulnerable to mosquito-borne diseases because they migrate altitudinally in response to varying `ohi`a flowering phenology, potentially increasing their exposure to mosquitoes at lower elevations. Avian malaria was recently isolated from an `ākohekohe in Hanawī Natural Area Reserve (Feldman *et al.* 1995). Laboratory challenge experiments have shown that the `i`iwi (*Vestiaria coccinea*), which is closely related to the `ākohekohe but is more common and has a wider distribution, is extremely vulnerable to avian malaria, with 90 percent of experimental birds dying after being bitten by infected mosquitoes (Atkinson *et al.* 1995). Black and Polynesian rats are serious predators on adults and nests of Hawaiian forest birds and are abundant in `Ākohekohe habitat (Sugihara 1997, Malcolm *et al.* 2002), and Simon *et al.* (2001) found rat predation on an `Ākohekohe adult and egg, as evidenced by rat droppings and bird remains in the nest. The remains of an `Ākohekohe were found in a Barn Owl pellet from Hanawi, and feral cat scats also contained remains of other native forest birds (Kowalsky *et al.* 2002). Damage by feral pigs to understory vegetation may deplete nectar resources needed during times of year when `ōhi`a bloom is less available.

Conservation Efforts. Conservation efforts for the `Ākohekohe have included creation of the 3,035 ha (7,500 acre) Hanawi Natural Area Reserve in 1986; fencing of 800 ha (2000 acres) in the upper portion of Hanawi by 1996 and removal of all ungulates by 1997 (Bill Evanson, Maui DOFAW, pers. comm.); protection of adjacent forest through acquisition and management of lands by the National Park Service and formation of the East Maui Watershed Partnership (DLNR 1996). Ecological and life history research has been conducted since 1992 (Simon *et al.* 1998, 2001; Berlin *et al.* 2001; Pratt *et al.* 2001; VanGelder and Smith 2001).

Recovery Strategy. The recovery strategy for the 'Ākohekohe is to protect habitat within the entire current range, increase the amount of suitable habitat and establish a second viable population, and to better understand threats to the species in order to optimize management methods. The tools available for this work are fencing and ungulate control, predator control using broad-scale methods, population research, and translocations. Captive propagation and reintroduction are also an option, but initial attempts at getting birds to breed in captivity were unsuccessful due to the aggressive nature of this species (ZSSD 2001).

Interim Recovery Objectives. In order to meet the long-range recovery goals for the 'Ākohekohe the following short-term goals should be accomplished first.

- Maintain the existing population, which appears to be stable.
- Increase the size and distribution of the existing population, particularly in leeward east Maui.
- Determine habitat suitability and disease status of West Maui and Molokai for establishment of a second population.

If these objectives are met within five years, then new interim recovery objectives will be identified to continue to guide progress toward full recovery. If these objectives are not met within five years, then the causes for failure should be identified and rectified if possible. If it is not possible to correct the causes for failure and the current strategy is deemed ineffective, then a new strategy will be developed and new actions identified.

Five-year Recovery Actions (2003-2007). In order to realize the interim recovery objectives described above, the following actions are needed.

- Protect Existing Habitat.
    - Maintain existing fences in Hanawi NAR, Waikamoi, and Haleakalā National Park (NPS, FWS, TNC, and DOFAW).
    - Complete fencing of lower Hanawi NAR (EMWP).
    - Begin public outreach about importance and benefits of controlling rodents and safety of diphacinone (FWS/DOFAW).
    - Conduct large-scale rodent control by aerial broadcast of diphacinone in at least one site and monitor population and individual-level responses. Possible sites include Hanawi and Kipahulu.
- Continue research to document distribution, threats, and management needs.
    - Complete population trend and distribution analysis and habitat suitability modeling (Interagency Database Project, BRD, FWS, NPS, DOFAW).
    - Document distribution in the Waikamoi and Manawainui areas (MFBRP, FWS, DOFAW, NPS).
    - Further document effects of ungulate removal and predator control on demography in Hanawi NAR (MFBRP, FWS, DOFAW).
    - Investigate disease prevalence and dispersal and altitudinal migration as a mechanism of exposure to mosquito borne disease.
- Investigate/Improve Habitat Suitability in West Maui, leeward East Maui and Moloka`i.
    - Follow-up on `I`iwi translocation to West Maui if possible, including survival and dispersal.
    - Continue fencing and removal of ungulates from potentially suitable habitat on West Maui, leeward East Maui, and Moloka`i (TNCH, Maui Land and Pine, Hawaii DLNR, NPS).
    - Monitor mosquito abundance, disease prevalence, and `ohi`a flowering phenology to determine readiness for translocation.
    - Support the formation of a Leeward Maui Watershed Partnership and local habitat restoration efforts.

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