U.S. Fish & Wildlife Service

Draft Revised Recovery Plan for Hawaiian Forest Birds

DRAFT REVISED RECOVERY PLAN

FOR

HAWAIIAN FOREST BIRDS

August 2003

Original plans completed:

February 3, 1983 (Hawaii Forest Birds)
July 29, 1983 (Kauai Forest Birds)
May 30, 1984 (Maui-Molokai Forest Birds)
June 27, 1986 (Palila)

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

Approved: ____
Regional Director, U.S. Fish and Wildlife Service

Date: ____

Dedication

To the naturalists and scientists of Hawai`i

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 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 are needed throughout all recovery habitat 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 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 information on 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 recovery habitat on each of the main Hawaiian Islands where they occur, criteria used to delineate the recovery habitat 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 Action 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 Hawaii by Pukui *et al.* (1976).

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

Section 4(f) of the Endangered Species Act (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 (Service) and the NOAA Fisheries have been delegated the responsibility of administering the 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 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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U.S. Fish and Wildlife Service. 2003. Draft Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, OR. 428 pp.

This plan may be viewed on the U.S. Fish and Wildlife Service Region 1 website:
http://www.r1.fws.gov/ecoservices/endangered/recovery/default.htm

ACKNOWLEDGEMENTS

The recovery planning process for Hawaiian forest birds has benefited from the collaboration, advice, and assistance of many individuals over the past several years. We thank Rick Camp and Marcos Gorreson for producing maps of recovery habitat and species distributions and updated status reports on Hawaiian forest birds; and Thomas Smith, former member of the Hawaiian Forest Bird Recovery Team, who helped write an earlier draft of the Rare Bird Discovery Protocol and participated in early discussions of recovery criteria. We also thank the following people for their assistance (U.S. Fish and Wildlife Service Ecological Services staff italicized), and apologize to anyone who was omitted from this list inadvertently: Jamie Bruch, Jeff Burgett, *Earl Campbell*, Jim Groombridge, *Paul Henson*, Christina Hermann, *Scott Johnston*, Carl Jones, David Ledig, Greg Massey, *Mark Metevier*, Patrick Morris, Cathleen Natividad, Michelle Reynolds, Bruce Rideout, *Karen Rosa*, *Craig Rowland*, *Ron Salz*, *Carol Schuler*, Tom Snetsinger, Valerie Stein, Carol Terry, and Thierry Work.

We also thank the following agencies and organizations for their assistance: the Hawai`i Department of Land and Natural Resources, Division of Forestry and Wildlife; Kamehameha Schools; the University of Hawai`i; U.S. Army Garrison, Pōhakuloa Training Area; the U.S. Geological Survey, Biological Resources Division and Pacific Cooperative Studies Unit; The Nature Conservancy of Hawai`i; the Secretariat for Conservation Biology; the Zoological Society of San Diego; and The Peregrine Fund.

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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 species, and 1 is a species of concern. Ten of the listed taxa have not been observed reliably in more than 10 years and may be extinct, including the Maui nuku pu`u (*Hemignathus lucidus affinis*); Kaua`i nuku pu`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 with only three individuals known to exist despite intensive surveys. 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) to 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 probably is extinct. The candidate species, the `akikiki or Kaua`i creeper (*Oreomystis bairdi*), has an estimated population of 2,000 to 3,000 individuals.

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 at elevations as low as 100 meters (330 feet) in nonnative forests on O`ahu. Sub-fossil 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 and O`ahu `alauahio or O`ahu creeper. The `io or Hawaiian hawk (*Buteo solitarius*) and the `alalā or Hawaiian crow (*Corvus hawaiiensis*) also are federally listed Hawaiian forest birds. The `Io has its own recovery plan (U.S. Fish and Wildlife Service 1984b). A revised recovery plan for the `alalā is in preparation. 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 benefit the `alalā and `io, which utilize many of the same habitat areas on the island of Hawai`i as forest birds on Hawai`i described in this plan.

Five Primary Threats to Species Recovery: We consider five major threats to a taxon in order to list, delist, or reclassify the taxon. These are: A) Present or threatened destruction, modification, or curtailment of habitat or range; B) Over-utilization for commercial, recreational, scientific, or educational purposes; C) Disease or predation; D) Inadequacies of existing regulatory mechanisms; and E) Other natural or man-made factors affecting the continued existence of a species. Recovery actions in this recovery plan address these threats in order to achieve recovery objectives.

The principle threats to Hawaiian forest birds are habitat loss and degradation by agriculture, urbanization, grazing by cattle, browsing by introduced ungulate species, timber harvest, predation by alien rodents and feral cats, and diseases carried by alien mosquitoes. Additional threats include the expansion of invasive nonnative plant species into native dominated plant communities and the resulting conversion of native ecosystems to alien plant communities. The majority of recovery actions therefore address threats to habitat (threat A) and disease and predation (threat C). The direct over-utilization of Hawaiian forest birds for commercial, recreational, scientific, or educational purposes (threat B) currently is not a significant threat. The `akikiki, a candidate species for listing, is not on the Federal list of threatened and endangered species, but is threatened by inadequacies of existing regulatory mechanisms (threat D). 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 man-made factors such as hurricanes and wildfires (threat E). Population monitoring and research do not fit into the above threat categories per se, but they are essential for recovery in order to evaluate population trends, determine the nature and importance of threats, and to measure population responses to management actions.

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 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. 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 intrinsic growth rate (lambda) 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 recovery habitat is protected and managed to achieve criteria 1 and 2 above.
4. The mix of 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 Habitat: To better address the recovery needs of endangered Hawaiian forest birds, recovery habitat areas have been established to emphasize where recovery efforts should be focused. Recovery habitat in this plan is defined as those areas that will allow for the long-term survival and recovery of endangered Hawaiian forest birds. Recovery habitat is the result of a biological evaluation of habitat potentially important for the recovery of Hawaiian forest birds and conveys no legal obligation on the part of any non-Federal entity to manage lands that they own or have management responsibility over for forest bird recovery. The foremost concern, in identifying recovery habitat for the great majority of endangered Hawaiian forest birds, is existing habitat and restorable habitat at upper elevations, because the cooler temperatures at these elevations are less suitable for both the introduced mosquito vector and the malarial parasite that causes avian malaria. Recovery habitat in most cases contains existing endangered forest bird populations, as well as habitat areas from which these species have disappeared in the recent past, but which likely still provide or could provide the conditions and resources necessary to support populations of endangered forest bird species. The elevational boundaries of recovery habitat 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 the naturally occurring habitat heterogeneity that can shape local adaptation and genetic variability 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, and actions such as ungulate, predator, and disease control. In some instances sufficient habitat for recovery is still available; however, in many cases habitat restoration is needed to recover degraded areas and provide sufficient suitable habitat for species recovery. Management emphasis may differ among species, because taxa are affected differently and to varying degrees by different limiting factors. However, key to management in many cases will be the control of feral ungulates that degrade forest habitat, promote the spread of introduced plant species, and create breeding sites for disease-carrying mosquitoes; control of introduced rodents and feral cats; control of invasive plant species; and reductions in the number of mosquito breeding sites. Habitat management and restoration will encourage the expansion of current populations into unoccupied habitat; however, the establishment of new populations using various translocation and/or captive propagation techniques will be needed in some cases to accelerate population expansion and to establish new populations in suitable habitat.

Monitoring and Research Program: Monitoring is fundamental to an evaluation of population status, for the development and evaluation of the effectiveness of management actions, and the reclassification of a taxon. Systematic surveys of all recovery habitat at least once every 5 years, with more frequent monitoring in core areas, will be required to determine changes in distribution and population size of native and non-native forest birds. Systematic searches that target the most rare species will be required to determine the status of forest birds that have not been sighted in recent years. Because of unique properties of populations (e.g., low dispersal, source/sink relations, and social habitat selection), research on habitat carrying capacity, limiting factors, and general species biology must occur in conjunction with management actions.

Recovery Planning for Hawaiian Forest Birds: The Hawaiian Forest Bird Recovery Team wrote the Draft Revised Recovery Plan for Hawaiian Forest Birds during two periods of intensive work from 1994 to 1996 and 2000 to 2002. The Team's goal was to revise existing single island recovery plans for each of the main Hawaiian Islands and to bring these together into a single comprehensive multi-island recovery plan for Hawaiian forest birds. In addition, the Draft Revised Recovery Plan for Hawaiian Forest Birds includes two listed species, the O`ahu `elepaio (*Chasiempis sandwichensis ibidis*) and O`ahu creeper (*Paroreomyza maculata*), 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 island teams within the Hawaiian Forest Bird Recovery Team met more frequently to work on sections of the recovery plan pertaining to each island. Team members with expertise on a species or a particular topic, such as captive propagation and 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 the contributions of individual team members. The Hawaiian Forest Bird Recovery Team is composed of State biologists from the Hawai`i Department of Forestry and Wildlife biologists; biologists from Federal agencies including the National Park Service, the U.S. Geological Survey-Biological Resources Division, and the U.S. Fish and Wildlife Service; avian captive propagation specialists; university specialists; 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 some individuals not on the team for drafting the recovery habitat and species distribution maps and answering certain questions regarding individual species biology and recovery needs.

Implementation Participants: Forest bird habitat in Hawai`i includes Federal, State, and private landholdings. Although we have the statutory responsibility for implementing this recovery plan, and only Federal agencies are mandated to take part in the effort, recovery cannot 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 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.

Date of Recovery: Because 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, the date of recovery will be dependent on the effectiveness of management strategies in controlling limiting factors and on the response of species populations. Habitat areas that are badly degraded will take decades, in some instances, to recover. Not all habitat restoration can begin immediately. Some species with larger current populations and wider distribution may be recovered in 30 years. Other species will first need the substantial recovery of some habitat areas. We estimate that, on average, we can expect all species in this plan that have current populations of greater than 300 individuals to be recovered in 50 years. An estimated recovery date for all species in this category (with the exception of the Po`ouli and species that have not been seen in recent years) is the year 2,052.

Total Estimated Cost of Recovery: Total estimated cost of recovery is $3,627,340,000 over the 50 years it will take to recover the above species. This figure may be substantially reduced with the development of more effective methods to address threats, specifically in the areas of predator and feral ungulate control. 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.

The total above is broken down by priority number as follows:

Priority 1 actions: $1,186,110,000

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

Priority 2 actions: $1,548,570,000

> 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: $892,667,000

> All other actions necessary to meet recovery objectives.

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FIGURES

I. INTRODUCTION

Recovery of the endangered forest birds of the Hawaiian Islands is a massive operation in terms of number of species and diversity of threats. Over two-thirds of the remaining forest birds are listed, 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 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 of the introduced plant species have the potential to permanently alter ecosystems in which endangered birds exist.

This recovery plan includes species from four families of birds, with the majority being Hawaiian honeycreepers (subfamily Drepanidinae, family Fringillidae). Evolutionary biologists consider these birds the premier 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. The number of listed 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. Other forest birds covered in this plan include a monarch flycatcher (Monarchidae), two honeyeaters (Meliphagidae), and three solitaires or thrushes (Turdinae).

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 Drepanids. Divergence of populations on different Hawaiian Islands reflects a similar process of colonization, isolation, time, and selection. Thus, 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 are local: the species have evolved 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 are the outcome of resource partitioning shaped by past interspecific competition. Moreover, the specialized nature of many species makes them vulnerable to habitat alteration and has resulted in lower population density in degraded forest, and also limits their ability to respond adaptively to novel resources available in introduced forests. Timber harvesting and browsing by introduced cattle, goats, and sheep has degraded many native forests, and rooting by feral pigs has destroyed the understory in some areas.

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 silvestris*), and the small Indian mongoose (*Herpestes auropunctatus*) have severely impacted populations of native forest birds (Atkinson 1977, Scott *et al.* 1986, VanderWerf and Smith in press). An adaptive response by Hawaiian birds to the novel selection pressure of mammalian predators cannot be expected because of the limited time of exposure and high predation rate. No social insects existed in 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 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 (Warner1968, van Riper *et al.* 1986, Scott *et al.* 1986, Atkinson *et al.* 1995). Most remaining populations of endangered birds are found at higher elevations, where the cooler temperatures limit development of both the mosquito and the avian malarial parasite during its development in the mosquito (van Riper *et al.* 1986, LaPointe 2000). Global warming could move transmission of pox and malaria to higher elevations, threatening remaining populations of endangered birds.

This recovery plan addresses some of the most difficult recovery efforts. Several of the covered species are so rare that they have not been sighted for years. One species, the po`ouli (*Melamprosops phaeosoma*), has only three known individuals. Another species, the O`ahu `elepaio (*Chasiempis sandwichensis ibidis*), exists entirely within the range of introduced mosquitoes and pathogens (VanderWerf *et al.* 2001). The remaining species are restricted to upper elevations, frequently in degraded habitat (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 to update records from the 1976 to 1981 Hawai`i Forest Bird Survey (Reynolds and Snetsinger 2001).

Habitat loss from ranching and logging has been addressed 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). 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, and from much of the acreage in other areas important to the recovery of endangered forest birds (Stone 1985, Katahira *et al.* 1993).

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, subspecies, or distinct population segment. However, studies on 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 in press). Increases in the number of `akiapōlā`au (*Hemignathus munroi*) have been documented on Kamehameha Schools land above Hawai`i Volcanoes National Park after control efforts for rats and cats were implemented (T. Casey 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 lacking. There currently are no efforts to control competing species within recovery habitat 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, 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 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 at Keauhou Ranch in 1977 and since have resulted in encouraging increases in `akiapōlā`au and native Cerambycid beetles after only 25 years (T. Casey pers. comm.). This bodes well for the value of the koa reforestation efforts at Hakalau Forest National Wildlife Refuge to endangered forest birds. 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 (*Oreomystis mana*), Hawai`i `ākepa (*Loxops coccineus coccineus*), and other non-endangered 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), and has been particularly effective in the dry māmane 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 are tools by which this might be accomplished. Artificial nesting boxes have proven effective in attracting cavity-nesting endangered birds, which have successfully fledged young from them. Use of these techniques to increase quality of younger forests for Hawai`i `ākepa, as well as to replace natural cavities lost by tree-fall in old-growth forest, appear to be a viable management option (Freed 2001).

The captive propagation of Hawaiian forest birds has made significant progress over the past 17 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, eight species have now bred in captivity: Hawai`i `amakihi (Kuehler *et al.* 1996), `i`iwi, `ōma`o, `apapane (P. Luscumb, pers. comm.), puaiohi, Hawai`i creeper, palila, and Maui parrotbill (Kuehler *et al.* 2001). In the puaiohi, a founder flock of 15 birds from wild eggs has produced over 60 chicks in captivity. Forty-three puaiohi have been released in the Alaka`i Wilderness Reserve over 4 years beginning in 1999. Several of the birds released to the wild have reproduced successfully (Tweed *et al.* 1999, Kuehler *et al*. 2000). Restoration and management of forest bird habitat will continue to be used 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. Plans have been initiated to release palila at Pu`u Mali on the northern side of Mauna Kea, and several areas on Maui are being considered for releases of 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 property owners and increased public support for endangered species recovery.

Table 1. Federally listed endangered species of Hawaiian forest birds included in this recovery plan and the International Union for the Conservation of Nature species status listing (IUCN 1994). Guidelines for determining Recovery Priority Number are in Appendix C.

Table 1				
Species (common name, scientific name, 4-letter acronym)	Total Population Estimate	Federal Listing Date and Reference; State Listing Date	Federal Status; Recovery Priority Number	IUCN Status Listing
O`ahu `elepaio, *Chasiempis sandwichensis ibidis*, OAEL	1,970	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 28 Apr 1987	11 March 1967 (USFWS 1967, 1980); 22 March 1982	Endangered; 4	Extinct
`Ō`ū, *Psittirostra psittacea*, OU	Last detected in 1979	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 nuku pu`u, *Hemignathus lucidus*	Last confirmed detection in	11 March 1967 (USFWS 1967, 1970, 1980); 22	Endangered; 5	Critically Endangered

Table 1				
Species (common name, scientific name, 4-letter acronym)	Total Population Estimate	Federal Listing Date and Reference; State Listing Date	Federal Status; Recovery Priority Number	IUCN Status Listing
Hanapepe, KANU	1960s	March 1982		
Maui nuku pu`u, *Hemignathus lucidus affinis*, MANU	Last detected in 1979	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
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	3	25 September 1975 (USFWS 1975, 1992); 22 March 1982	Endangered; 4	Critically Endangered

Table 2. Candidate species and species of concern included in this recovery plan. Guidelines for determining Listing Priority Number are in Appendix D.

Table 2				
Species (as above)	Total Population Estimate	Conservation Status, including State Listing	USFWS Listing Priority Number	IUCN Status Listing
Kaua`i creeper, Oreomystis bairdi, KACR	2,000-3,000, current estimate pending	Candidate species (USFWS 1999a)	5	Endangered
Bishop's `ō`ō, Moho bishopi, BIOO	Last detected in 1904	Species of concern	N/A	Endangered

Table 3. Gazetteer of place names used in this plan and identified in Figures 2-5.
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
Kahaualea 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
West Maui Mountains	MA	12
Hālawa	MO	1
Kalaupapa National Historic Park	MO	2
Kamakou Preserve	MO	3

Table 3		
Place Name	Island	Number on Map
`Ō`hialele 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`ulu	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
Pahole 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
Halemanu Steam	K	4
Halepa`akai Stream	K	5
Kawaikōī Stream	K	6
Koai`e Stream	K	7

Table 3		
Place Name	Island	Number on Map
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

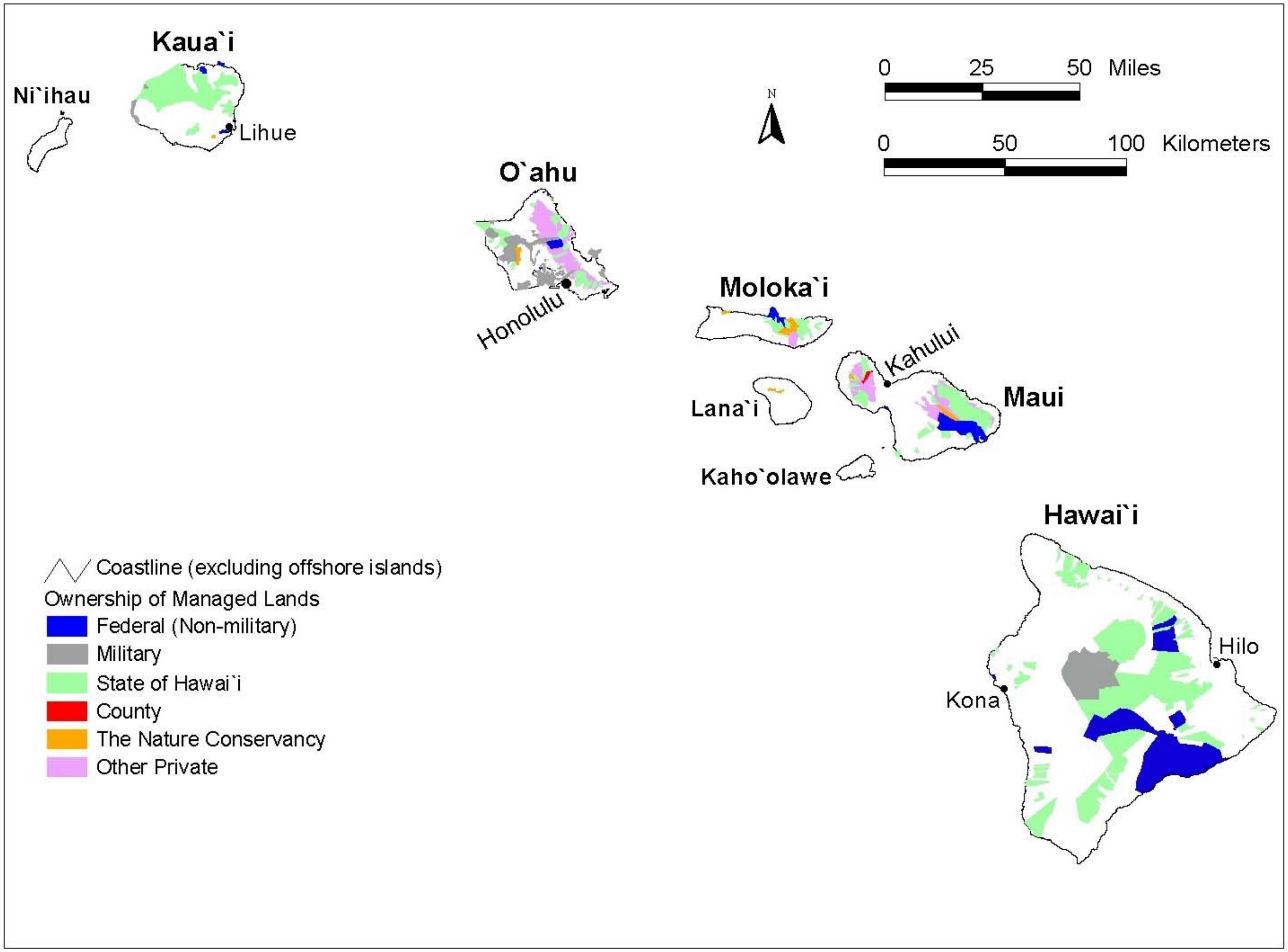


Figure 2. Locations of land parcels on the island of Hawai`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

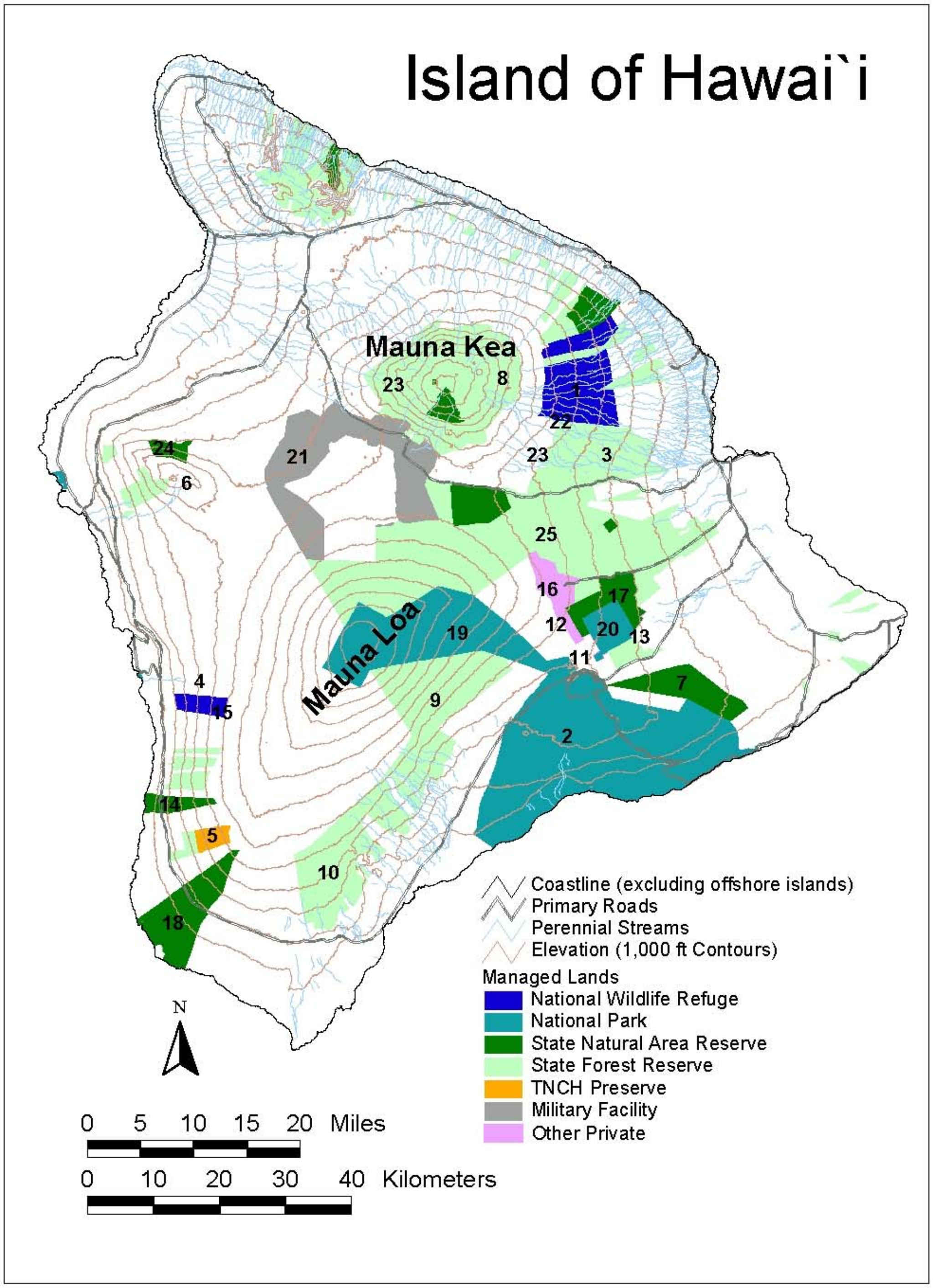


Figure 3. Locations of land parcels on the islands of Maui and Moloka`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

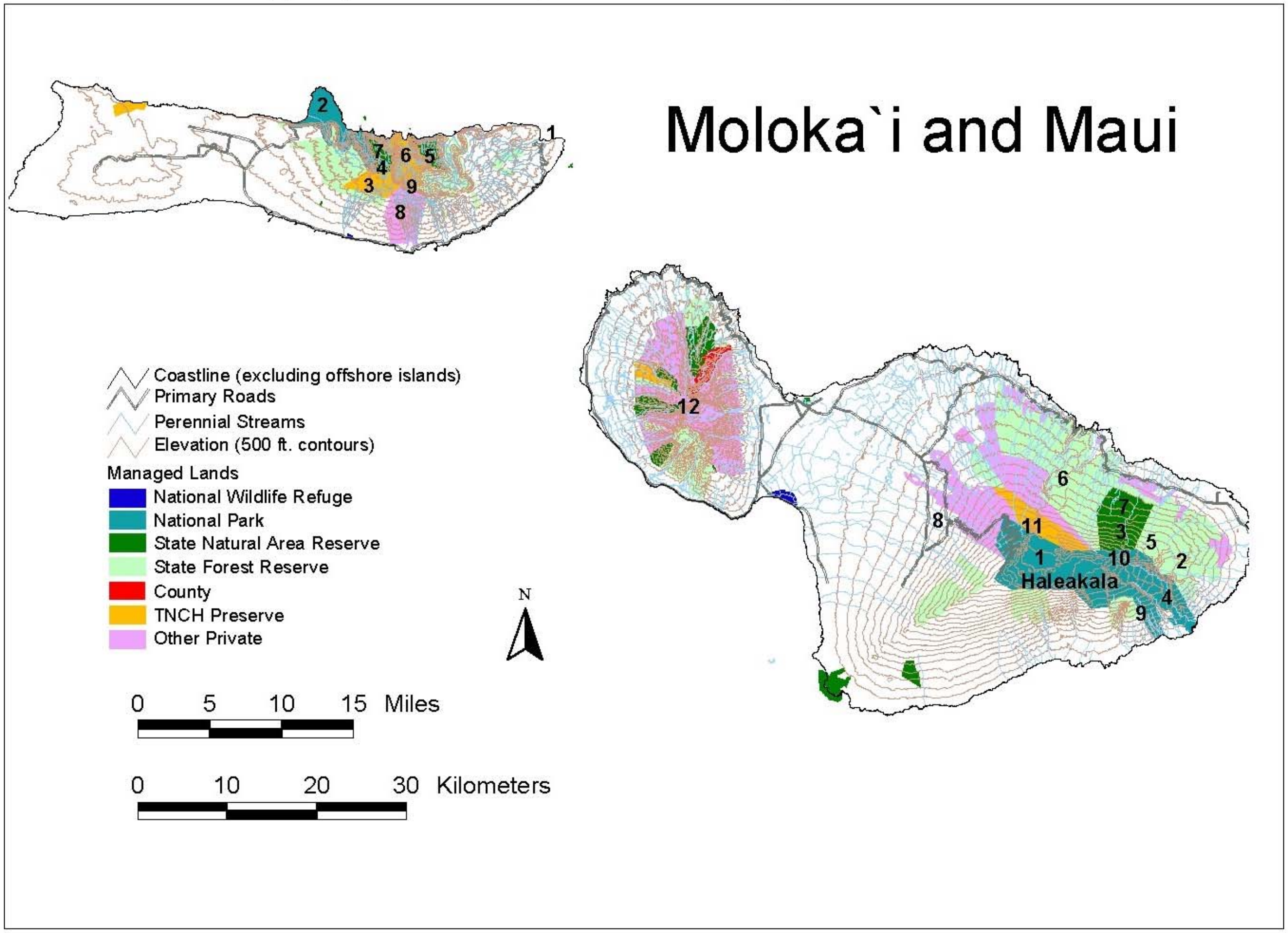


Figure 4. Locations of land parcels on the island of O`ahu that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

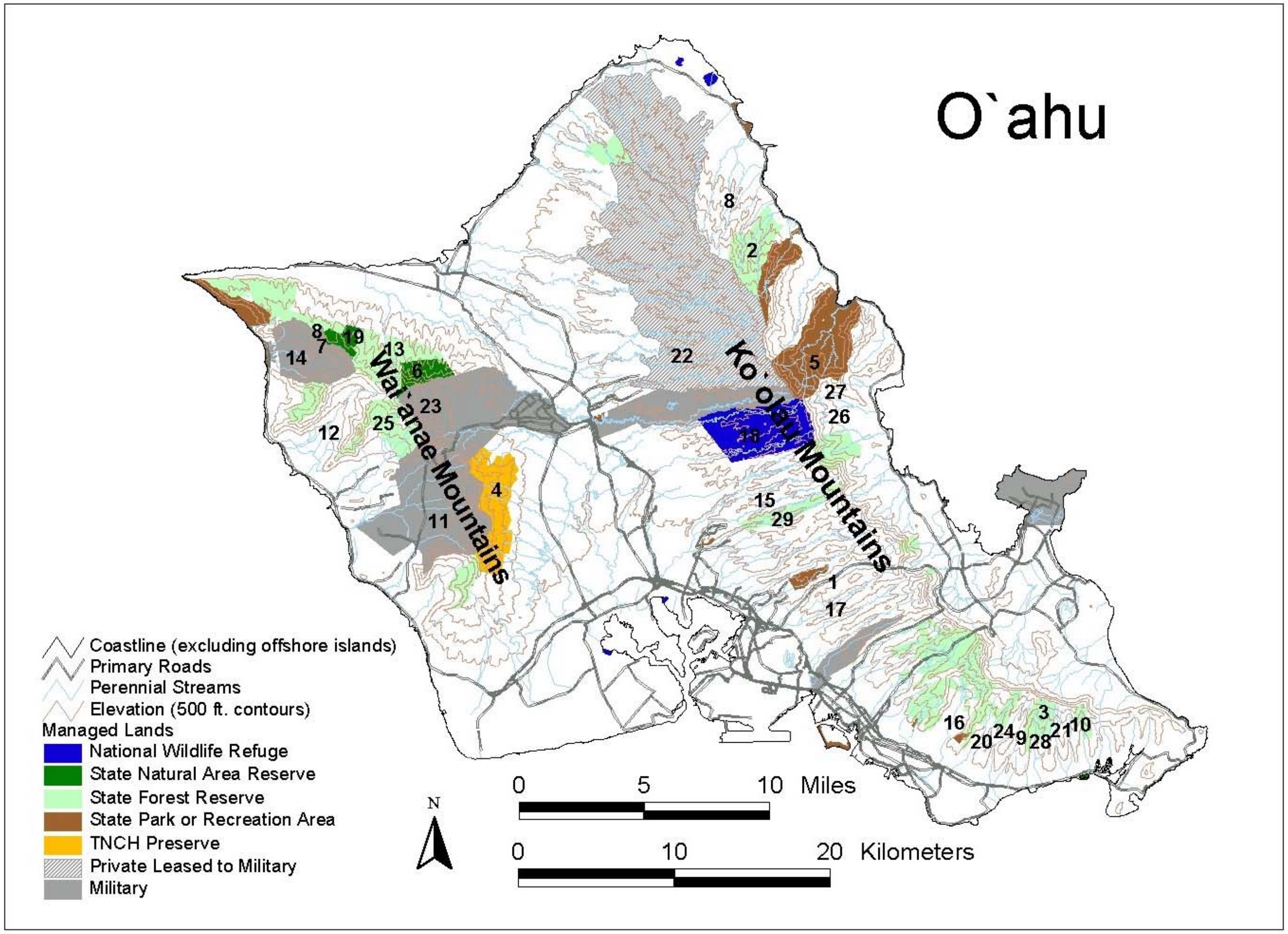
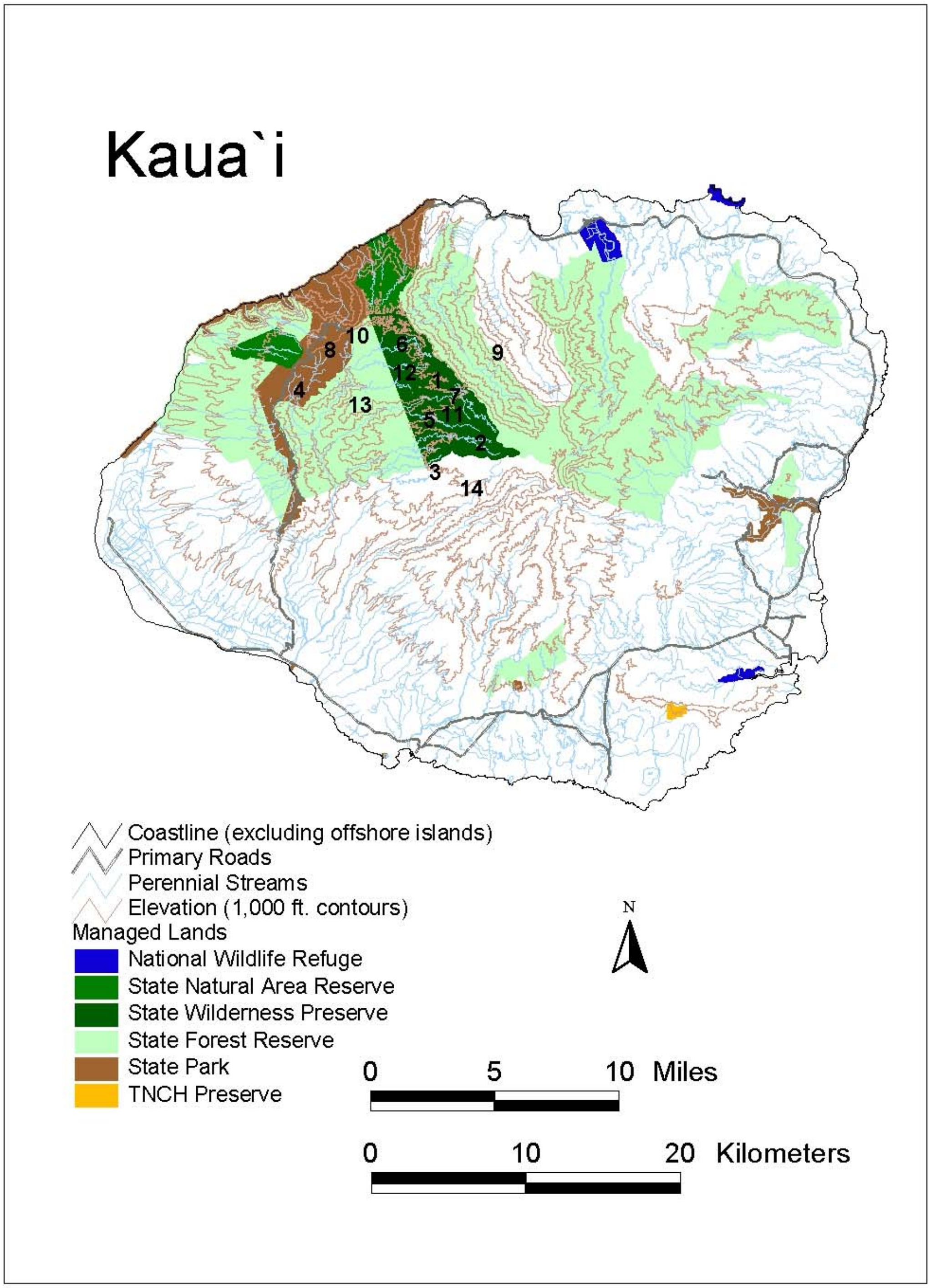


Figure 5. Locations of land parcels on the island of Kaua`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).



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 (1997). Distribution and recovery habitat for these species are shown in Figures 7-20 at the end of all the species accounts, and are ordered by Hawaiian Island. This recovery plan includes all listed and candidate species of passerine birds occurring in the main Hawaiian Islands except the `alalā or Hawaiian Crow (*Corvus hawaiiensis*), whose conservation is guided by a different recovery team (National Research Council 1992). The purpose of these accounts is not to be a complete reference for each species, 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 species of 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. Therefore the priority placed on each component of the recovery strategy varies among species. The species accounts build on and refine the overall recovery strategy discussed in the Introduction (Section I), explain and justify the recovery criteria in Section III, and the recovery actions and priorities presented in the Recovery Action 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. For most species, maps showing the historical and current distribution and recovery habitat appear together following the accounts.

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

DESCRIPTION AND TAXONOMY

Description. The O`ahu `elepaio is a small (12.5 grams (.4 ounces) average weight, 15 centimeters (5.9 inches) total body length) monarch flycatcher (Monarchidae; VanderWerf 1998b). It is dark brown above and white below, with light brown streaks on the breast. The tail is long (6.5 cm, 2.6 inches) and often cocked up at an angle. Adults have conspicuous white wing bars, a white rump, and white tips on the tail feathers that are often displayed prominently. 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 (areas between the eye and bill) are white and the auricular (ear patch) is often black. Juveniles and subadults are rufous above and on the breast, with a white belly and rusty wing-bars. `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 and the soles are cream-colored. The iris is dark brown. Rictal bristles are present at the base of the bill and average 9 to 11 millimeters (0.35 to 0.43 inches) in length. 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 by birds varies to playbacks of different local dialects, indicating they recognize songs from different areas (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 wing-bars. Juvenile `elepaio can be confused with juvenile `Apapane (*Himatione sanguinea*), which are similar in size and overall color and also may cock the tail up, but have a curved black bill and lack contrasting wing-bars and tail tips.

Taxonomy. The `elepaio comprises a monotypic genus of the monarch flycatcher family (Monarchidae) that is endemic to the Hawaiian Archipelago (American Ornithologists Union 1997). The closest relatives of the `elepaio are other monarch flycatchers from the Pacific region, but generic relationships within the family are not well known (Boles 1979, Sibley and Ahlquist 1990). 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.* (1997) and Pyle (1997), 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.

LIFE HISTORY

Demography and Reproduction. `Elepaio are non-migratory and defend all-purpose territories year-round (Conant 1977, VanderWerf 1998a). The average territory size on O`ahu was 2.0 hectares (4.9 acres) in forest composed of introduced plants species (Conant 1977), but territory size likely varies with vegetation structure (VanderWerf 1998a). O`ahu `elepaio are socially monogamous, and approximately 63 percent of pairs remain together between years (E. VanderWerf unpubl. data). Site fidelity is high, with 96 percent of males and 67 percent of females remaining on the same territory between years. Young birds are subordinate and act as floaters while they attempt to acquire a territory and a mate. Annual survival of adults is high (approximately 80 percent) in the absence of disease and nest predation (VanderWerf and Smith in press).

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, freestanding cup made of rootlets, bark strips, leaf skeletons, lichen, and spider silk, and is placed in a fork or on top of a branch (Conant 1977, VanderWerf 1998b). Nests have been found in a variety of plants, including 6 native species and 13 introduced species (E. VanderWerf unpubl. data). Both sexes participate almost equally 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. Clutch size is usually 2, sometimes 1 or 3, 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 removed the mean number of fledglings per pair is 0.75 per year (VanderWerf and Smith in press; 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, probably in association with climatic factors that affect populations of nest predators and disease-carrying mosquitoes. These annual variations appear to be unpredictable in nature and are thus not cyclic, but the average interval of occurrence of both rodent irruptions and disease episodes may be approximately 5 years. Demographic monitoring from 1996 to 2001 revealed that there was one year (1996) with high disease prevalence and one year (1999) with high rodent abundance and nest predation (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 pāpala kēpau (*Pisonia umbellifera*), lama (*Diospyros sandwicensis*), 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 1998b). Nest site selection by O`ahu `elepaio is non-specialized; nests have been found in 7 native and 13 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* sp.) 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-`Çhi`a (*Metrosideros polymorpha*); low exotic; `Çhi`a dominant; and `Çhi`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 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 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. 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 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.

Current Range and Status. 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). 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 it 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 declined by roughly 75 percent in the last 25 years.

The total current population of O`ahu `elepaio is approximately 1,970 birds that are distributed in 6 relatively large populations and several small population remnants (Table 4, Figure 17 (p. 135); 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

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

Table 4			
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
P. Waianu Valley	1	0	8
TOTAL	1,982	1,774	5,663

populations in each mountain range. Although the central Ko`olau population covers the largest area (Table 4), `elepaio are sparsely distributed in 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 and Ko`olau mountains (Table 4), 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 (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 (.621 miles) (VanderWerf 1998a), but most `elepaio populations on O`ahu are separated by many kilometers of unsuitable urban or agricultural habitat. There may be some 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). The genetic population structure is unknown.

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 practically no `elepaio remain in 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 forest habitat currently are unoccupied, demonstrating that habitat loss is not the only threat. `Elepaio were observed regularly into the 1970's or early 1980's at Poamoho, Schofield-Waikāne, Mānana, Waimano, and other areas (Figure 17; Shallenberger 1977, Shallenberger and Vaughn 1978), but `elepaio have disappeared from all these areas even though the forest is still 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 factors reducing these parameters on O`ahu are nest predation by alien black rats (*Rattus rattus*) and introduced diseases, particularly avian pox

(*Poxvirus avium*), which is carried by the introduced southern house mosquito (*Culex quinquefasciatus*). Each of these threats is known to reduce both nesting success and adult survival.

Annual survival of birds with active avian pox lesions (60 percent) was lower than annual survival of healthy birds (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 (*Plasmodium relictum*) 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 investigated.

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 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 a 112 percent increase in reproduction and a 66 percent increase in survival of adult females compared to control areas (VanderWerf and Smith in press). Both sexes of `elepaio incubate the eggs and brood the nestlings, but only females incubate at night, making them more vulnerable to predation by nocturnal predators like rats (VanderWerf and Smith in press).

The relative threat posed by disease and nest predation can be determined by calculating the finite rate of population growth, or lambda, 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 in press). 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 ± 0.15, 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 0.93. If disease could be eliminated and rats were removed, lambda might be as high as 1.11, which would allow the population to double in only 7 years. Removal of rats or disease alone may prevent further decline of O`ahu `elepaio, but may not be enough to allow rapid recovery of `elepaio populations.

Other Natural and Man-made Factors. The remaining `elepaio subpopulations are small and isolated, comprising 6 core subpopulations that contain between 100 and 500 birds, and numerous small remnant subpopulations, most of which contain fewer than 10 birds (Table 4). Even if the threats responsible for their decline were controlled, the existing subpopulations would be unlikely to persist because their small sizes and restricted distributions make them vulnerable to extinction due 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 (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 tree-snake (*Boiga irregularis*) from the Mariana Islands. O`ahu `elepaio at U.S. Army Schofield Barracks are not affected by noise from military training (VanderWerf *et al.* 2000), but fires ignited by military training activities have reduced the amount of suitable habitat for `elepaio and continue to threaten areas designated as critical habitat.

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), but `elepaio currently are not found on the refuge.

Conservation efforts for the O`ahu `elepaio thus far have included surveys to determine the current distribution and abundance (VanderWerf *et al.* 1997, 2001), demographic monitoring to assess population status and identify threats (VanderWerf 1999), and removal of introduced predators (VanderWerf and Smith 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 less 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 reproductive success and survival of adult females, and ground-based rat control using snap traps and diphacinone bait stations has been conducted by the Hawai`i State Division of Forestry and Wildlife in the Honolulu 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 and U.S. Department of Agriculture, Wildlife Services, in Lualualei Valley beginning in 2002. Blood samples have been collected from over 150 individuals for use in disease screening, determination of genetic population structure, and to assist in identification of disease-resistant populations or individuals.

RECOVERY STRATEGY

There are several important components to the recovery strategy for the O`ahu `elepaio, including: identification of recovery habitat 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, they probably have lost less genetic diversity than smaller populations, and they 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.  In addition to the extensive loss of habitat described in Current Threats, forest habitat supporting `elepaio also is threatened by fires resulting from human activities, such as military training at U.S. Army Schofield Barracks.

Recovery Habitat. `Elepaio are adaptable and able to forage and nest in a variety of forest types composed of both native and introduced species (Conant 1977, VanderWerf 1993, 1994, 1998a).  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 continious canopy and dense understory (VanderWerf *et al.* 1997).

The remaining O`ahu `elepaio populations are small and isolated; even if the threats responsible for their decline were controlled, the existing subpopulations would be unlikely to persist because their small sizes and restricted distributions make them vulnerable to extinction. `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 1998b). 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. The recovery habitat therefore includes areas that currently are 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 miles) in search of a territory (VanderWerf 1998b). Because the areas currently occupied by `elepaio are separated by many kilometers (Figure 17, p. 137) and `elepaio are unlikely to disperse long distances, the existing populations probably are isolated (VanderWerf *et al.* 2001). Maintaining or restoring links among subpopulations 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, 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 habitat therefore includes 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 habitat can be expected to support approximately 10,000 `elepaio (Table 5; VanderWerf *et al.* 2001).

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

Table 5			
Recovery habitat area	Area in hectares (acres)	`Elepaio density in currently occupied parts of unit (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 Units	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 in press). 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 for rodent control with the U.S. Environmental Protection Agency should be actively pursued and supported. Aerial broadcast of some currently used 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 therefore will 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 (Warner 1968), and all populations of O`ahu `elepaio appear to be affected by disease (E. VanderWerf unpubl. data). 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.), and the best 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.

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 range-wide 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 habitat management. Demographic monitoring will require mist netting, banding, and resighting of birds to measure survival rate, nest searching to measure reproductive success, and data analysis. Measurement of demographic parameters should follow methods used in VanderWerf (1999) and VanderWerf and Smith (in press). Depending on what demographic data is available, calculation of lambda values should follow (in order of increasing information required) Pulliam (1988), Pease and Grzybowski (1995), Caswell (1989), or another biologically valid method.

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, probably due to epizootics of disease and variation in predator (rodent) populations (VanderWerf 1999). 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. Because the number of O`ahu `elepaio remaining in the wild is relatively large, recovery may be achieved more cost-effectively through habitat management, and captive propagation and release of O`ahu `elepaio is not necessary for recovery at this time. However, captive propagation and/or rear and release of O`ahu `elepaio may become necessary 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 strongly 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 2000, 2001). 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

Early descriptions of the kāma`o were made by Stejneger in 1887 from specimens provided to the Smithsonian Institution by Valdemar Knudsen in the 1880's (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) solitaire, gray-brown above, tinged with olive especially on the back, and light gray below with a whitish belly and under tail coverts. The legs are dark gray-brown and relatively short, but the ventral surface of the toes are 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 also has 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 heaviest periods of 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 eggs 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. 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. In more 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.), probably are associated with good kāma`o habitat. The `ie`ie vines highly favored by the kāma`o still exist in some areas of the island, but not in the higher elevations to which the birds may be currently restricted. That plant 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 now is 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 1960's. At this time it remained only in the uppermost regions of the Alaka`i in very sparse numbers. From 1968 to 1973, Sincock *et al.* (1984) 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 19, p. 137). In the summer of 1985, two kāma`o were seen during an intensive 2-week survey of the Alaka`i. This followed the moderately severe Hurricane Iwa that occurred in November 1982 (Hawai'i Department of Land and Natural Resources 1985). 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 Natural Resources 1989). The more recent hurricane named "Iniki" severely damaged Kaua`i's forests in September 1992. No sightings of kāma`o were made during a brief post-hurricane survey made in February 1993 (Hawai'i Department of Land and Natural Resources 1994), nor in more intensive surveys conducted in February and March 1994 and March 2000 (Hawai'i Department of Land and Natural Resources 1995).

Although the kāma`o has not been seen since 1989, it should be noted that its smaller congener, the puaiohi or small Kaua`i thrush, went many years without being seen, but then began to reappear in small numbers. 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. The fact that the kāma`o has not been seen since 1989 places this species on the brink of extinction, if it is not already extinct.

REASONS FOR DECLINE AND CURRENT THREATS

Avian disease is by far the most significant factor suspected to limit the kāma`o. Early historical observations were made of pox lesions on the kāma`o at the lower edges of its mid-19th century range, indicating the kāma`o was susceptible to alien diseases for which it had little or no immunity. 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 solitaires generally are, predators such as rats (*Rattus* spp.) may severely limit nesting success and explain why some of the smaller arboreally nesting species have had a greater degree of nesting success. Feral cats occasionally are 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, Melodious Laughing-thrush (G*arrulax canorus*), and White-rumped Shama (*Copsychus malabaricus*) share the same habitat with the kāma`o to some degree and may compete with the kāma`o for food and nest sites. These and other alien bird species, including the recently established Japanese Bush-warbler (*Cettia diphone*), also may serve as reservoirs of disease. 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, p. 191).

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 also could 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 direct prey items of 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 other endangered Kaua`i forest birds and their 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 birds have survived in during the past half century. The Forest Reserve Act of 1903 was an important action that protected watersheds in Hawai`i, and it was 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 values from certain degrading factors caused by human activities. The Hawai'i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 1960's. 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 *et al.* 1984). 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 1981, 1985, 1989, 1993, 1994; Woodworth *et al.* in prep.).

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. Alternatives are of limited effectiveness, expensive, and logistically difficult. 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.

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 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

The kāma`o is so critically rare, if not already extinct, that no specific recovery strategy can be devised at this point other than to include it within the general framework of the Rare Bird Discovery Protocol outlined in Section III. D.

Although the kāma`o has never been managed in captivity, it is reasonable to assume that many of the same techniques that have proven successful for the `ōma`o and the puaiohi (egg collection, artificial incubation and rearing, captive propagation, and reintroduction) would prove effective with this congeneric solitaire species. If a breeding pair or nest is ever found, the eggs, nestlings, or juveniles should be collected to establish a captive population.

3. Oloma`o, *Myadestes lanaiensis*

DESCRIPTION AND TAXONOMY

The oloma`o or Moloka`i thrush is a medium-sized (21 centimeters, 8.3 inches) 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 show 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).

Recent changes in the taxonomy of the Hawaiian thrushes have done away with the long-standing 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). With the wing measuring 95 millimeters and the tail 80 millimeters (3.7 and 3.1 inches, respectively), the oloma`o is slightly smaller and has a proportionately longer tail than the `ōma`o (*M. obscurus*). The two races, *M. l. lanaiensis* of Lāna`i Island and *M. l. rutha* of Moloka`i Island (more grayish below), cannot be safely distinguished by coloration or measurements (Pratt 1982). Questions remain regarding systematics of the Hawaiian solitaires. The `amaui (*M. oahensis*) of O`ahu and subfossil remains of solitaires from Maui may actually be oloma`o (Pratt 1982, James and Olson 1991).

LIFE HISTORY

The breeding biology of the oloma`o is largely unknown. Three nests attributed to oloma`o were 8 to 9 meters (26 to 30 feet) up in `ōhi`a (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). By comparison, `ōma`o also build a cup nest in trees, often on a ledge formed by a branch or trunk (van Riper and Scott 1979, Wakelee *et al.* 1999). Modal clutch size is two for `ōma`o, and both young usually fledge. `Ōma`o parents tend their fledglings for about 6 weeks. 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 taken at all levels in the forest (Rothschild 1893 to 1900, Perkins 1903, Bryan 1908). 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 ranges (Bryan 1908, Ralph and Fancy 1994b). They do not make long flights over the canopy, but do 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 difficult to locate (Bryan 1908). The song is beautiful, thrush-like, "of a jerky nature" (Rothschild 1893 to 1900), and similar to `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 (1964) claimed that the Lāna`i bird was "no singer at all." Calls are "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). Recent records have all been from dense rainforest above 1,000 meters (330 feet) adjacent to the steep pali (cliff) of Pelekunu (Scott *et al.* 1986).

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range encompassed the mountains of East Moloka`i and Lāna`i (Figure 15, p. 133). Bryan reported that oloma`o were most abundant at Hālawa, Moloka`i, where closed forest provided pristine 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 1860's (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 of 1979 and 1980 (Figure 15); and (4) a fleeting glimpse in 1988 on Kapapamoa ridge somewhat above 1,220 meters (4,000 feet) (A. Engilis 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 the late 1980's and 1990's turned up no oloma`o (Reynolds and Snetsinger 2001, Hawai`i Department of Land and Natural Resources unpubl. data). Currently, the oloma`o population is undetected, if it survives at all.

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 died out from 1923 to 1931 when Lāna`i City was built, and "the people brought bird disease with their poultry and these, evidently carried by mosquitoes, were fatal to the native bird population" (Munro 1964). Extensive habitat exists on O`ahu, Moloka`i, Lāna`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. If a breeding pair or nest is ever found, the eggs, nestlings, or juveniles should be collected to establish a captive population. Consideration should be given to establishing a population at high elevation on East Maui, where the habitat is relatively intact and free of threat from mosquitoes and avian disease. While recovery of Hawaiian solitaires is valuable in itself, recovery of these fruit-eating birds also would restore an important natural seed disperser to native ecosystems. Although the oloma`o has never been managed in captivity, it is reasonable to assume that many of the techniques that have proven successful for the `ōma`o and the puaiohi (egg collection, artificial incubation and rearing, captive propagation, and reintroduction) would be effective with this congeneric solitaire species.

4. Puaiohi, *Myadestes palmeri*

DESCRIPTION AND TAXONOMY

The puaiohi or small Kaua`i thrush is a medium-sized (16.5 to 17.8 centimeter [6.5 to 7.0 inch] 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 under tail 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).

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).

LIFE HISTORY

Puaiohi nest in cavities or ledges on cliff faces, using small vegetation-lined cavities 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.* 1999). Prior to intensive field efforts in the Upper Mōhihi area from 1996 to 1998 (Snetsinger *et al.* in prep.), only four nests of the species had been found. The field study located 209 nests of which 113 were active (Snetsinger *et al.* in prep.). 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. 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.* (1999) observed one- and three-egg clutches in captive-bred released birds. Eggs are grayish-green to pale greenish-blue with irregular reddish-brown splotches (Berger 1972). Eggs hatch after 13 to 15 days. Male and female share responsibility for provisioning the chicks, although the female is 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 genetic 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 (6 months) and high rates of nest success (83 to 91 percent), led to remarkably high productivity in 2 years studied - an average of 2.8 and 5.0 fledglings/pair in 1996 and 1997 respectively. In 1998, when El Niño Southern Oscillation drought struck the islands, breeding seasons were shortened (3.5 months) and nest success decreased (54 percent), leading to productivity of only 0.4 young per pair per year. The decrease in nesting success appeared to be due to an increase in 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 a population increase of rats after 2 favorable years, is unknown. Regardless, based on this limited evidence, it appears that puaiohi are vulnerable to severe drought and 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. Adult survival is estimated at about 74 percent and juvenile (first year) survival at approximately 25 percent (T. Snetsinger in prep.). Dispersal frequency and distances appear to be small, a fact that has important implications for the rate of natural recolonization of recovering habitat.

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 fruit and 18 percent insect 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 trees, which currently do not occur within the existing puaiohi range. Caterpillars and seeds were identified in the stomachs of type specimens (Perkins 1903).

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 rainfall/year, 39 to 79 inches) to extremely wet (2,500 to 13,000 millimeters rainfall/year, 98 to 512 inches) 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 (*Acacia koa*) and `ōhi`a (*Metrosideros* spp.), 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, e.g., 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 rainfall/year(236 inches), at 1,050 to 1,300 meters (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).

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 most readily on steep banks of small streams that drain the Alaka`i Wilderness Preserve to the south and west. Species density is currently very low in some apparently suitable habitat. 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 about seven captive and wild birds.

HISTORICAL AND CURRENT RANGE AND STATUS

Even in the late 1800's, 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 kilometers (9.5 square miles) study area in the heart of the Alaka`i.

Today the total population of puaiohi is estimated to consist of approximately 200 to 300 individuals, 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 (Snetsinger *et al.* 1999; Figure 20). The breeding population is restricted to an area < 20 square kilometers (7.6 square miles) in size, and 75 percent of the breeding population occurs in only 10 square kilometers (3.8 square miles). The puaiohi exists in high densities 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, puaiohi can be found at a density of approximately 16 breeding pairs per square kilometer (0.621 square mile), plus an undetermined number of floaters and helpers at the nest (Snetsinger *et al.* in prep.). Densities decline with elevation to about 1,050 meters (3,450 feet) in these drainages (documented in the Mōhihi, theoretical in the Waiakoali). 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). Anecdotal observations suggest that the population may have declined significantly in the last decade (T. Pratt pers. comm.). Because of the abundance of cliffside habitat and relatively low use of the area by hunters, this area is perhaps the best puaiohi-inhabited area for experimental ungulate and predator control (see Recovery Strategy).

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 pers. comm.). These surveys did confirm 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/U.S. Geological Survey unpubl. data). Lā`au Ridge, where an incidental observation of puaiohi was made in 1969 (Sincock *et al.* 1984), has rarely been visited in recent decades; our crews did not detect any puaiohi there in March 2000 (C. Melgar pers. comm. to J. Foster).

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). As of September 1999, following one season of breeding in the wild, the area was home to a population of approximately 12 birds (Tweed *et al.* 1999). The captive propagation program released an additional 5 birds in February 2000, and another 15 in 2001 (The Peregrine Fund 1999, The Peregrine Fund and The Zoological Society of San Diego 2000, The Zoological Society of San Diego 2001).

REASONS FOR DECLINE AND CURRENT THREATS

Disease. Early ornithologists did not note difficulties with lumps on the feet and bills (avian pox, *Poxvirus avium*) of puaiohi as they did with the kāma`o. 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, Tom's Camp, 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.). The malarial fatality of a Kaua`i `Amakihi in the fall of 1999, in Kōke`e State Park indicated that active malarial transmission was occurring in the park at that time (C. Atkinson pers. comm.).

To date, only five wild Puiaohi 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 malaria infection (C. Atkinson/U.S. Geological Survey unpubl. data). 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 serious limiting factors on puaiohi nesting success. 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 confirmed rat predation including a total of three females taken on their nests. Moreover, 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 passerines. Several introduced birds, including the Japanese White-eye (*Zosterops japonicus*), Melodious Laughing-thrush (G*arrulax 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 and nest sites. These and other alien bird species, including the recently established Japanese Bush-warbler (*Cettia diphone*), also may serve as reservoirs of disease. 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. 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. New insects, such as the two-spotted leaf hopper (*Sophonia rufofascia*) are causing serious damage to many native and nonnative plants. Many of the food producing plants used by puaiohi could be negatively affected, reducing their range, fruit set, and even survival. Other introduced predatory insects may reduce or eliminate specialized native insects that are necessary for pollination of certain food plants. Introduced snails that prey on indigenous snails could reduce food resources of the puaiohi. 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 200 to 300 birds in a number of widely separated subpopulations, falls well below the 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, 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, and it was 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 values from certain degrading factors caused by human activities. The Hawai`i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 our cooperation and that of the Biological Resources Division, U.S. Geological Survey (then the National Biological Service), the Hawai`i Division of Forestry and Wildlife, The Peregrine Fund, and the Kamehameha Schools Bishop Estate. A team of biologists was tasked with locating and learning more about the life history of the puaiohi. Over 200 nests were located, and the breeding behavior, 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 planned or in preparation (e.g., Snetsinger *et al.* in prep.). 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 Division, 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. Although it is a formidable task, hopes exist for finding ways of mitigating the disease problem of rare native forest birds exist.

Captive Propagation and Reintroduction. Beginning in 1995, we have cooperated with The Peregrine Fund, U.S. Geological Survey, and the Division of Forestry and Wildlife in developing and testing rear-and-release/reintroduction 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).

A captive breeding flock of puaiohi was established at The Zoological Society of San Diego's Keauhou Bird Conservation Center on Hawai`i and at the Maui Bird Conservation Center. The captive 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 birds), (2) the newly-established population of Puiaohi is not genetically isolated, dispersal distances of captive-reared released birds are long, 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 Zoological Society of San Diego may elect to augment the captive flock with wild-collected eggs (C. Kuehler pers. comm.).

In January and February 1999, The Peregrine Fund released 14 captive-bred birds (8 females and 6 males) in 2 hack towers in 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). Birds were observed consuming insects shortly after release, and most did not return to the hack site for food after initial release. Follow-up monitoring by U.S. Geological Survey showed that all 14 birds survived at least 9.5 weeks post-release, and 5 of 8 (63 percent) that were under long-term observation survived the breeding season. Seven birds (50 percent) established breeding territories in the Kawaikōī and the rest dispersed to other drainages. Both captive-captive and captive-wild pairings were documented. In total, of 21 nests built from March to September, 18 became active, 7 were depredated, and 6 fledged young (Tweed *et al.* 1999).

As of December 1999, the Kawaikōī population totaled 12 birds (up from 2 a year earlier): 4 captive-bred birds, 2 wild birds, and 6 fledglings. On February 1, 2000, an additional five birds (four females, one male) were released by The Peregrine Fund/Zoological Society of San Diego. As of March 1, 2000, all five birds were known to be alive; one female had settled in the vicinity of the hacktower with a male from the 1999 release and was prospecting for nest sites.

No further data were collected on the released population after March 1, 2000 (The Peregrine Fund and The Zoological Society of San Diego 2000).

An additional cohort of 15 birds was released in spring 2001. Twelve of the 15 released birds survived to independence (greater than 30 days). The overall release strategy for the 3 consecutive years releases (1999 to 2001) is considered to be highly successful, with 31 of 34 released birds surviving to independence, and with confirmed breeding in the wild from the released animals (The Zoological Society of San Diego 2001).

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 1960's. 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 *et al.* 1984). 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 1986 and Woodworth *et al.* in prep).

The Hawai`i Rare Bird Search Team made an intensive systematic effort to locate any surviving endangered Kaua`i forest bird populations (see description in Section D, Rare Bird Search Protocol). 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).

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. 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. At present the Hawai`i Department of Land and Natural Resources does not consider ungulate fencing and removal to be an economically or politically feasible option for protecting large areas of the Alaka`i, and supports development of alternative lethal methods in remote (non-hunted) areas. It is clear that long-term protection of the Alaka`i from feral ungulates will require creativity, commitment, political savvy, an extensive public relations campaign, and significant financial backing.

Small mammal control. Rat control using registered rodenticides should be used in core nesting habitat or habitats where populations of puaiohi have been restored or are being established.

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 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. Most recently, Audubon magazine featured the puaiohi recovery effort in its February 1999, issue.

RECOVERY STRATEGY

Habitat Protection. Prospects for recovery 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. A need exists to develop, test, register, and apply toxicants for control of feral cats and introduced rodents in remote forested habitat. Prevention of additional introductions of exotic plants, insects, mammals (especially the 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 desireable. 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.

Other. Continued public information sharing is needed to maintain program support.

5. Kaua`i `Ō`ō, *Moho braccatus*

DESCRIPTION AND TAXONOMY

The Kaua`i `ō`ō or `ō`ō `ā`ā is one of four known Hawaiian species of *Moho* and one of five known Hawaiian bird species within the family *Meliphagidae.* It is 19.5 centimeters (7.7 inches) long, shorter-tailed, and somewhat smaller than the `ō`ō's of 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, except for the soles of the feet that are 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 have been 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 *et al.* 1984). 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 40 feet (12 meters) 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.

CURRENT AND HISTORIC RANGE AND POPULATION 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 19; 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 1960's, the Kaua`i `ō`ō population was estimated at only 36 birds (Sincock *et al.* 1984). 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 that 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 (Hawai'i Department of Land and Natural Resources/J. Krakowski 1987 pers. comm.). It is very likely that the Kaua`i `ō`ō is now extinct, because no subsequent sightings or vocalizations have been documented despite three comprehensive forest bird surveys in 1989, 1994, and 2000, and a rare bird search conducted in 1996 (Reynolds and Snetsinger 2001).

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 2 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 probably 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 1700's. The demise of many of Hawai`i's forest birds seemed to have coincided 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 federallylisted 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. 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 values from certain degrading factors caused by human activities. The Hawai'i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 Rare Bird Discovery Protocol in Section III. D.

6. \`Ō\`ū, *Psittirostra psittacea*

DESCRIPTION AND TAXONOMY

The \`ō\`ū is a heavy-bodied Hawaiian honeycreeper 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 under tail coverts. The wings and tail are a darker brownish olive. \`Ō\`ū are sexually dichromatic, males having a bright yellow head that contrast 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. 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 1800's (Henshaw 1902, Perkins 1903), 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. 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\`ụ̄ are also known to feed on young 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 forest with `ie`ie was considered to be preferred habitat (Perkins 1903, Bryan 1908). Although wide elevational movements from the upland māmane 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 the mid-elevation (900 to 1,500 meters; 3,000 to 5,000 feet) mesic and wet `ōhi`a forests with 1,200 to >2,500 millimeters (47 to 98 inches) annual rainfall. In this area the canopy is dominated by `ōhi`a 10 to 25 meters high (33 to 82 feet), with a subcanopy of `ie`ie, hāpu`u tree fern (*Cibotium* spp.), `ōlapa *(Cheirodendron* sp.), kāwa`u (*Ilex anomola*), 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 7; Perkins 1903, Scott *et al.* 1986). The `ō`ū is currently one of the rarest birds in Hawai`i, with populations extremely localized in occurrence, 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 7). 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 1970's indicated 400 ± 300 (95 percent CI) birds on Hawai`i Island and 3 ± 6 (95 percent CI) 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).

REASONS FOR DECLINE AND CURRENT THREATS

Modification and loss of habitat has had a significant role on 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 mosquitos 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, was inundated by the 1984 Mauna Loa lava flow, destroying thousands of acres of forest, 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 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 ounce). 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. 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 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).

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 = 53–205; 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/100 hectares (6 ± 2 nests/247 acres) in māmane-dominated forest, whereas 4 ± 1 nests/100 hectares (4 ± 1 nests/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 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, 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 (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 Kelley 1990). Palila may re-nest after failure, and some palila are able to successfully 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 (U.S. Geological Survey unpubl. data; Pratt *et al.* 1997a).

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 (zero 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 $\geq$ 13 years of age helped at a nest. Annual survival averages 0.63 ± 0.05 (SE), 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 small population size, great annual variation in the number of pairs attempting to nest, small clutch size, and long nesting cycle. van Riper (1980a) found 14.8 pairs/100 hectares (14.8 pairs/247 acres) and 1.8 young/pair/year in his study area, resulting in 26.1 young/100 hectares/year (26.1 young/247 acres/year). By comparison, Hawai`i `Amakihi (*Hemignathus virens virens*) productivity was 203.5 young/100 hectares/year (203.5 young/247 acres/year) in the same study area. Although the number of pairs nesting varies greatly from year to year, at least half of all eggs 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). Fertility of eggs was 4 to 11 percent from 1996 to 2000, suggesting that infertility is not a major problem (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 fledging 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

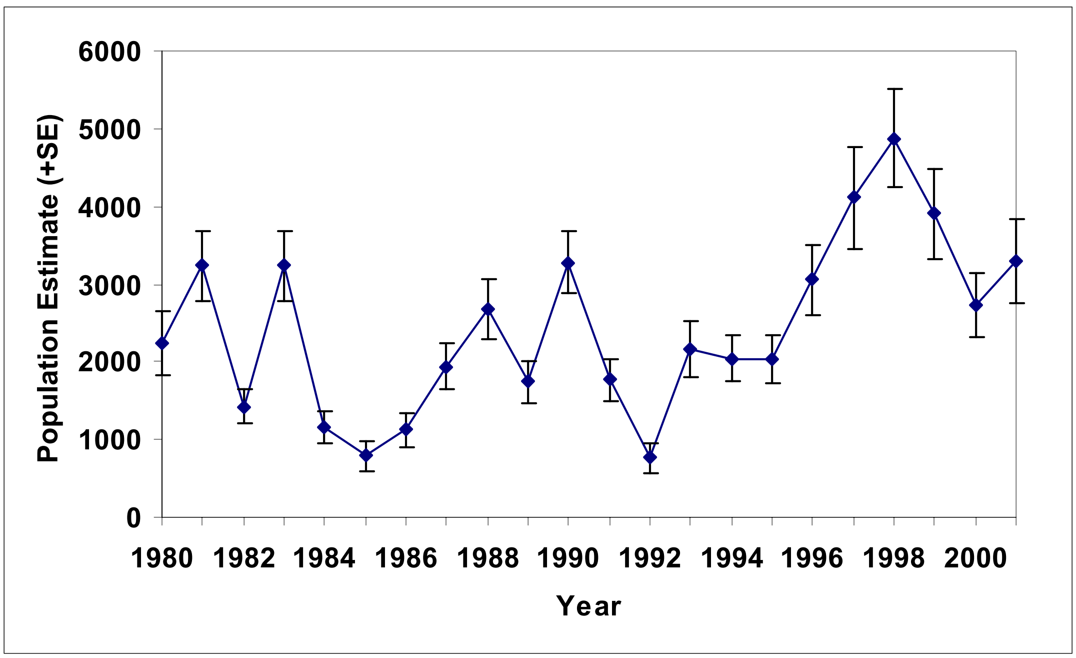
Palila are dependent on the māmane and māmane/naio forests for all their needs. Highest densities of palila occur in areas of greater crown cover, taller trees, and higher proportion of native shrubs near 2,300 meters (7,550 feet) elevation in māmane-dominated or mixed māmane-naio forest (Scott *et al.* 1984, 1986). 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 palila population and nearly all 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 response of palila 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 8). In the 1890's, 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). The range of palila apparently shrank relatively quickly in the early 1900’s to this small area on the upper slopes of Mauna Kea, because Munro (1944) determined that the species was in danger of extinction.

The distribution of palila (Figure 6) has remained fairly constant in recent decades. 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 1980's 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 (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 range contraction.

Figure 6. Population trends of palila.



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 (Jacobi *et al.* 1996). Annual surveys from 1980 to 1995 yielded a mean population estimate of 3,390 ± 333 (SE) palila (Figure 8; Jacobi *et al.* 1996). Annual population estimates have ranged from 5,685 in 1981 to 1,584 in 1985, but such variability is common for passerines. Much of the perceived variation in numbers may be due more 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 could not have occurred. The reproductive potential of palila, for example, is insufficient to have produced population increases by factors of 2.9 (1986 to 1987), 2.4 (1992 to 1993), or 2.0 (1995 to 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/pair, and 2) all adults and fledglings must survive until the next census. 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.

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 1800's and have since caused widespread loss and modification of palila habitat. Cattle, feral sheep, mouflon sheep, 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 1820's and the sheep population reached about 40,000 animals by the early 1930's (Bryan 1937). Heavy browsing effectively lowered 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 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 clandestinum*), 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 (*Deleiria 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 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 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 (*Dacstylis glomerata*) especially may spread; however, native grasses and shrubs may also increase after fire. For example, *Eragrostis atropioides* almost completely dominated the vegetation following fires that started along Saddle Road on the western slope of Mauna Kea during the 1990's (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 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 former range at lower elevations, including Pōhakuloa Flats.

Predation by black rats, feral cats, 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 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 terminal forks of a tree (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 formal listing 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-1900's (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 1900's to protect the māmane woodland and watershed of 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 (*Ovis musimon*) 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 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 misguided 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. Department of Fish and Wildlife 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 palila was completed in 1978, and revised in 1986 (U.S. Fish and Wildlife Service 1986), and these 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 1970's and early 1980's, 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 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 also will 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 one 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 have been undertaken with the goal of testing techniques for reestablishing a population on the northern slope of Mauna Kea, near Pu`u Mali. While 53 birds have been translocated in 3 different trials, there is little to suggest so far that birds will remain indefinitely in a new area (U.S. Geological Survey unpubl. data). Although some birds stay in the target area for over a year, most return to their original home ranges within a few months. Another trial is anticipated in 2002, environmental conditions and funding permitting, when a larger number of birds will be translocated to test the hypothesis that a more natural social environment and a larger pool of potential mates will encourage more birds to stay longer and breed. In conjunction with the 2002 translocation, it is hoped that captive-reared palila can be released on the northern slope to compare the survival, breeding, and other behavior between the two groups. Captive-bred palila will be 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). Prior to translocating and releasing captive-reared birds on the northern slope, predators will be removed and food and habitat conditions assessed to increase chances of success.

In 1996, a captive propagation program was initiated as a collaborative effort between National Biological Survey (now Biological Resources Division of 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. The progeny of the captive-propagation program are now being considered for release into recovery habitat.

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 1980's (J. Scott 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 is imperceptibly slow, if it is occurring at all, 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 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 Pōhakuloa Training Area on the southern slope of Mauna Kea. Land below Mauna Kea Forest Reserve will be fenced and cattle will be withdrawn, probably by 2003. 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 also will 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 e.g., 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 former range on Hualālai and Mauna Loa are much less certain. Although māmane forest remains over relatively large areas, habitat conditions have not been evaluated carefully to determine their recovery potential. Except 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. Habitat at Kīpuka `Alalā within Pōhakuloa Training Area may be rehabilitated sufficiently to eventually 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 1950's (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.

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 Saddle Road mitigation, large areas of former habitat would continue to be grazed. However, 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. Administrative commitment to recover palila and its habitat will be easier to muster 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. Involving citizens in palila recovery seems practical and could greatly promote palila recovery. Many areas of habitat are accessible by four-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. Therefore, a large cross-section of the public potentially could 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. They could also plant trees and other native species and assist with fire fuel management and fire education. There are significant opportunities to incorporate environmental education and recreation into habitat restoration activities. For example, with imagination and funding one or more sites on Mauna Kea could become 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 will be initiated in 2003, 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, 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 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 are 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

The Maui parrotbill is one of the larger (20 to 25 grams; 0.68 to 0.85 ounce) and more unique Hawaiian honeycreepers. It has a large head, powerful neck, a massive curved, parrot-like bill, stout legs, and short wings and tail. Adult Maui parrotbill 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. 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 safely 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 the yellow like adults.

The Maui parrotbill is a monotypic species with no known geographic variation in plumage or morphology. It is most closely related to the \`akiapōlā\`au based on morphology and molecular genetics (Simon *et al.* 1997, Fleischer *et al.* 1998), 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 \`alkali (*Rubus hawaiensis*), kanawao (*Broussaisia arguta*), and \`ōhi\`a. Parrotbills also pluck and bite open fruit in search of insects, particularly kanawao, but do not eat the fruit. 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.* in press). Parrotbills frequently occur in family groups, due to the prolonged 5 to 8 month long dependency of fledglings on their parents (Simon *et al.* 1997).

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 reported below. Both sexes play a role in the selection of the nest site between November and June. The open cup nest composed mainly of lichens (U*snea* sp.) and pukiawe (*Styphelia temeiameia*) twigs is built by the female an average of 12 meters (40 feet) above ground in a forked branch just under the outer canopy foliage. Simon *et al.* (1997) reported only single egg clutches, but reports of two-chick broods are known. 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. Males feed the nesting females, and females feed the nestlings with food obtained from the male. Once fledged, the young are frequently fed directly by the male. Development of the large bill and specialized feeding techniques proceed slowly, and fledgling dependency on parental care lasts 5 to 8 months.

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

HABITAT DESCRIPTION

At present, Maui parrotbills survive in mid- to upper-elevation montane wet forest now dominated by \`ōhi\`a (*Metrosideros polymorpha*), and in a few more 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 generally is steep and highly dissected by deep gulches and narrow ridges. The climate is montane year-round, with frequent clouds, mist, and rain. Annual precipitation may reach as much as 8,500 millimeters/year (335 inches). 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 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 13). 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).

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 (.386 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.

REASONS FOR DECLINE AND CURRENT THREATS

The Maui parrotbill is subject to the same threats that negatively impact other forest birds on Maui, including habitat loss and degradation, predation, and introduced diseases. The parrotbill has a very low reproductive rate, however (see Life History), which may make 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 remain a persistent threat.

Habitat Loss and Degradation. 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.* in press).

Predation. The importance of predation in limiting parrotbill populations is not clear. However, predation of nests and adults by rats, cats, mongoose, and owls is suspected to have a significant impact on many native Hawaiian bird species (Atkinson 1977, VanderWerf and Smith in press). Recent surveys indicate rat densities are very high in the Hanawī area where much of the parrotbill population currently occurs (Sugihara 1997, T. Malcolm 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 4,500 feet (1,350 meters), where mosquitoes are common. This pattern contrasts with that of 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 nuku pu`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. Later, the State of Hawai`i, The Nature Conservancy, Haleakalā National Park, Hāna Ranch, and Alexander and Baldwin (East Maui Irrigation Company) joined together to protect 404,687 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 removed to the Maui Bird Conservation Center, following the recommendations of Ellis *et al.* 1992 (The Peregrine Fund 1997). Subsequently, two additional wild eggs were collected, hatched, and reared in 1999 (The Peregrine Fund 1999). One pair formed from this trio, producing two chicks in 2000 (The Peregrine Fund and The 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 (The 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 program, with the intention of producing more birds for reintroduction into managed recovery habitat. It is anticipated that progeny from the captive flock will provide young Maui parrotbill for a pilot release program in the forests of East Maui.

RECOVERY STRATEGY

The recovery strategy for the Maui parrotbill centers on protection, restoration, and management of native high elevation forests on East Maui (Haleakalā), West Maui, and East Moloka`i, research to optimize efforts at mitigating 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 Haleakala is needed to promote natural demographic and evolutionary processes.

Recovery Habitat. Parrotbills are currently restricted to the windward forests of East Maui from Waikamoi to Kaupo (Figure 13). Interagency efforts and the East Maui Watershed Partnership have had landmark success in protection of this habitat for the parrotbill. However, extensive work is still needed to fence and protect the lower elevation areas from Hanawi Natural Area Reserve to Waikamoi, which provide habitat within the current range of the parrotbill, and much potential habitat that is apparently on the fringes of the current range. Additional fencing and ungulate eradication in this area will allow an intact and diverse native subcanopy vegetation to develop, thereby increasing 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" of suitable forest should be reconnected around the mountain, especially at upper elevations where mosquitoes are rare. Although the current 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 promote natural demographic and evolutionary processes. Restoration of koa (*Acacia koa*) to these montane areas is a key element of habitat restoration in these areas.

A small amount of unprotected, remnant mesic koa forests currently exists on State Forest Reserve and Department of Hawaiian Homes land in the Kahikinui region of southern Haleakala. This area holds great potential to provide suitable habitat for the parrotbill, and relative to other more degraded areas of East Maui, likely will be the most cost-effective area to begin restoration work. Completion of fencing projects and initiation of programs to eradicate ungulates are needed to restore the native canopy and understory. 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 more highly degraded by ungulates. These areas, in addition to fencing and ungulate control, will require more intensive, long-term restoration to become suitable for endangered forest birds.

Much of the potential parrotbill habitat on West Maui and East Moloka`i is managed as native ecosystems mostly free of ungulates. However, the suitability of these areas with respect to the presence of introduced mosquito-borne diseases is not clear. Much of the potential habitat lies at elevations below 4,500 feet (1,350 meters), where mosquitoes may be common. 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. Control of small mammalian predators is needed throughout recovery habitat. Predator control may be especially important for parrotbill populations, because this species has an intrinsically low reproductive rate and is particularly sensitive to unnaturally high rates of nest loss and adult mortality (Simon *et al.* 2000). Currently, intensive control of rats is underway in a portion of Hanawī Natural Area Reserve in association with Po`ouli recovery efforts. An important component of parrotbill recovery should be evaluation of the effect of rodent control on parrotbill reproduction and survival, and an expansion of the scale of the work if warranted.

Disease. Protecting and restoring habitat in upper elevation disease-free areas is the principle feasible recovery strategy with respect to disease. Identification of resistance or tolerance to disease within the population is a second important strategy. Resistance or tolerance appears to be evolving in populations of some birds (Cann and Douglas 1999), and may exist for parrotbill as well. Parrotbills may occur at lower elevations in Kipahulu Valley than elsewhere, but the causes are not clear, and this pattern may be related to habitat management rather than disease resistance. Further research into the causes of this pattern is needed. Identification of resistant individuals holds the potential to identify genetic markers that are associated with resistance. If this is successful, incorporation of these individuals into captive breeding and translocation programs could greatly enhance recovery efforts.

Captive Propagation and Reintroduction Programs. Captive propagation may play a significant role in recovery of the Maui parrotbill once recovery habitat is managed, allowing for the release and reestablishment of additional populations of this species. To establish a second population, current efforts should continue to build a captive-breeding population for eventual reintroduction of Maui parrotbill to southern Haleakala, and to West Maui or East Moloka`i. 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. Currently, areas on the fringe of parrotbill range in Waikamoi and Manawainui may provide suitable habitat for pilot releases. Work is needed presently to evaluate vegetation and parrotbill densities in those areas in order to assess the suitability of those sites as pilot release areas. Other potential sites on southern Haleakalā to the west of Kaupo Gap, such as the Kahikinui remnant forests, will need evaluation of habitat suitability and may require restoration before they are able to support a parrotbill population. The suitability of habitat for parrotbill on West Maui and East Moloka`i is not clear for the reasons discussed above. Pending an evaluation of their suitability, any releases in those areas would have to be considered experimental, with extensive evaluation of their success. It is therefore important that an evaluation be carried out to document the relative costs associated with habitat evaluation versus experimental reintroduction.

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

DESCRIPTION

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 has a long history of nomenclatural change (Olson and James 1995).

LIFE HISTORY

The life history of the Kaua`i `akialoa is poorly known, mainly from observations at 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 stejnegeri*).

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 (Figure 19). After a hiatus of many decades, the species was seen again in the late 1960's, and one specimen was collected. It has not been seen since, despite efforts by ornithologists (Conant *et al.* 1998), birders, and six intensive surveys by wildlife biologists in 1968 to 1973, 1981, 1989, 1994, and 2000 (Hawai'i Department of Land and Natural Resources 1995, Reynolds and Snetsinger 2001). The Kaua`i `akialoa is probably extinct.

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 also are 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, and it was 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 values from certain degrading factors caused by human activities. The Hawai'i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 nuku pu`u (*Hemignatus lucidus hanapepe*)

DESCRIPTON AND TAXONOMY

The Kaua`i nuku pu`u is a long-billed Hawaiian honeycreeper, larger than the 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 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 nuku pu`u differ from Maui nuku pu`u by their larger size and subtle differences in plumage (see Maui nuku pu`u species account).

The Kaua`i nuku pu`u is one of two subspecies of nuku pu`u that may still survive (the other is the Maui nuku pu`u, *H.l. affinis*). The Kaua`i nuku pu`u was described by Wilson (1889). Evidence is mounting that the Kaua`i, O`ahu, and Maui forms of nuku pu`u are distinct species (T. Pratt, J. Lepson, and R. Fleischer unpubl. data).

LIFE HISTORY

The historical record provides little information on the life history of the Kaua`i nuku pu`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 account for that species). Kaua`i nuku pu`u extracted or excavated invertebrates from epiphytes, bark, and wood using their unusual bill in a manner similar to that of the `akiapōlā`au. Nuku pu`u often join mixed species foraging flocks, especially Kaua`i creeper (*Oreomystis bairdi*). The song of the Kaua`i nuku pu`u resembles the warble of a House Finch (*Carpodacus californicus*), 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 century indicate that the Kaua`i nuku pu`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 nuku pu`u have been reported, so our understanding of the original distribution of this subspecies is limited to the historical record. Since 1960, the nuku pu`u has been reported infrequently from Kōke`e and the Alaka`i (Figure 19; 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) failed to find the Kaua`i nuku pu`u, and it seem likely that this bird is extinct (Pratt and Pyle 2000).

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 Pauiohi species account).

CONSERVATION EFFORTS

The Kaua`i nuku pu`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 nuku pu`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, and it was 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 values from certain degrading factors caused by human activities. The Hawai'i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 nuku pu`u, *Hemignathus lucidus affinis*

DESCRIPTION AND TAXONOMY

The Maui nuku pu`u is a medium-sized, approximately 23-gram (0.78 ounce), Hawaiian honeycreeper 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 supercilliary line. Maui nuku pu`u differ from Kaua`i nuku pu`u by their smaller size, yellowish rather than whitish vent, and grayish-green rather than yellowish-green back.

The Maui nuku pu`u is one of three subspecies. The Maui and Kaua`i subspecies (*H.l. hanapepe*) 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 nuku pu`u are distinct species (T. Pratt, J. Lepson, and R. Fleischer unpubl. data). The Maui nuku pu`u was described by Rothschild (1893 to 1900).

LIFE HISTORY

The historical record provides little information on the life history of the Maui nuku pu`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 account for that species). Maui nuku pu`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 nuku pu`u was reported by Perkins (1903) to be small weevils and larvae of coleoptera and lepidoptera. 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 nuku pu`u take nectar from flowers. Maui nuku pu`u often join mixed species foraging flocks (Perkins 1903). Their song resembles the warble of a House Finch (*Carpodacus californicus*), 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 century, indicate that the Maui nuku pu`u inhabited mixed koa/`ōhi`a forest from 1,220 meters (4,000 feet) to timberline (Perkins 1903, Banko 1984b, The Nature Conservancy Natural Heritage Database) on the northwestern slope of Haleakalā. Sightings since the 1967 rediscovery of the Maui nuku pu`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 nuku pu`u on Moloka`i and Maui show that the species once inhabited dry forests.

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, the Maui nuku pu`u is known only from Maui, but subfossil bones of a probable Maui nuku pu`u from Moloka`i show that the species formerly inhabited that island (James and Olson 1991). A nuku pu`u specimen from Hawai`i Island does not represent the Maui form and instead could be a mislabeled O`ahu bird (Olson and James 1994, R. Fleischer pers. comm.). 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 nuku pu`u. As on Kaua`i, introduced mosquitoes (Hardy 1960) and avian diseases may have already limited these birds to forests at higher elevations. However, we can presume that the Maui nuku pu`u once had a much wider geographic range.

In 1967, W. Banko rediscovered Maui nuku pu`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 nuku pu`u is difficult to evaluate. Scott *et al.* (1986) estimated a population of 28 ± 56 birds based on a single sighting. The most intensive surveys to date (1995 to 1999) did not detect nuku pu`u in these locations (Baker 2001, Hawai'i Department of Land and

Natural Resources unpubl. data), and the Maui subspecies may be extinct (Pratt and Pyle 2000).

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 account.

CONSERVATION EFFORTS

The Maui nuku pu`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 nuku pu`u. Subsequently, the species has benefited, or could benefit, from thorough surveys of the best habitat, predator control, and habitat restoration at locations where the last sightings were reported (seep po`ouli species account).

RECOVERY STRATEGY

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

12. `Akiapōlā`au, *Hemignathus munroi*

DESCRIPTION AND TAXONOMY

The `akiapōlā`au is a medium-sized (14 centimeter, 28 gram; 5.5 inch, 0.9 ounce), stocky, short-tailed Hawaiian honeycreeper 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 under parts, a greenish back and wings, and black lores. Adult females differ in color, with a yellow 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 nuku pu`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 this fascinating and unusual species currently is the subject of an intensive study by L. Pejchar of the University of California at Santa Cruz.

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`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. Usually only one young is fledged, followed by an extended period (>4 to 5 months) of juvenile dependency, so that only a single young typically is produced per year. In one study of a declining population, annual productivity was found to average 0.86 young per pair, which is low compared to most passerines (Ralph and Fancy 1996).

The aspect of the `akiapōlā`au's life cycle most important to conservation is the low intrinsic rate of reproduction, which puts a premium on success of nesting events and on adult survival. Even under optimal conditions, `akiapōlā`au populations cannot be hoped to grow as rapidly as that of other Hawaiian honeycreepers sharing their habitat; indeed, under threat they may be expected to decline more quickly.

`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, hooked upper mandible is used as a probe to extract insect larvae and spiders from crevices or insect borings. Despite their different lengths, the two mandibles can 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). What drives sexual foraging differences is unknown. Tree species preferred for foraging include koa, kōlea, māmane, and naio, 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.

While this species rarely takes nectar from flowers, 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. It is not clear how these "sap" trees are selected, and the prevalence of this behavior and the importance of this nutritional source have yet to be investigated.

`Akiapōlā`au often join mixed species foraging flocks, perhaps to benefit from their 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 censusing 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.* 2001). Home ranges are defended as territories, and there is little evidence of daily or seasonal movement patterns. Some birds appear temporarily in areas where they are usually not seen, suggesting some seasonal movement; others remain on territory year-round. What factors influence the huge range in territory size, and therefore population size, is unknown, but would be important to understand. With so little disease-free habitat available to this species, it would be valuable to explore how to increase population density as a means of increasing population size.

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. The recent discovery of `akiapōlā`au inhabiting young koa plantations demonstrates that this species may not be restricted to old growth. Although koa/`ōhi`a forest occurs below 1,300 meters elevation (4,000 feet), 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.

`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. What constitutes a barrier to habitat use or to dispersal is unknown.

While habitat preferences of `akiapōlā`au in primary forest are well documented, their use and persistence in successional habitats and in habitat mosaics needs 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. Study of habitat use is needed at the individual and metapoplulation 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 9; Pratt *et al.* 2001). Perkins (1903) reported that they were abundant and occurred as low as 500 meters (1,650 feet) in forests near Hilo. In the 1940's, 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 1970’s, `akiapōlā`au were found in four disjunct populations inhabiting koa-dominated montane forests: in Hāmākua south across the upper Waiākea kīpuka to Kūlani and Keauhou, in Ka`ū and Kapāpala, in southern Kona, and in central Kona (Figure 9). A fifth population occupied subalpine dry forest on Mauna Kea. Originally these populations were all connected, but they have been isolated mainly due to 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). An estimated 793 `akiapōlā`au, or 68 percent of the population, was found in koa-dominated forests on the Hāmākua coast. The population in the Kūlani and Keauhou Ranch area was estimated at 312 `akiapōlā`au, and the Ka`ū/Kapāpala population was estimated at 44 individuals. Only three `akiapōlā`au remained in the māmane forest on Mauna Kea in 2000. Another few birds inhabit koa/`ōhi`a forests of central Kona, and the status of the birds in southern Kona is unknown. The central and southern Kona populations have not been censused in 25 years.

The Hawai`i Forest Bird Surveys in the late 1970's found `akiapōlā`au in the same disjunct populations, with a total estimated population size of 1,500 birds ± 400 (95 percent confidence interval; Scott *et al.* 1986). Compared with the early 1990's estimates mentioned above, a decline is evident in range and numbers. The most significant change has occurred in the Ka`ū/Kapāpala area, where the population apparently has decreased from an estimated 533 to 44 individuals for unknown reasons; the area, some of which is recovering from grazing, should be resurveyed to verify this decline. The dry forest population has decreased from an estimated 46 individuals to less than 10, an unexpected outcome as the habitat is recovering. The Hāmākua population seems to be maintaining its numbers, although the species' distribution has contracted somewhat since the 1970's, and the population there in the 1970's may have been underestimated (Fancy *et al.* 1995).

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 censused. 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 censusing methodology to supplement standard point-counts, and by initiating a comprehensive investigation of the species metapopulation.

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 remain a persistent 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 mamane-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 also has lead to a fragmentation of 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, mongoose, and owls is suspected to have a significant impact on many native Hawaiian bird species (Atkinson 1977, VanderWerf and Smith in press), 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 4500 feet (1,350 meters), 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 1980's, and a research project dedicated specifically to `akiapōlā`au was initiated in 2000, by L. Pejchar of the University of California at Santa Cruz.

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 220,000 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 recovery habitat and could serve as sites for reintroducing `akiapōlā`au.

RECOVERY STRATEGY

Recovery of the `akiapōlā`au will require protection, management, and restoration of native forests above 4,500 feet (1,350 meters), 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 and census methodology, followed by mapping and censusing 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; 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 Habitat. The most important component of the recovery strategy for the `akiapōlā`au is protection, management, and restoration of koa/`ōhi`a forests above 1,300 meters (4,000 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 Hakalau Forest National Wildlife Refuge. It is important that this action include all recovery habitat (Figure 9). Several numbers reinforce this point: the current average density of `akiapōlā`au is one pair per 20 hectares (49 acres). By comparison, 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 habitat encompasses 238,000 hectares (588,000 acres; Figure 9), much of which requires extensive restoration.

Old-growth koa/`ōhi`a forest on many parcels in recovery habitat 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 in press). 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 10.8 to 13.0 centimeters in length (4.3 to 5.1 inches) and 13.7 grams (0.48 ounces) average weight. 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 (*Hemignathes virens*), Hawai\`i \`ākepa (*Loxops coccineus coccineus*), and Japanese White-eye (*Zosterops japonicus*) (Scott *et al.* 1979).

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 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 hectares (9.9 to 17.3 acres) 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 (17.3 acres), and join other forest birds in mixed-species flocks (VanderWerf 1998a).

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; see Remsen and Robinson 1990 for definitions of foraging terms). 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 and koa trees; the remainder of maneuvers were in subcanopy trees (specifically, `ōlapa), 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 (about 120 to 180 days), and molt occurs from May to August (Ralph and Fancy 1994a, Woodworth *et al.* 2001). A small proportion (<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 1998a, Woodworth *et al.* 2001). Based on 61 nests found at Hakalau Forest National Wildlife Refuge from 1994 to 1999, Hawai`i creeper generally build cup nests at mid-canopy at about 13 meters (range 2.8 to 24 meters) in height (43 feet, range 9 to 79 feet) and about 1.5 meters (range 0 to 4.8 meters) from the main bole of the tree (5 feet, range 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 2 eggs, nest building requires 11 to 19 days, incubation 13 to 17 days, and nestling period 18 days (Sakai and Johanos 1983, VanderWerf 1998a, Woodworth *et al.* 2001). Approximately one-third of recorded nesting attempts have been abandoned before egg-laying commenced (33 percent, n = 6, VanderWerf 1998a; 27.9 percent, n = 61, Woodworth *et al.* 2001). At Hakalau Forest National Wildlife from 1994 to 1999, daily survival rates of active creeper nests was 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 1998a; 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 (Nelson *et al.*, in prep). 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 1998a; Woodworth *et al.* 2001). If a complete nesting cycle requires about 50 days plus post-fledging care, and breeding seasons typically last at least 120 days, then there appears to be ample time for pairs to start a second brood. However, a daily nest failure rate of 5 percent might effectively prevent this from occurring very often.

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 refugia, above the level of mosquito populations.

In general, 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 to Hawai`i. 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 Hawa`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 (range 4.3 to 27.1 hectares, 10.6 to 66.9 acres), and individuals banded birds have been observed in different locations 1 to 4 kilometers (.62 to 2.48 miles) apart (VanderWerf 1998). Snetsinger (1995) observed a Hawai`i creeper in mamane 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 1500 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 (*Metrosideros polymorpha*) and koa (*Acacia koa*). The subcanopy is composed of `ōlapa (*Cheirodendron trigynum*), pūkiawe (*Styphelia tameiameiae*), `ōhelo (*Vaccinium calycinum*), `ākala (*Rubus Hawaiiensis*), kolea (*Myrsine sandwicensis*), kawa`u (*Ilex anomola*), and *Cibotium* tree ferns (Woodworth *et al.* in prep.).

Hawai`i creeper, along with `akiapōlā`au (*Hemignathus munroi*) and Hawai`i `ākepa (*Loxops coccineus*), show a decreasing population density gradient from south to north across three sites in Hakalau Forest National Wildlife Refuge (2.18 ± 0.50 birds/hectare in the south at Pua `Ākala, compared with 0.57 ± 0.23 birds/hectare in the north at Maulua). The causes for the density gradient are unknown, but based on correlative studies, habitat structure, cavity availability, relative abundance of feral cats and rodents, or presence of breeding mosquitoes have been ruled out as probable causative factors. Feral pig sign was negatively correlated with Hawai`i creeper density across the three sites. Other possible limiting factors remaining to be investigated include abundance of arthropod prey and periodic disease epizootics in the northern sections of the refuge (Woodworth *et al.* in prep).

HISTORICAL AND CURRENT RANGE AND STATUS

In the 1890's, 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; Perkins 1903). Creepers were recorded in the Kona and Ka`ū districts as well as the forests above Hilo (Figure 10). Perkins noted that they were very abundant and generally distributed but had 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 1930's and 1940's 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 10;

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 1980's (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, particular black rats (*Rattus rattus*) into their habitat. Hawai`i creeper nests may be particularly 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 (*Zosterops japonicus*, 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, 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 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 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 the early 1990's, and over 250,000 koa seedlings have been planted thus far. The `Ōla`a/Kīlauea Partnership and Kona unit of Hakalau Forest National Wildlife Refuge also provided 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 habitat 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 1980's. The productivity, recruitment, and survival of the Hawai`i creeper was investigated as part of a larger study by 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 creeper 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 10). To maintain connectivity and allow dispersal among fragmented patches of habitat, cattle should be removed from several key parcels and habitat restoration pursued. Management for avian disease should focus on reduction of breeding habitat for mosquitoes through drainage of stock ponds, public education/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. Progeny from captive-propagation efforts would provide birds for reintroduction in order to establish and enhance populations of Hawai`i creeper in managed recovery habitat.

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

DESCRIPTION AND TAXONOMY

Description. The O`ahu creeper, or O`ahu `alauahio, is a small, sexually dichromatic Hawaiian honeycreeper 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 chloris*), 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 (American Ornithologists Union 1997). It is currently placed in the genus *Paroreomyza* (Olson and James 1982b, Pratt 1992b, American Ornithologists Union 1997), 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 1,000 to 2,000 feet (300 to 600 meters), 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 16). 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 1890’s,” 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 1,500 feet (350 meters) elevation.

The O`ahu creeper has undoubtedly declined very seriously since it was first observed, and it may already be extinct. 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 `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.

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).

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 cold temperatures (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 (VanderWerf and Smith in press), 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

The kākāwahie, or Moloka`i creeper, was known only from Moloka`i, but now is assumed to be extinct. 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 was short and straight. Its calls were 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*).

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 1960's (Perkins 1903, Munro 1944, Pekelo 1963). This species was an insectivore that gleaned vegetation and bark of the wet `ōhi`a (*Metrosideros polymorpha*) forests. Only minimal information exists about nests and young Munro (1944).

HABITAT DESCRIPTION

No detailed habitat description for the species is available. The boggy forested upper areas of Moloka`i have been reported by Munro (1944) and Pekelo (1963) as the species' habitat. The last detections of 1960's were on the west rim of Pelekunu Valley on the `Ōhi`alele Plateau in moss-shrouded `ōhi`a and `ōlapa (*Cheirodendron trigynum*).

HISTORICAL AND CURRENT RANGE AND STATUS

Historically, the species was recorded only from Moloka`i (Figure 15). 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 still earlier searches (Scott *et al.* 1986). All surveys and special searches since 1988 have failed to detect this species (Hawai`i Department of Land and Natural Resources 1988, U.S. Geological Survey 1995, Hawai`i Department of Land and Natural Resources 1995, U.S. Geological Survey 1996, Reynolds and Snetsinger 2001). This species is likely extinct.

REASONS FOR DECLINE AND CURRENT THREATS

Reasons for the early 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), 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). 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 typically 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. All females are entirely gray during their second year. Thereafter they can acquire a trace of a yellow breast-band, a full yellow breast-band, an orange yellow breast-band that extends onto the throat, and extensive orange-yellow that covers the entire head and breast (Freed and Lepson in review). These increasing color classes are loosely related to age, but most females do not acquire the orange-yellow and extensive classes. Juvenal plumage, similar in both sexes, is grayish green above, pale gray below, often with a whitish superciliary line (Lepson and Freed 1997).

The Hawai`i `ākepa has a long notched tail. The bill is conical and generally pale yellow in color, with variation that includes a brown ridge on the culmen (central ridge of the upper mandible) and orange cutting edges. 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 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).

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 probably is 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 and 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/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 v. virens), `i`iwi (*Vestiaria coccinea*), and `apapane (*Himatione sanguinea*). Only one brood can be completed 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, 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 provision of nestlings. Despite the potential vulnerability of cavity nesting species to predators like 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. The displays include an arboreal display of 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" rising as high as 100 meters (330 feet) before breaking up.

It appears that variation in female plumage and fitness drives this competition. Females in the more colorful classes have both higher annual survival and higher nesting success than duller females of the same age (Freed and Lepson in review). 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 extensively on small insects, spiders, and caterpillars throughout the year. It rarely feeds on nectar. Foraging is mainly on the terminal leaf clusters of `ōhi`a (*Metrosideros polymorpha*), and to a lesser extent among koa (*Acacia 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 berry pulp (*Rubus hawaiiensis*) 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 (13.9 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 feet) in diameter at breast height (Freed 2001). `Ōhi`a are 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 *et al.* in prep.).

HISTORICAL AND CURRENT RANGE AND STATUS

The historical range is shown in (Freed 1999). The major change in distribution has been the loss of birds from lower elevations, below 1,300 meters (4,300 feet). However, the range at also has contracted somewhat at upper elevations (compare Freed 1999 with Scott *et al.* 1986).

Hawai`i `ākepa are currently found in 5 disjunct populations in `ōhi`a/koa forests in Hāmākua, Kūlani/Keauhou Ranch, Ka`ū, southern Kona, and Hualālai, totaling approximately 14,000 ± 2,500 birds in 1980 (Figure 11; 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 remaining forest habitat. Hawai`i `ākepa are especially sensitive to the loss of old growth forest due to their exceptional 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).

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 or desiccation than smaller trees. The areas of highest `ākepa density are in disturbed areas and nest-site sized trees are falling at a rate of five trees per square kilometer (.621 per square mile) per year at Hakalau Forest National Wildlife Refuge. Reduced 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). The next source of monopodial trees is not obvious from existing seedlings.

`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). Both the mosquito and malarial parasite are limited in elevation by temperature. Greater exposure of remaining `ākepa populations to vectors and pathogens is likely to occur with global warming. 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 the early 1990's, and over 250,000 koa seedlings have been planted thus far. The `Ōla`a/Kīlauea Partnership and Kona unit of Hakalau Forest National Wildlife Refuge also protect and manage 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 habitat that could serve as sites for reintroducing Hawai`i `ākepa.

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) 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 in press). 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 has been developed for the Hawai`i `ākepa in case it is needed to help reestablish wild populations. 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

The Maui `ākepa closely resembles the better known Hawai`i `ākepa (*L. c.coccineus*) in coloration and biometrics (Lepson and Freed 1997, and 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.

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 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 vs. hollows in branches would be important to discover. Refer to the account of Hawai`i `ākepa for comparable information about that race.

HABITAT DESCRIPTION

All specimens of Maui `ākepa were collected in `ōhi`a/koa rainforest at 1,200 to 1,800 meters (4,000 to 6,000 feet) 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 race also may have once occupied all forests within its range. 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 (Figure 14). This range suggests that the birds were missing from forests at lower elevations, perhaps due to the introduction of disease-transmitting mosquitoes to Lāhainā in 1826 (Hardy 1960). However, it may be that the Maui `ākepa originally occupied all forests on Maui. Complete destruction of habitat has not been 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. In fact, no reliably detectable population has been known during this period, and there is little evidence to dispute that the Maui `ākepa has been extinct for decades. Regardless, the current population, if it exists, is undetected and 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).

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 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). Surveys to locate the bird in 1995 to 1999 yielded no definite detections (Reynolds and Snetsinger 2001).

RECOVERY STRATEGY

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

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

DESCRIPTION AND TAXONOMY

The \`ākohekohe, or crested honeycreeper, is the largest (24 to 29 gram) (0.8 to 1.0 ounce) honeycreeper remaining on Maui Nui. 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. Feet and legs and bill 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 and \`i\`iwi.

LIFE HISTORY

The \`ākohekohe is primarily nectarivorous, but also feeds on caterpillars (Lepidoptera), spiders, and dipterans (Perkins 1903, Carothers 1986, VanGelder 1996). Nectar is primarily sought from flowers of \`ōhi\`a (*Metrosideros polymorpha*), but also from several subcanopy tree and shrub species (VanGelder 1996, Berlin *et al.* 2000). 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.

Investigation of the \`ākohekohe's life history and ecology began with studies of its distribution in the late 1970's (Scott *et al.* 1986), followed by its role in the nectarivore community (Carothers 1986), and several reproductive and ecological investigations (VanGelder 1996, Berlin *et al.* 2001, U.S. Geological Survey unpubl. data). \`Ākohekohe maintain and defend relatively discrete feeding and nesting territories throughout the year by chasing and calling (VanGelder 1996, Pratt *et al.* in press). The species appears to be monogamous for more than one breeding season, with pair formation starting in October, and nesting occurring mainly between November and May (VanGelder 1996, Berlin and VanGelder 1999). These authors also reported two to three successful broods in a season. `Ākohekohe typically nest 14 meters (46 feet) above ground in the terminal ends of branches below the canopy foliage of `ōhi`a trees (VanGelder 1996, Berlin and VanGelder 1999). 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, VanGelder 1996, Berlin and VanGelder 1999).

HABITAT DESCRIPTION

At present `ākohekohe survive in montane wet and mesic forests dominated by `ōhi`a (*Metrosideros polymorpha*). The habitat is generally as described for the Maui parrotbill, 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.

HISTORICAL AND CURRENT RANGE AND STATUS

The `ākohekohe is currently found only in 58 square kilometers (22 square miles) of wet and mesic montane forests on the northeastern slopes of East Maui on Haleakalā Volcano, Maui, from 1,100 to 2,300 meters elevation (3,600 and 7,550 feet), with nearly all birds occurring from 1,500 to 2,100 meters (5,000 to 6,600 feet); (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 through the Ko`olau and Hāna Forest Reserves east 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 12; 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 1890's on the western slopes of Kula in mesic koa (*Acacia koa*)/`ōhi`a forested, 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 that 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 1995), and limited surveys 1995 to 1997 by U.S. Geological Survey biologists, indicated approximately the same densities of birds within the same range.

REASONS FOR DECLINE AND CURRENT THREATS

The `ākohekohe is seemingly vulnerable to all of the same threats that negatively impact other honeycreepers on Maui (Berlin and VanGelder1999). Mortality from mosquito-borne diseases likely limits the species at lower elevations (Scott *et al.* 1986), and avian malaria was recently isolated from an `ākohekohe in Hanawī Natural Area Reserve (Feldman *et al.* 1995). `Ākohekohe may be particularly vulnerable to mosquito-borne diseases because they migrate attitudinally in response to varying `ōhi`a flowering phenology, potentially increasing their exposure to mosquitoes at lower elevations. 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). 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

The `ākohekohe was federally listed as endangered on March 11, 1967 (U.S. Fish and Wildlife Service 1967), automatically protected under State of Hawai`i endangered species law on March 22, 1982, and was included in the previous Maui-Moloka`i Forest Bird Recovery Plan (U.S. Fish and Wildlife Service 1984a). For information on habitat protection and restoration see the Maui parrotbill account; these two species share roughly the same geographical range.

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 these two species 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.

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 (Figure 12). 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 habitat should remain an option if translocations of wild birds do not succeed in establishing a second population. Suitability of West Maui and Moloka`i as release sites for translocated birds currently is questionable due to the presumed presence of avian diseases in these lower elevation areas.

19. Po`ouli, *Melamprosops phaeosoma*

DESCRIPTION AND TAXONOMY

The po`ouli is a medium-sized, 26 gram (0.9 ounce), stocky Hawaiian honeycreeper 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 under parts, whereas females (and perhaps young males) have a grayish throat and breast. Fledglings have whitish under parts, 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 discovered in 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 (*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 like the other bark-foraging honeycreepers, the `akiapōlā`au and Maui parrotbill. In 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 the 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 about 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. Throughout nesting, the male fed the female at or away from the nest. 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 pūkiawe 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 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, kawa`u (*Ilex anomola*), and `ōhi`a (Mountainspring *et al.* 1990, Pratt *et al.* 1997b). Po`ouli glean from, 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 (Kepler *et al.* 1996).

Po`ouli often associate with mixed species foraging flocks of other insectivorous honeycreepers, especially Maui `alauahio (*Paroreomyza montana*) and Maui parrotbill, 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 po`ouli. 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 more 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 (Jamie Bruch, pers. comm.).

HABITAT DESCRIPTION

Po`ouli currently 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. Rainfall, delivered mostly by the trade wind weather system, exceeds 5 meters (200 inches) annually. The vegetation is mixed shrub montane wet forest (Jacobi 1985) with a canopy averaging 13 meters (43 feet) height and 60 percent crown cover, dominated by `ōhi`a (*Metrosideros polymorpha*). 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 as such are intolerant of habitat alteration by feral pigs.

HISTORICAL AND CURRENT RANGE AND STATUS

The po`ouli apparently was unknown to the Hawaiians; it eluded western naturalists during the discovery period of Hawaiian ornithology at the end of the 19th century, and was discovered by a team of university students in 1973 (Casey and Jacobi 1974). Historically, po`ouli have been confined to a 1,300-hectare (3,200 acres) section of forest on the northern and eastern slopes of Haleakalā Volcano, Maui (Figure 14; 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, implicating a much broader geographic and habitat range (James and Olson 1991).

Po`ouli numbers and range have declined to a tiny population difficult to detect over at most a few hundred hectares. Attempts to estimate population size and density have met with frustration because of the bird's poor delectability. Mountainspring *et al.* (1990) reported densities at the type locality of 76 ± 8 (SE) birds/square kilometers in 1976, 15 ± 7 birds/square kilometers in 1981, and 8 ± 4 birds/square kilometers in 1985 (30.8 ± 3.2 birds/100 acres in 1976, 6.1 ± 2.8 birds/100 acres 1981, and 3.2 ± 1.6 birds/100 acres in 1985). No birds were found in the type locality in 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); (Reynolds and Snetsinger 2001, Baker 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). These last three birds, now known to consist of one male and two females, occur in separate, non-overlapping home ranges, so there are no known breeding pairs.

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. Of these factors, the most important are presumed to be nest predation by rats and mortality from mosquito-borne diseases. Both black and Polynesian rats are abundant in po`ouli habitat (Sugihara 1997). 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 State of Hanawī Natural Area Reserve. Through fencing and control efforts, the State has removed feral pigs from sections of Hanawī Natural Area Reserve and State Forest Reserve that harbor po`ouli immediately to the east. These actions have stabilized soil erosion and stimulated vegetation recovery, improvements that should benefit the po`ouli. To the south, in habitat that appears suitable for po`ouli, the National Park Service has also erected fences and removed pigs.

Portions of The Nature Conservancy's Waikamoi Preserve are managed as native ecosystems and could also serve as habitat for po`ouli. Habitat downhill from the fenced portions of Hanawī Natural Area Reserve is proposed for fencing.

Several agencies and groups have initiated research and recovery. The East Maui Watershed Partnership, a consortium of government agencies, nongovernmental agencies, and private landowners seeks to protect 40,000 hectares (100,000 acres) of rainforest, of which the higher elevations contain the last population of po`ouli. The Hawai'i Department of Land and Natural Resources and the U.S. Geological survey Biological Resources Division are continuing searches for the po`ouli in the Hanawī Natural Area Reserves and adjacent habitat. The Hawai'i Department of Land and Natural Resources and the U.S. Fish and Wildlife Service have entered into a cooperative agreement to 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, surveys for native land snails, and mist netting, banding, and collecting blood samples to monitor demography and disease prevalence in native bird populations, including the po`ouli. The same program has included an attempt to translocate one po`ouli into the home range of another to encourage breeding (see Recovery Strategy for more detail).

RECOVERY STRATEGY

Fundamental to the long-term strategy for recovery of the po`ouli is 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. Recovery of vegetation should proceed rapidly at first as ferns and native shrubs move into disturbed areas. Regeneration of subcanopy trees will be slower, but within a few decades should return the forest to a restored condition. Forested lands below the lower boundary of Hanawī Natural Area Reserve should be fenced, and feral pigs removed, to provide a buffer for current po`ouli home ranges and to protect any po`ouli that have not been detected.

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 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 efforts began in January 2002. If a breeding pair is created by translocation, every effort should be made to search for nests, and any eggs produced should be brought to the appropriate facilities for rearing and establishment of a captive flock that eventually would produce birds for release back into the wild.

While surveys for po`ouli have nearly exhausted the possibility of locating new birds, additional searches may be warranted adjacent to areas already covered. In addition, research should be conducted on the feasibility of large-scale habitat management through application of rodenticide by hand broadcast or by aerial broadcast. Additional information on the abundance and distribution of the bird's prey-base would increase our understanding of whether food limits the po`ouli population.

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) and 11.5 to 17.0 grams (0.39 to 0.58 ounces), endemic to the Island of Kaua`i. Its head, back, sides, and flanks are dull gray to olive, the throat, breast, belly, and under tail 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.

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.* in press), and the species has been 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 1993, 1998) following Pratt (1979, 1992b), but its inclusion with the Hawai`i creeper in the genus is a matter of serious and 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.* in press).

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.* (in press) 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 pers. comm., T. Snetsinger pers. comm.). `Akikiki also form mixed-species flocks with `akeke`e (*Loxops caeruleirostris*), `anianiau (*Hemignathus parvus*), Kaua`i `amakihi (*Hemignathus stejnegeri*), and Kaua`i `elepaio (*Chasiempis sandwichensis sclateri*), and historically with `akialoa (*Hemignathus ellisianus*), and Kaua`i nuku pu`u (*Hemignathus lucidus hanapepe*) (Perkins 1903, Munro 1944).

Nest construction has been observed 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 pers. comm.), and the breeding season is believed to last into June or July. Only seven nests of Kaua`i creeper have been found (J. Foster pers. comm.) and only three of these have been reported in the literature (Eddinger 1972; Foster *et al.* in press). 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 at 8 to 9 meters (26 to 29 feet) high in the crowns of `ōhi`a 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 bark (J. Denny pers. comm.). 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 nestling period probably lasts 17 to 19 days, based on traits of the closely related Hawai`i creeper (Woodworth *et al.* 2001) and Maui `alauahio (Baker and Baker, 2001). Family groups of parent(s) and one to 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. Nests can fledge two young successfully, 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 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. Nectarivory and frugivory have rarely been observed.

No data are available on the annual survival rate of `akikiki. 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 (>1,500 meters, 5,000 feet) where these data were collected (see below).

HABITAT DESCRIPTION

The habitat description that follows has been taken from Foster *et al.* (in press). Kaua`i creepers are most common in mesic and wet forests from 600 meters to 1,600 meters (2,000 to 5,300 feet) elevation. In the eastern edge of the species range, annual rainfall exceeds 13,000 millimeters/year (512 inches), declining to 1,100 millimeters (43 inches) at the western edge at Kōke`e State Park. This rainfall gradient, combined with varied topography, lead to great variability in habitat in `akikiki range. The montane wet forest is dominated by `ōhi`a (*Metrosideros polymorpha*) with a subcanopy of `ōlapa (*Cheirodendron trigynum*), 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*), *Clermontia faurei*, 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 `akikiki was considered to be common from high to low elevation in native forests in the late 1800's (Perkins 1903), and was locally abundant in and near the Alaka`i Wilderness Preserve as late as the early 1960's (Figure 18; Richardson and Bowles 1964). In 1968 to 1973, J. Sincock made the first attempt to estimate the total population of `akikiki (Sincock *et al.* 1984). 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 1981, the Hawai`i Forest Bird Survey, using different methods, estimated that there were approximately 1,650 ± 450 `akikiki in a 25 square kilometer (9.5 square miles) area of the southeastern Alaka`i, in the vicinity of what is now known as Sincock's Bog (Scott *et al.* 1986). This is similar to the 2,300 ± 700 birds that Sincock had estimated in the same area. However, the range of the population has been contracting, resulting in an overall decline in numbers. In the heart of its range, `akikiki densities reached 101 to 200 birds/square kilometer (.386 square miles) in 1981 (Scott *et al.* 1986).

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.

Disease. Avian diseases, including both pox and malaria (*Plasmodium relictum*), are thought to play a major role in limiting the distribution of Kaua`i creeper. Mosquitoes have been captured as high as Sincock's Bog at 4,400 feet (1,330 meters) elevation and are likely to occur to the highest elevations on Kaua`i (D. LaPointe pers. comm.). Mist netting of forest birds from 1994 to 1997, at three locations, Pihea/Alaka`i Swamp Trail, Koai`e Camp, and Sincock's Bog, established that 2 to 5 percent of all birds have active malaria infections and up to 12 percent have 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.

To date, 10 `akikiki have been tested for disease. Of these, none had either active infections or evidence of past infection with malaria (C. Atkinson/U.S. Geological Survey unpubl. data). However, it is impossible to tell from these data how limiting a factor disease is for this species; low infection rates could reflect either low transmission rates or high mortality of infected birds.

Habitat degradation/Invasive species. 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 have been reviewed elsewhere (Cabin *et al.* 2000), including soil erosion, disruption of regeneration of beneficial plants, and spreading of alien weeds. 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 during 1968 to 1973. 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 `akikiki 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.

Predation from introduced and native species. Predation on `akikiki and their nests has not been documented. However, introduced mammals such as black rats (*Rattus rattus*), Polynesian rats (*R. exulans*), Norway rats (*R. norvegicus*), and feral cats (*Felis silvestris*) are present in the Alaka`i swamp on Kaua`i (Tweed *et al.* 2000) and are potential predators on roosting or incubating adults, nests, or young. Two species of owls, the native pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*) and introduced barn owl (*Tyto alba*), are known to depredate forest passerines (U.S. Geological Survey unpubl. data). For the time being at least, the small Indian mongoose (*Herpestes auropunctatus*) does not occur on Kaua`i.

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 1999b). 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. The surveys included the majority of interest native forest on Kaua`i above about 1,200 meters (4,000 feet). These data are currently being analyzed. Final products of this and subsequent survey efforts will include: (1) an up-to-date population estimate for the `akikiki and other bird species of concern on public lands on Kaua`i; (2) an analysis of population trends over the past 20 years for species of special concern in the 25 square kilometer (9.65 square miles) area in the southeastern Alaka`i, using historical and current data collected by the Hawai`i Forest Bird Survey and State Hawai'i Department of Land and Natural Resources; (3) an up-to-date distribution map (hard copies and GIS coverages) for `akikiki and other species of special concern in the region; and (4) a habitat suitability map for `akikiki.

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 maintained at the Keauhou Bird Conservation Center. 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 The 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 nuku pu`u (*Hemignathus lucidus hanapepe*), Kaua`i `akialoa (*Hemignathus ellisianus*), 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 and subsequent predator control were important actions that have 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 values from certain degrading factors caused by human activities. The Hawai'i Department of Land and Natural Resources established the 4,022 hectares (9,938 acres) 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 1960's. 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 *et al.* 1984). 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 1986 unpubl. Data; U.S. Geological Survey unpubl. data). 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 succeeds only in the more accessible areas of the preserve, and ungulate populations in more remote areas remain quite high. Alternatives are expensive, of limited effectiveness, logistically difficult, and/or politically contentious. Very 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. At present the Hawai'i Department of Land and Natural Resources does not consider large scale ungulate fencing and removal to be an economically feasible option for protecting the Alaka`i, and instead supports development of alternative lethal methods in remote (non-hunted) areas. It is clear that long-term protection of the Alaka`i from feral ungulates will require creativity, commitment, political savvy, an extensive public relations campaign, and significant financial backing.

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 and educate the public and gain support for funding to preserve endangered species. Privately funded filmmakers including the British Broadcasting Company and the National Geographic Society 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 Division, 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. Although it is a formidable task, there are hopes of finding some means of managing the disease problem of rare native forest birds.

RECOVERY STRATEGY

The primary strategy for the recovery of the Kaua`i creeper is the 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 18).

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

Captive Propagation and Reintroduction Programs. It could be necessary to continue development of captive breeding and release techniques for *Oreomystis* creepers as a model for potential implementation with the `akikiki.

Population Surveys and Monitoring. A primary need is an intensive demographic study of `akikiki 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 (concurrent or subsequent) management actions to mitigate key limiting factors. Also necessary is continued monitoring of the status of forest bird populations and their habitats to measure the effectiveness of management actions.

21. Bishop's `Ō`ō, *Moho bishopi*

DESCRIPTION and TAXONOMY

Bishop’s `ō`ō, now considered a “species of concern,” was a large, 12-inch (31 centimeters), vociferous, long-tailed black forest bird with a yellow ear patch, under tail coverts, and maxillary tufts. Bishop’s `ō`ō was known with certainty only from Moloka`i, and was a member of the honeyeater family (*Melaphagidae*), originating in Australia and the South Pacific and not related to the Hawaiian honeycreepers. The genus *Moho* was endemic to the Hawaiian Islands, but all four species in this genus are now extinct. The Bishop's `ō`ō was last seen in 1904 (Munro 1944). Detailed descriptions of this species and its calls are 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 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 and lobeliads in the upper elevations of Moloka\`i. Supposed 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 (Figure 15). 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 (1980-1984) 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). It seems clear that this species should 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 Hawaiians for its yellow plumes, and it is possible that unregulated feather collecting in the 1800's, when guns became available, contributed to the bird's demise.

CONSERVATION EFFORTS

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

RECOVERY STRATEGY

It is very unlikely that this species survives on either Moloka\`i or Maui. However, see the Rare Bird Discovery Protocol in Section III. D.

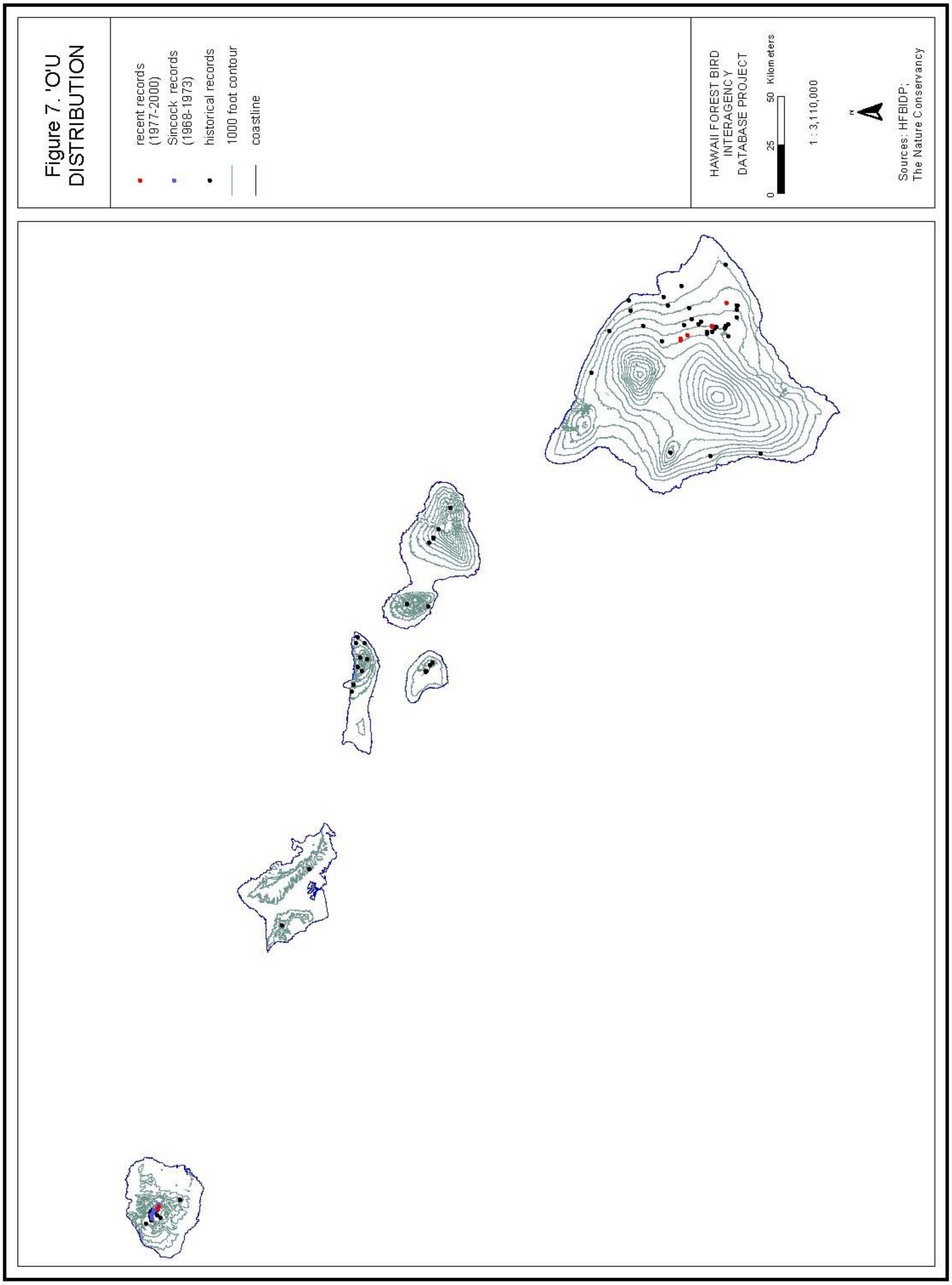


Figure 7. 'O'U DISTRIBUTION

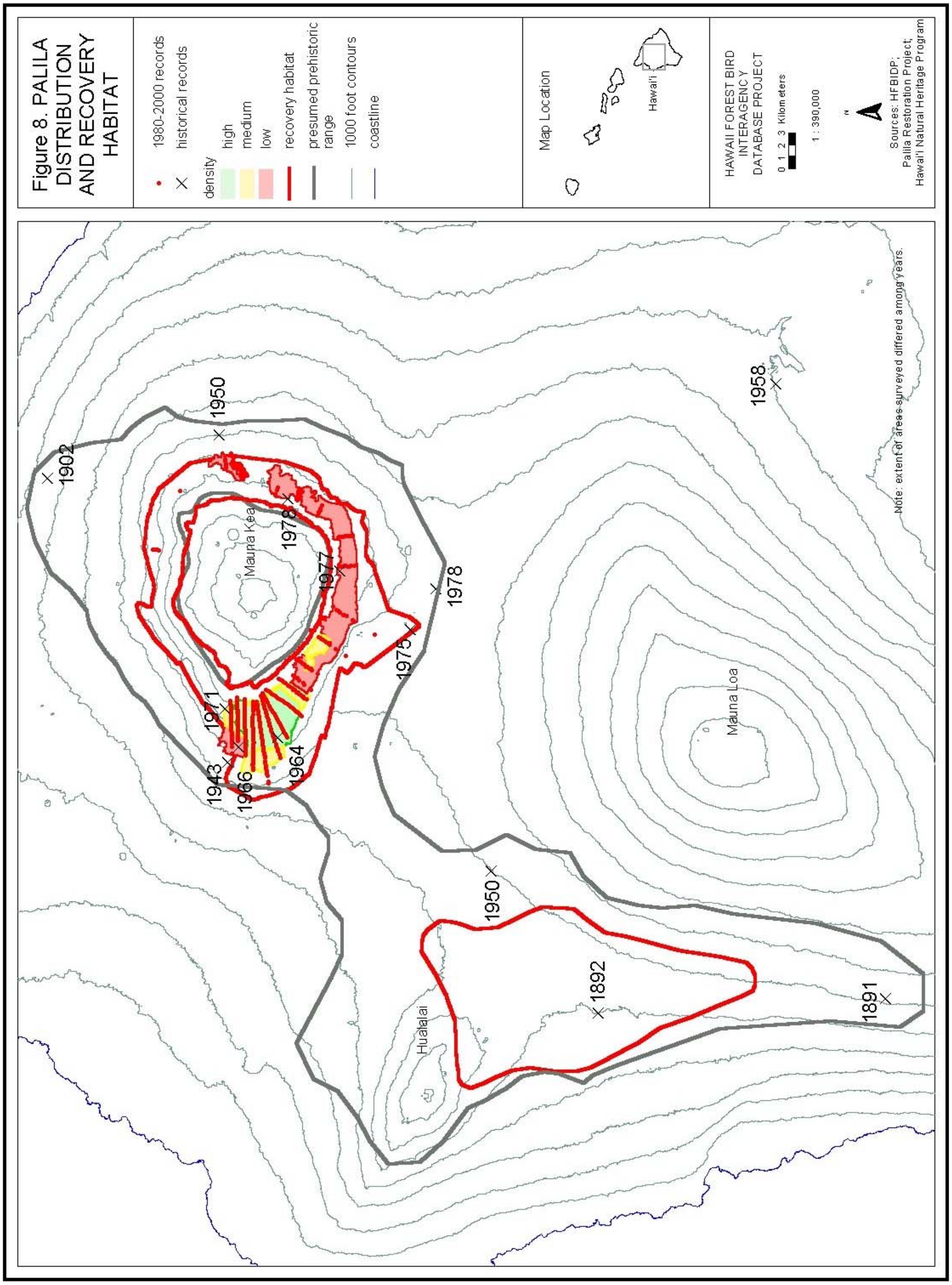


Figure 8. PALILA DISTRIBUTION AND RECOVERY HABITAT

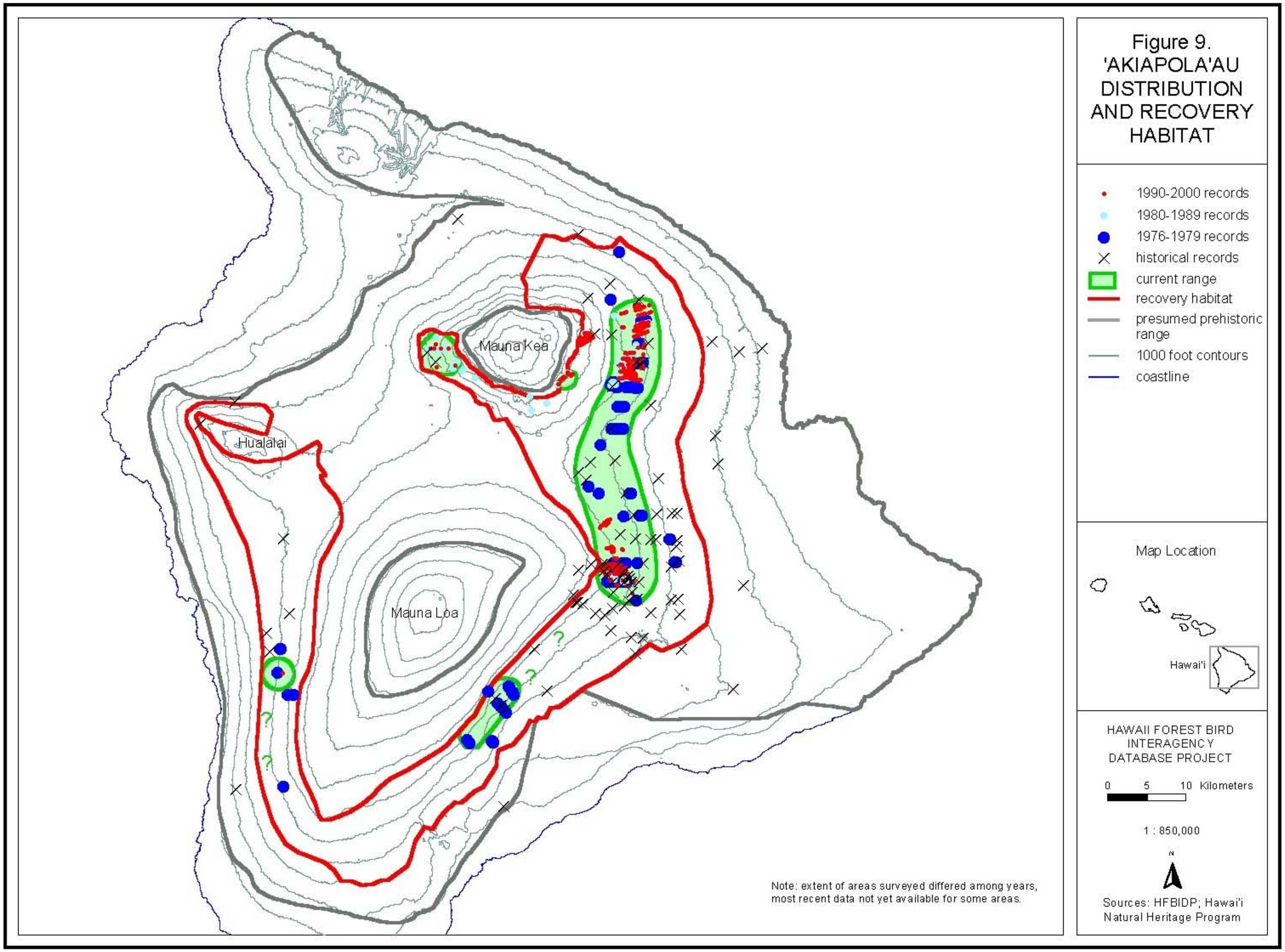


Figure 9.
'AKIAPOLA'AU
DISTRIBUTION
AND RECOVERY
HABITAT
1990-2000 records
1980-1989 records
1976-1979 records
historical records
current range
recovery habitat
presumed prehistoric range
1000 foot contours
coastline
Map Location
Hawai'i
HAWAII FOREST BIRD
INTERAGENCY
DATABASE PROJECT
0 5 10 Kilometers
1 : 850,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
Mauna Kea
Mauna Loa
Hualalai
Note: extent of areas surveyed differed among years, most recent data not yet available for some areas.

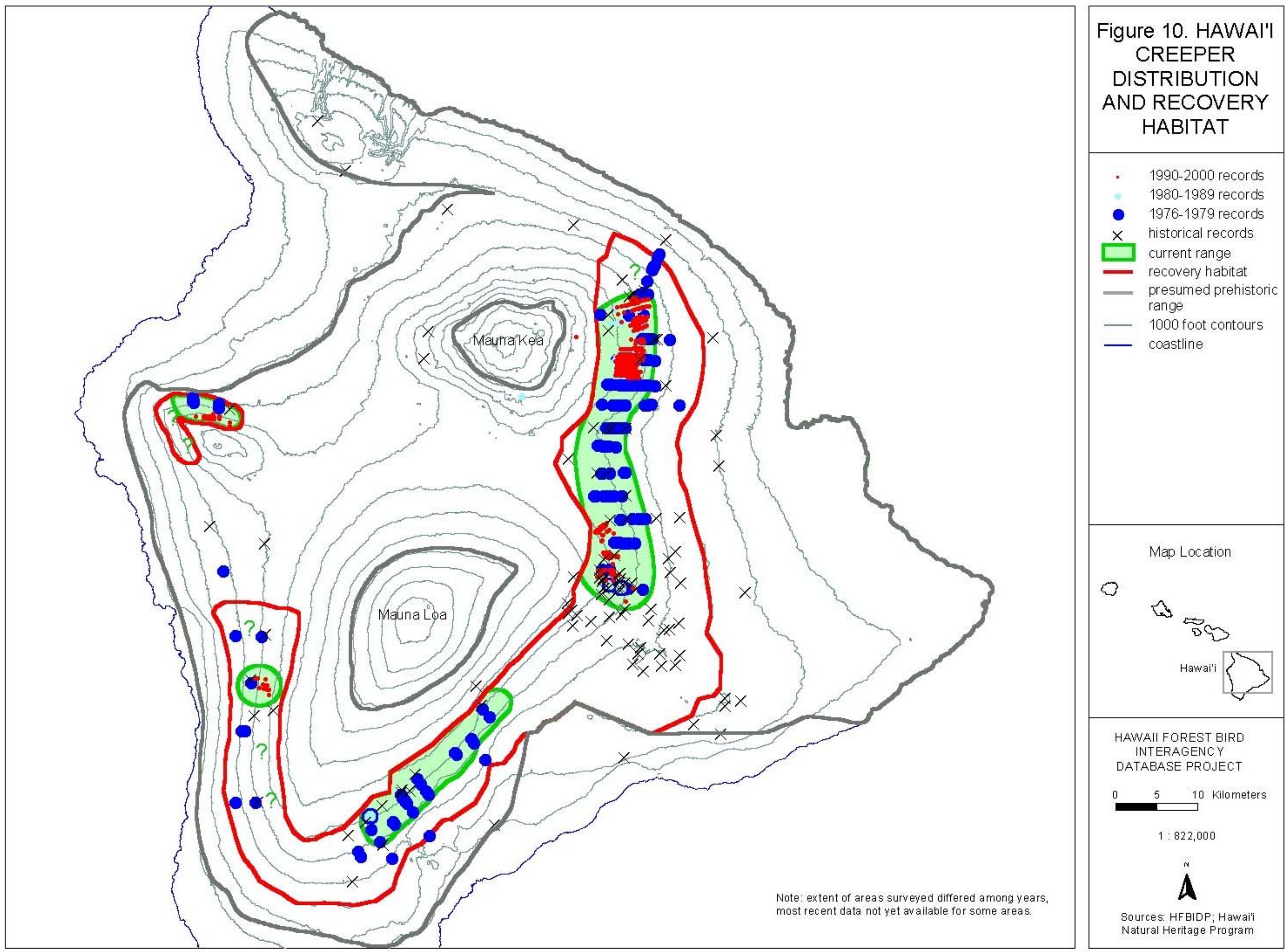


Figure 10. HAWAI'I CREEPER DISTRIBUTION AND RECOVERY HABITAT

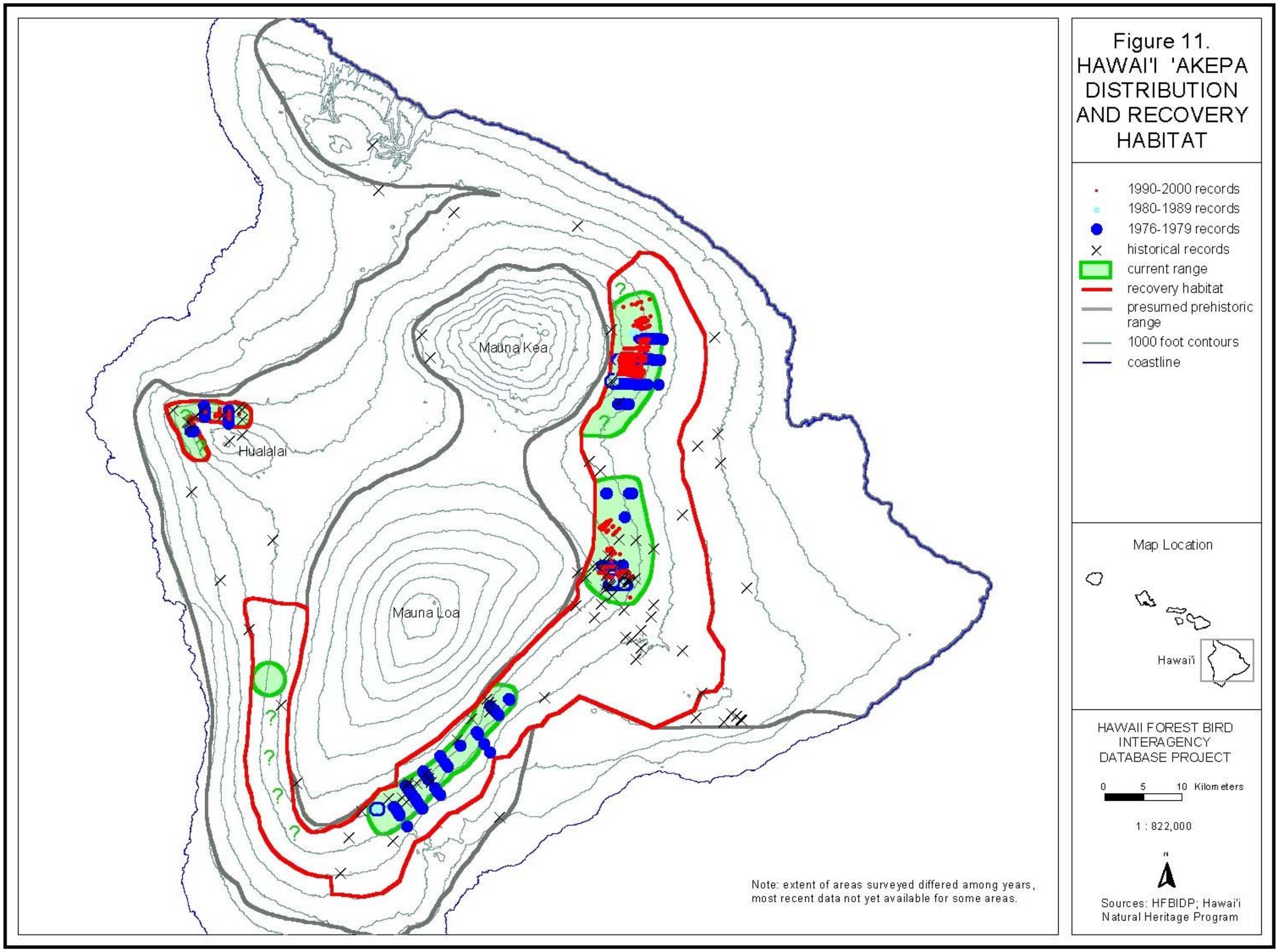


Figure 11.
HAWAI'I 'AKEPA
DISTRIBUTION
AND RECOVERY
HABITAT
1990-2000 records
1980-1989 records
1976-1979 records
historical records
current range
recovery habitat
presumed prehistoric range
1000 foot contours
coastline
Map Location
Hawai'i
HAWAII FOREST BIRD
INTERAGENCY
DATABASE PROJECT
0 5 10 Kilometers
1 : 822,000
Sources: HFBIDP; Hawai'i
Natural Heritage Program
Mauna Kea
Hualalai
Mauna Loa
Note: extent of areas surveyed differed among years,
most recent data not yet available for some areas.

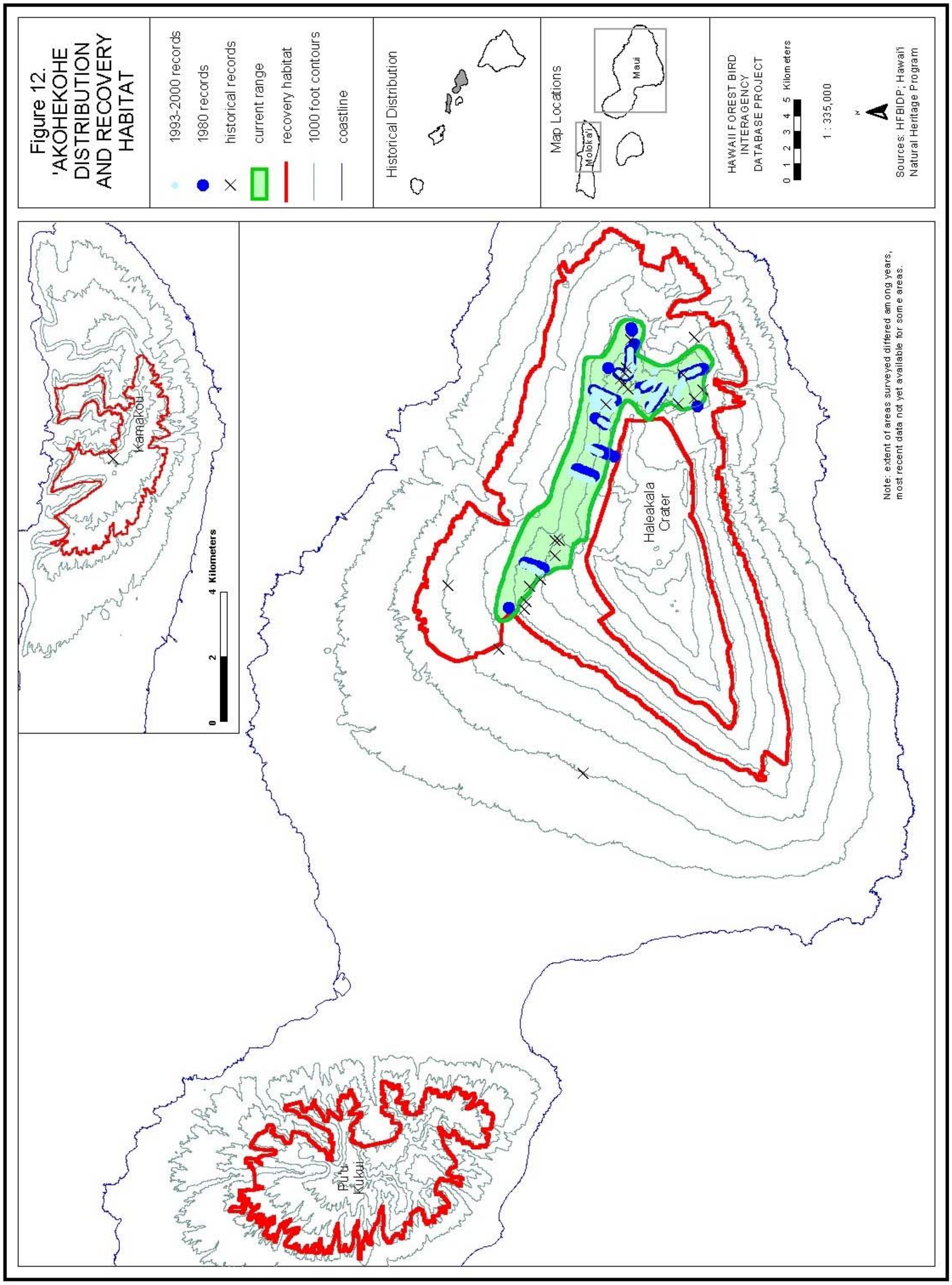


Figure 12.
'AKOHEKOHE
DISTRIBUTION
AND RECOVERY
HABITAT
1993-2000 records
1980 records
historical records
current range
recovery habitat
1000 foot contours
coastline
Historical Distribution
Map Locations
Moloka'i
Maui
HAWAII FOREST BIRD
INTERAGENCY
DATABASE PROJECT
0 1 2 3 4 5 Kilometers
1 : 335,000
N
Sources: HFBIDP; Hawai'i
Natural Heritage Program
Kamakou
0 2 4 Kilometers
Haleakala
Crater
Pu'u
Kukui
Note: extent of areas surveyed differed among years,
most recent data not yet available for some areas.

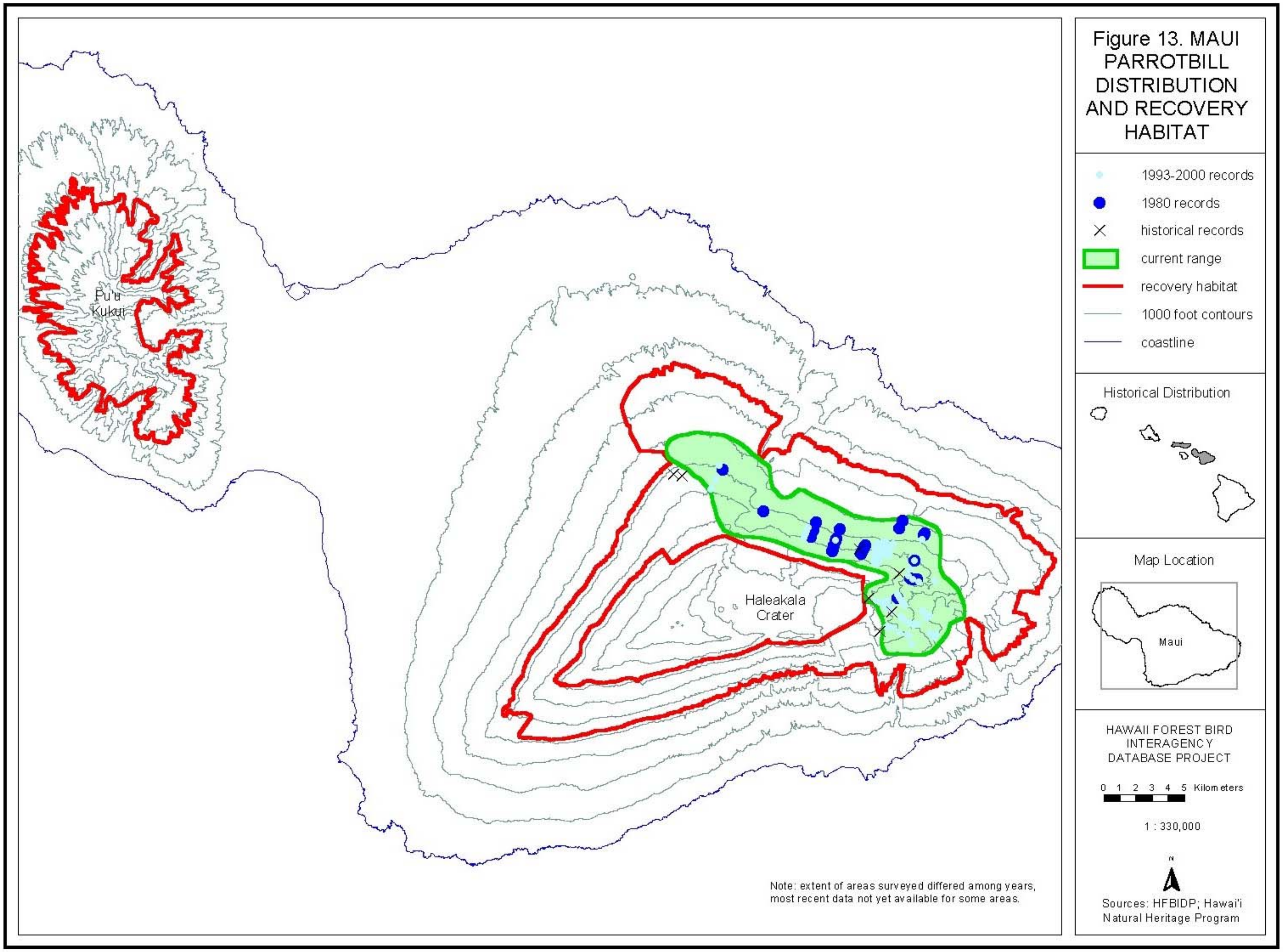


Figure 13. MAUI PARROTBILL DISTRIBUTION AND RECOVERY HABITAT
1993-2000 records
1980 records
historical records
current range
recovery habitat
1000 foot contours
coastline
Historical Distribution
Map Location
Maui
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0 1 2 3 4 5 Kilometers
1 : 330,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
Pu'u Kukui
Haleakala Crater
Note: extent of areas surveyed differed among years, most recent data not yet available for some areas.

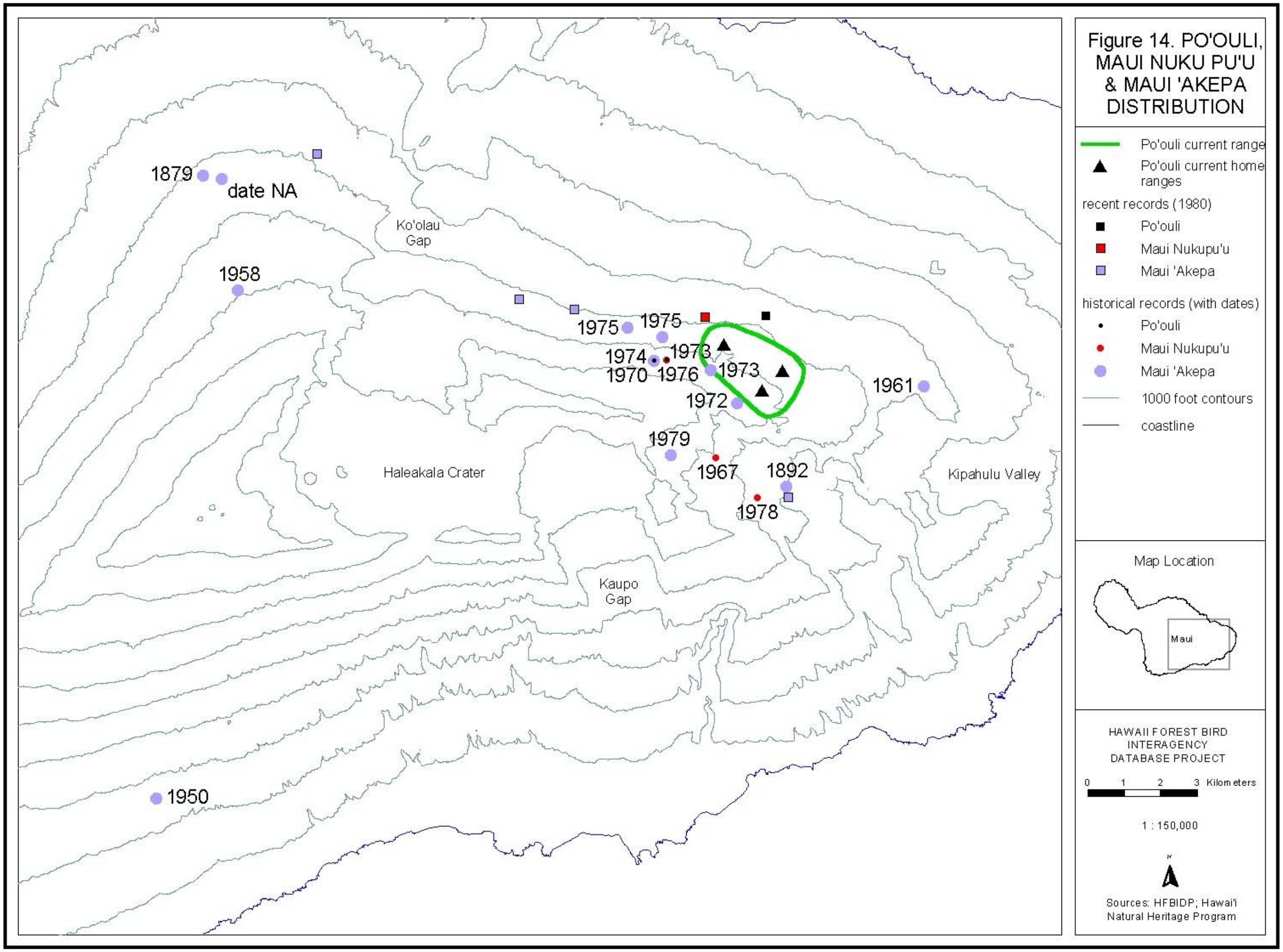


Figure 14. PO'OULI, MAUI NUKU PU'U & MAUI 'AKEPA DISTRIBUTION
Po'ouli current range
Po'ouli current home ranges
recent records (1980)
Po'ouli
Maui Nukupu'u
Maui 'Akepa
historical records (with dates)
Po'ouli
Maui Nukupu'u
Maui 'Akepa
1000 foot contours
coastline
Map Location
Maui
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0 1 2 3 Kilometers
1 : 150,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
1879
date NA
Ko'olau Gap
1958
1975
1975
1974
1973
1970
1976
1973
1972
1961
1979
1967
1892
1978
Haleakala Crater
Kipahulu Valley
Kaupo Gap
1950

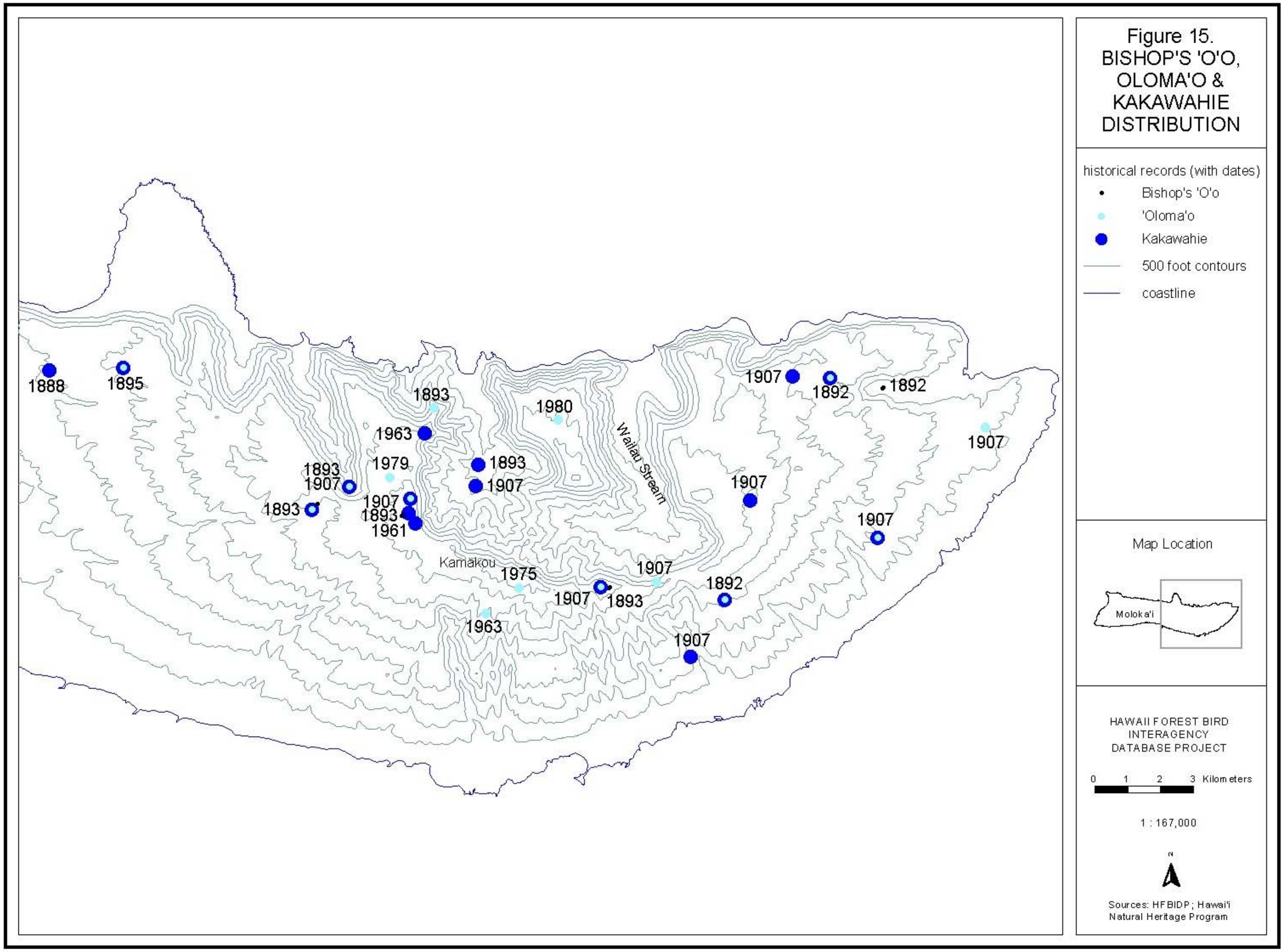


Figure 15.
BISHOP'S 'O'O, OLOMA'O & KAKAWAHIE DISTRIBUTION

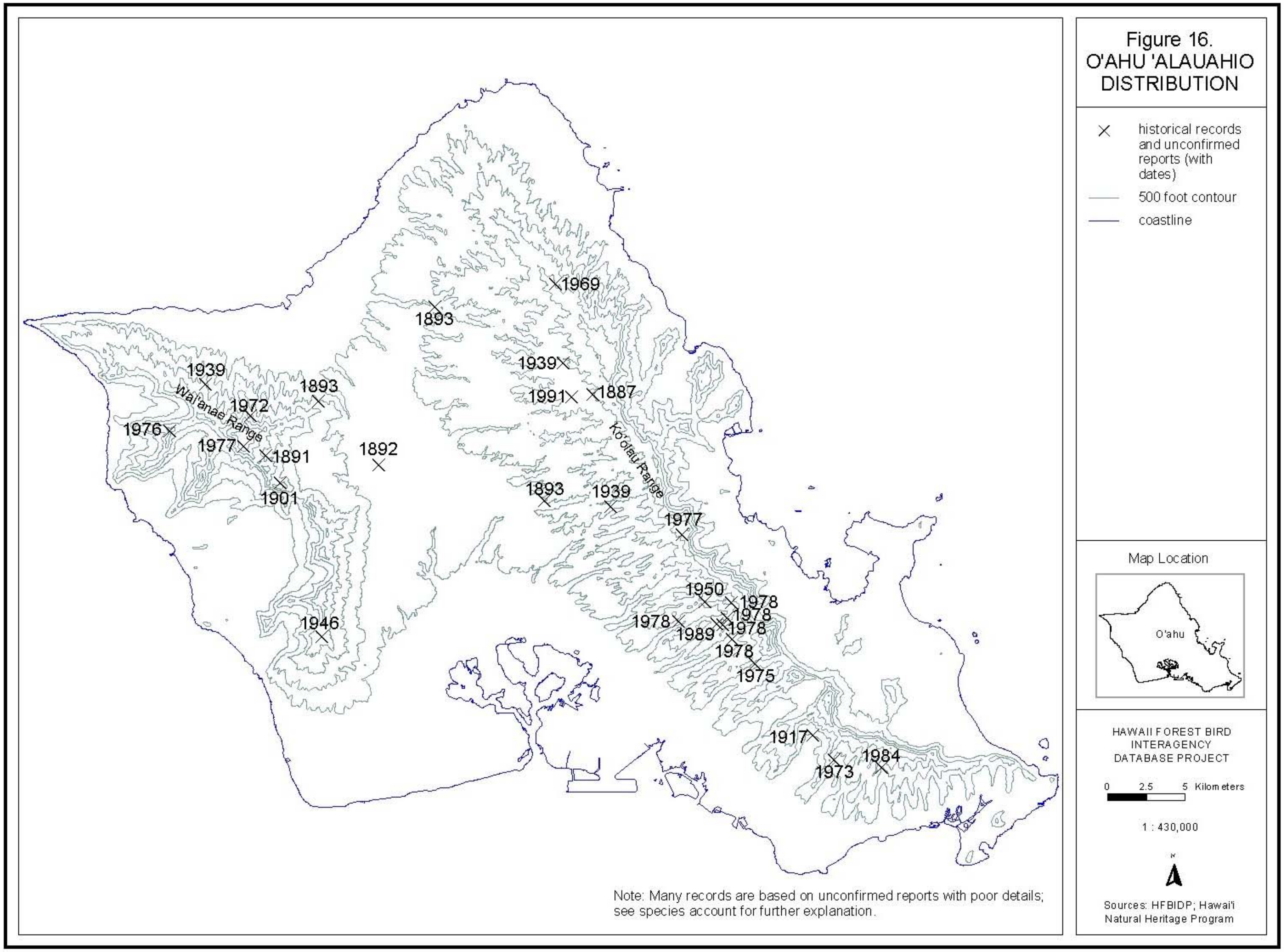


Figure 16.
O'AHU 'ALAUAHIO DISTRIBUTION
historical records and unconfirmed reports (with dates)
500 foot contour
coastline
Wai'anae Range
Ko'olau Range
1939
1893
1972
1976
1977
1891
1901
1892
1946
1893
1969
1939
1991
1887
1893
1939
1977
1950
1978
1978
1978
1989
1978
1978
1975
1917
1973
1984
Map Location
O'ahu
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0
2.5
5 Kilometers
1 : 430,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
Note: Many records are based on unconfirmed reports with poor details; see species account for further explanation.

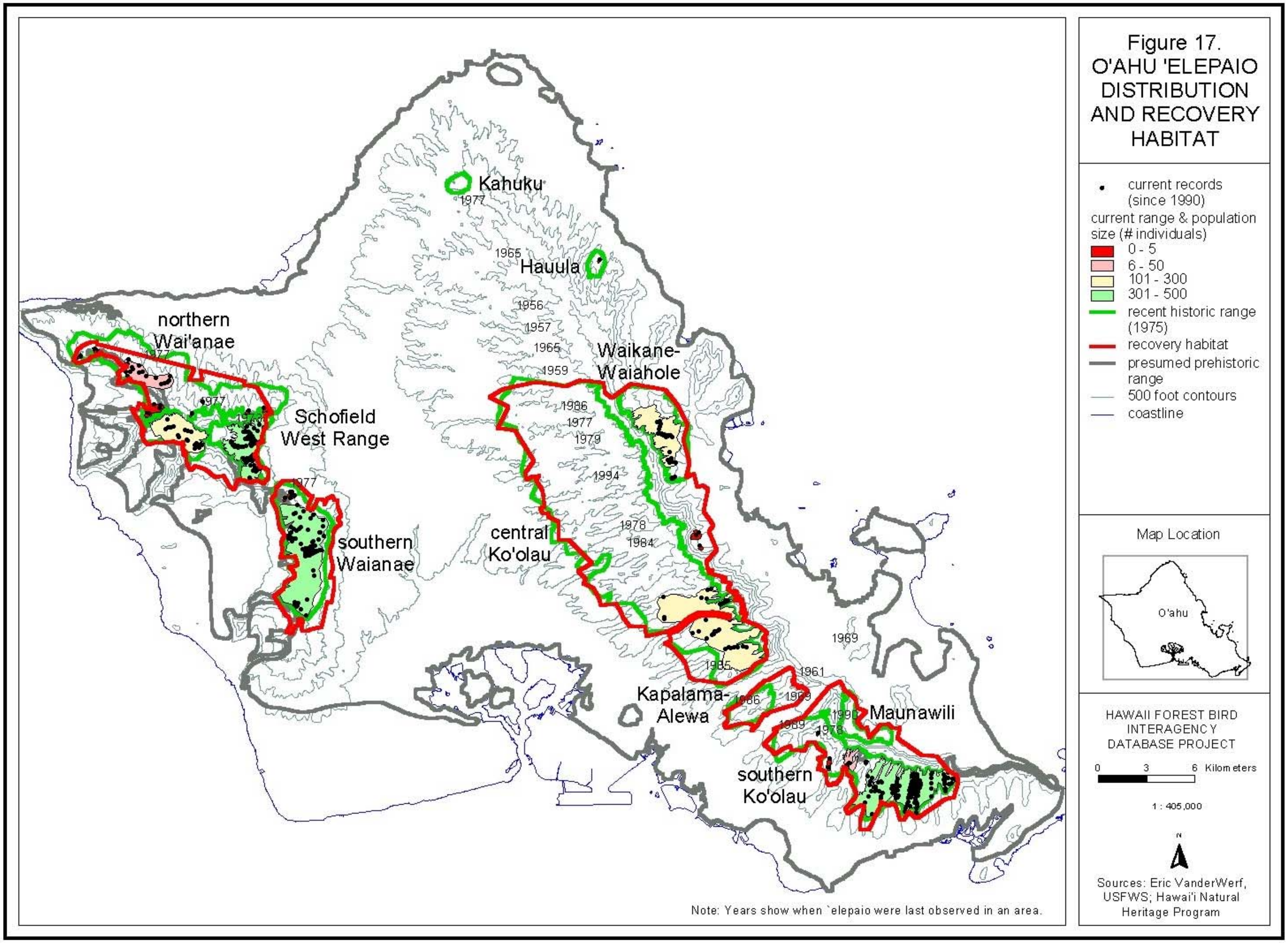


Figure 17.
O'AHU 'ELEPAIO DISTRIBUTION AND RECOVERY HABITAT
current records (since 1990)
current range & population size (# individuals)
0 - 5
6 - 50
101 - 300
301 - 500
recent historic range (1975)
recovery habitat
presumed prehistoric range
500 foot contours
coastline
Map Location
O'ahu
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0
3
6 Kilometers
1 : 405,000
Sources: Eric VanderWerf, USFWS; Hawai'i Natural Heritage Program
Kahuku
1977
1965
Hauula
1956
1957
1965
1959
northern Wai'anae
Schofield West Range
southern Waianae
Waikane-Waiahole
1986
1977
1979
1994
1978
1984
central Ko'olau
1969
1935
1961
Kapalama-Alewa
1986
1990
1989
1978
Maunawili
southern Ko'olau
Note: Years show when `elepaio were last observed in an area.

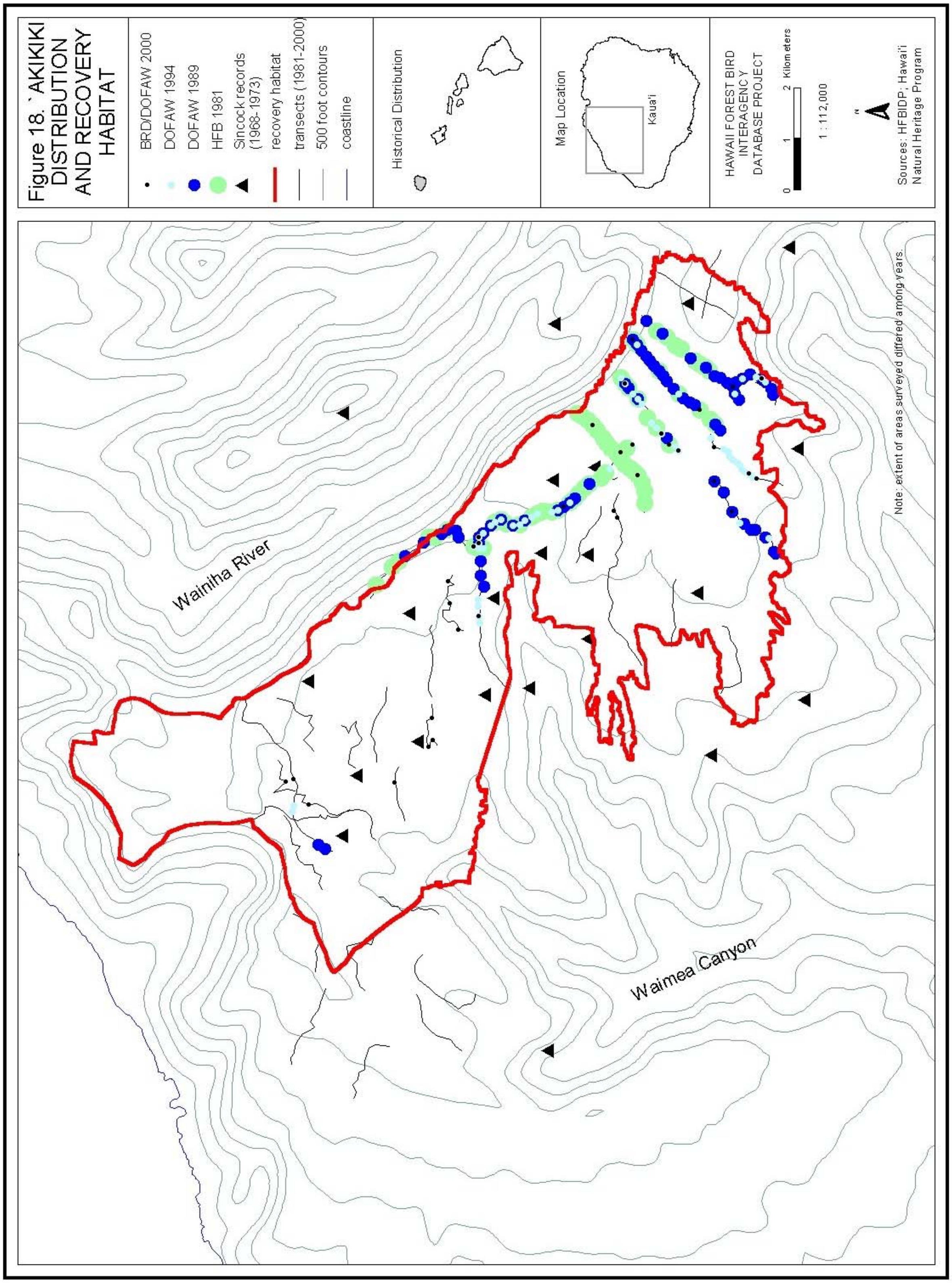


Figure 18. `AKIKIKI DISTRIBUTION AND RECOVERY HABITAT
BRD/DOFAW 2000
DOFAW 1994
DOFAW 1989
HFB 1981
Sincock records (1968-1973)
recovery habitat
transects (1981-2000)
500 foot contours
coastline
Historical Distribution
Map Location
Kaua'i
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0 1 2 Kilometers
1 : 112,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
Wainiha River
Waimea Canyon
Note: extent of areas surveyed differed among years.

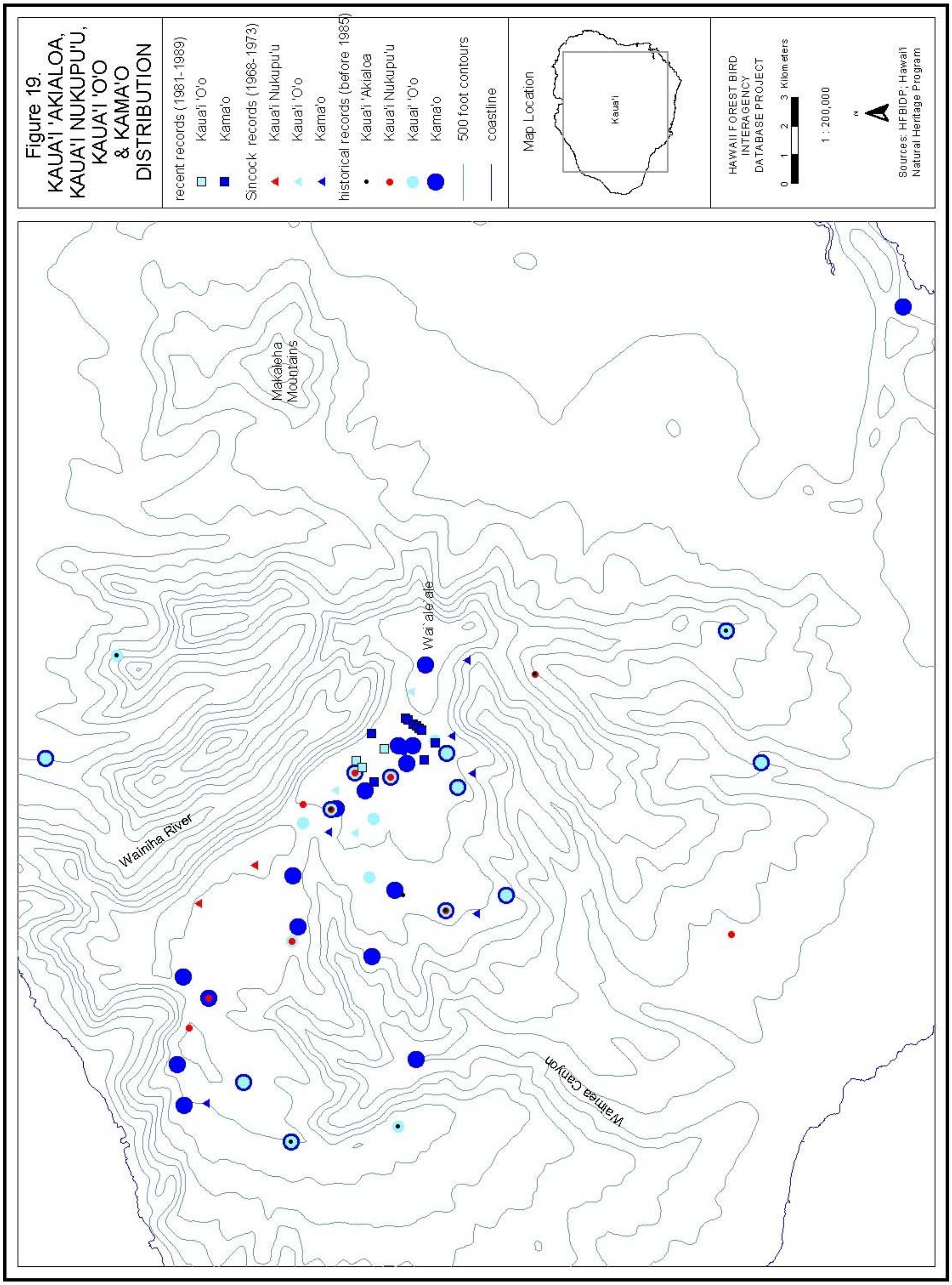


Figure 19. KAUA'I 'AKIALOA, KAUA'I NUKUPU'U, KAUA'I 'O'O & KAMA'O DISTRIBUTION

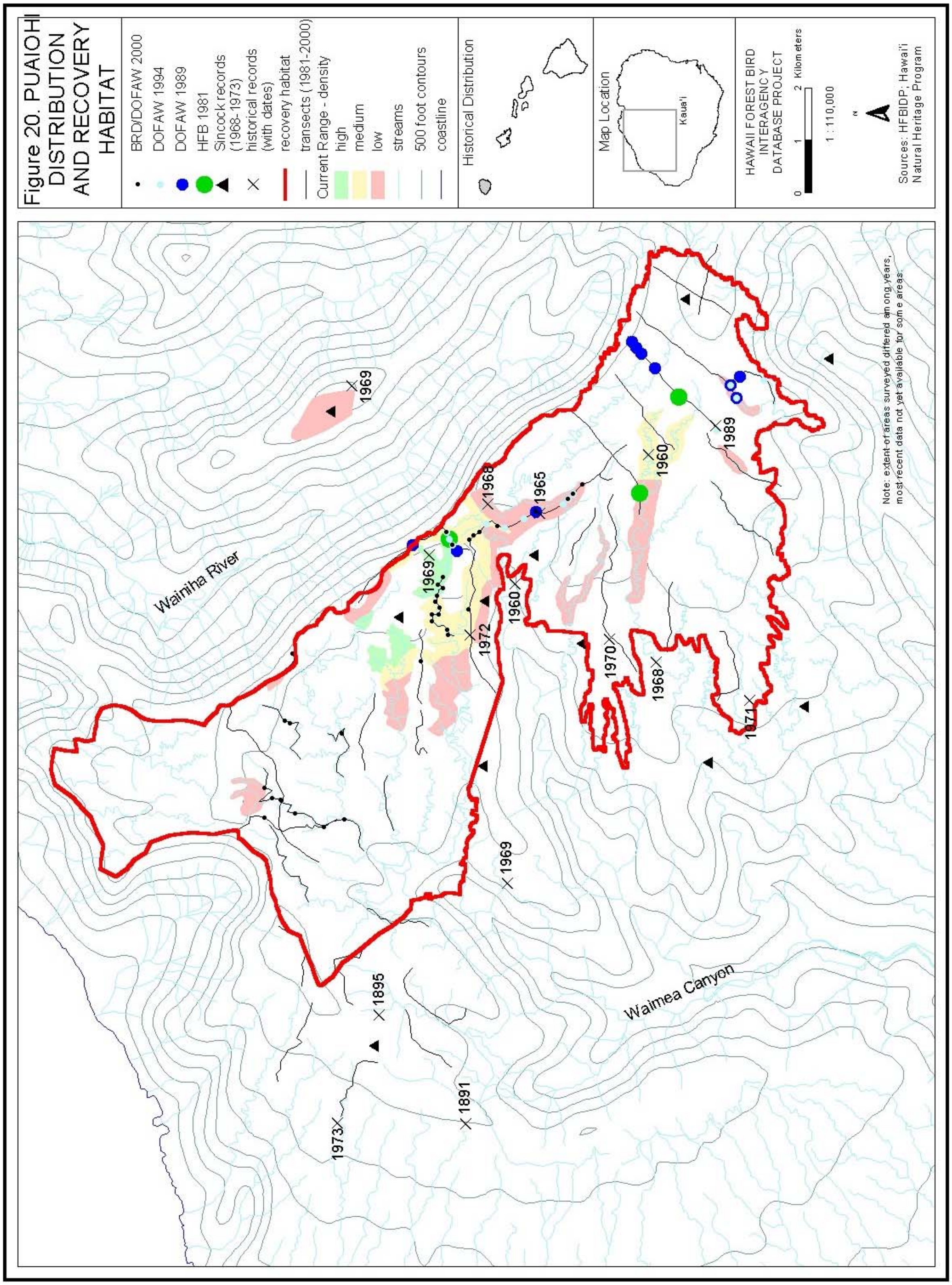


Figure 20. PUAIOHI DISTRIBUTION AND RECOVERY HABITAT
BRD/DOFAW 2000
DOFAW 1994
DOFAW 1989
HFB 1981
Sincock records (1968-1973)
historical records (with dates)
recovery habitat
transects (1981-2000)
Current Range - density
high
medium
low
streams
500 foot contours
coastline
Historical Distribution
Map Location
Kaua'i
HAWAII FOREST BIRD INTERAGENCY DATABASE PROJECT
0 1 2 Kilometers
1 : 110,000
N
Sources: HFBIDP; Hawai'i Natural Heritage Program
Wainiha River
Waimea Canyon
Note: extent of areas surveyed differed among years, most recent data not yet available for some areas.
1969
1968
1965
1969
1960
1972
1960
1989
1970
1968
1971
1969
1895
1891
1973

III. RECOVERY

A. Recovery Objectives

The primary objective of this Hawaiian Forest Bird Recovery 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 also 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 recovery of evolutionarily viable units. 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. Recovery objectives specific to particular taxa are listed in Table 6, and are discussed in detail in the species accounts for those taxa. A metapopulation as used below is defined as a group of partially isolated populations belonging to the same species among which exchange of individuals occurs.

A taxon may be downlisted from endangered to threatened when all four of the following criteria apply, 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. 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 intrinsic growth rate (lambda) 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 recovery habitat is protected and managed to achieve Criteria 1 and 2 above.

4. The mix of 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 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 when the downlisting criteria described above, as well as any species-specific criteria listed in Table 6, have been satisfied for at least 30 consecutive years.

Table 6. Additional species-specific recovery criteria for some Hawaiian forest birds. See individual species accounts for discussion of the recovery strategy and justification of recovery criteria.

Table 6		
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/Halepaakai, 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 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 Hamakua, 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 criterion 2 applies over a 30-year period.
Hawai`i creeper	Viable populations or metapopulations exist in Hamakua, Kūlani/Kīlauea/Keauhou, Ka`ū, and Kona dry forest, 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 Hamakua, Kūlani/Kīlauea/Keauhou, Ka`ū, south Kona, and Puu Waawaa/Hualalai, 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	Same as downlisting, and criteria 2 and 3 apply over

Table 6		
Species	Downlisting Criteria	Delisting Criteria
	period.	a 30-year period.
`Akikiki (candidate species)	Total population of 6,000 birds throughout 75 percent of the area occupied from 1968 to 1973 (Sincock surveys), 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), and criteria 2 and 3 apply over a 30-year period.

C. Recovery Habitat

1. General Guidelines for Establishing Recovery Habitat Boundaries

To better address the recovery needs of endangered Hawaiian forest birds, we established recovery habitat boundaries to emphasize where recovery efforts should be focused. We define recovery habitat as those areas that will allow for the long-term survival and recovery of endangered Hawaiian forest birds. Recovery habitat is a biological evaluation of habitat potentially important for the recovery of Hawaiian forest birds and conveys no legal obligation on the part of private landowners to manage their lands for forest bird recovery. Recovery habitat is not to be confused with "critical habitat," the formal designation that requires analysis of both biological and economic factors. Implementation of the recovery actions identified in the Recovery Action Narrative (Section IV) within the recovery habitat units 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 habitat 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 originally was much larger than the area identified as recovery habitat in this plan. The overall purpose of recovery habitat is to guide efforts to stabilize and recover listed species. Recovery habitat includes 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 habitat also includes intervening areas that will facilitate dispersal of birds and gene flow among high elevation populations that currently are isolated, thereby increasing the effective population size and possibly creating a metapopulation. Areas within recovery habitat currently differ in suitability for forest bird recovery; some areas already contain high quality habitat and support core populations of endangered forest birds, other areas may need intensive management and restoration before they can be considered suitable.

The foremost concern in determining recovery habitat 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 habitat therefore focuses on existing habitat and restorable habitat at high elevations, up to tree line on the higher islands (Maui and Hawai`i) and to the mountain summits on lower islands (Kaua`i, O`ahu, 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 habitat occurs in different units that are separated by large gaps of unsuitable developed land, while on other islands (Hawai`i, Kaua`i) there is one unit 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. 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 habitat 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 habitat units.

Within the identified recovery units, every attempt should be made to manage for continuous habitat that matches the historical distribution and environmental conditions in which 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. Maintenance or development of continuous habitat within recovery units will facilitate dispersal and connectivity. Contiguous recovery habitat also is 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. Density of birds is not expected to be uniform throughout the recovery habitat; source-sink dynamics, metapopulation dynamics, and seasonal movements in response to geographic variation in resources should be included where they naturally would exist.

For species that have not been detected in 10 or more years, recovery criteria still pertain in the long-term; however, the immediate recovery action 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 `ō`ū , Maui nuku pu`u, Maui `ākepa, Bishop's `ō`ō, `oloma`o, kākāwahie, O`ahu `alauahio, Kaua`i `akialoa, Kaua`i nuku pu`u, Kaua`i `ō`ō, and kāma`o. With the exception of the `ō`ū on the Island of Hawai`i, we have not identified separate recovery habitat for species that have not been seen recently because areas that should be searched are included in the recovery habitat for other species. We have identified recovery habitat 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 habitat and historical and current range for all 21 species listed in this plan appear together following the species accounts (Figures 7-20).

2. Hawai`i Recovery Habitat

<u>`Akiapōlā`au</u>

- Recovery habitat encompasses 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 can be restored. `Akiapōlā`au inhabit both koa/`ōhi`a forest and māmane forest. More than half of the recovery habitat 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 3,000 feet (910 meters) on the eastern slope of Mauna Kea, 3,000 feet (910 meters) on the eastern and southeastern slopes of Mauna Loa, 4,000 feet (1,210 meters) on the western slopes of Mauna Loa, and 3,800 feet (1,150 meters) on the northern slope of Hualālai.

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

Hawai`i `Ākepa and Hawai`i Creeper

- Recovery habitat encompasses 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 can be restored. Both species are found in koa-`ōhi`a forest, but do not inhabit māmane like the `akiapōlā`au. Hawai`i `•kepa currently are restricted to only a portion of their recovery habitat due to limited availability of large diameter trees for nesting as well as other limiting factors. These two species have very similar distributions and occupy similar habitat, but historical observations indicate the Hawai`i creeper once occurred at somewhat lower elevations (down to 3,000 feet [910 meters]) on the western slope of Mauna Loa.

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

- The upper limit of recovery habitat 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 seeds in green pods or in pods that are just beginning to turn brown. Palila are dependent on māmane and māmane-naio 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 4,500 feet (1,360 meters) on Mauna Kea and the western slope of Mauna Loa.

- The current population of palila is concentrated on the southwestern slope 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 habitat is delineated by the highest elevation edge of the historical m•mane and m•mane-naio forest on Mauna Kea and the upper limit of historical m•mane and m•mane-naio forest on the western slope of Mauna Loa.

3. Maui Nui Recovery Habitat

`Ākohekohe

- Currently there is only one population, on the windward side of Haleakalā. Additional habitat is needed to achieve at least two populations or a metapopulation on Maui Nui (Maui, Moloka`i, and Lana`i). To accomplish the goal for the second population, it will be necessary to establish the birds on West Maui or reestablish a Moloka`i population. Both sites may offer enough available habitat if disease is not a limiting factor.

- Haleakalā population: The `ākohekohe population on the windward side is currently about 3,800 birds, in only 5 percent of the estimated historical Maui range. Population increase could be achieved by increasing habitat or by increasing habitat and improving carrying capacity. Birds seem to occupy all suitable habitat in the current range, given disease constraints at lower elevations and boundaries of native vegetation. Carrying capacity increases in currently occupied range are not sufficient to achieve recovery criteria; therefore, additional upper elevation habitat must be restored from 4,000 to 7,000 feet (1,210 to 2,120 meters) on leeward slopes and from 5,000 to 7,000 feet (1,515 to 2,120 meters) on the Kula slopes. A lower elevational limit of 2,500 feet (750 meters) on windward Haleakalā would encompass nonbreeding habitat for some birds following seasonal flower bloom downslope, and enough habitat for expansion of the breeding population to a size at which the species could be downlisted.

- West Maui population: The indicated area, from 2,500 feet (750 meters) to the summit, encompasses all remaining forest habitat sufficient for forest bird inhabitation. Vegetation condition is currently almost pristine and managed for conservation. A population situated here could provide the second geographically disjunct population. Elevation is not high enough to provide disease- and vector-free habitat.

- Moloka`i population: The indicated area, from 2,500 feet (750 meters) to the summit, encompasses all remaining forest habitat sufficient for forest bird inhabitation. Habitat conditions and disease implications are similar to West Maui.

Maui Parrotbill

- Currently there is only one population, on the windward side of Haleakalā. Additional habitat is needed to achieve at least two populations or a metapopulation for Maui Nui.

- The Hawai`i Forest Bird Surveys of 1980 and 1995 to 1997 resulted in identification of one population of 500 birds in 5,000 hectares (12,350 acres) on Haleakalā. At present, birds seem to occupy all suitable habitat in current range, given disease constraints at lower elevations and boundaries of native vegetation. Therefore, to increase the Haleakalā population additional habitat must be restored on the leeward slopes from 4,000 to 7,000 feet (1,210 to 2,120 meters) and from 5,000 to 7,000 feet (1,515 to 2.120 meters) on the Kula slopes. The lower elevational range on windward Haleakalā slopes must be expanded down to 2,500 feet (750 meters).

- To attain two or more populations or a metapopulation to allow downlisting would require birds to occupy all of current Haleakalā forest habitat, currently unoccupied historical habitat, habitat needing restoration, and other Maui Nui areas as well. These areas include the two other remaining large tracts of Maui Nui forests: West Maui and East Moloka`i. Although there is no historical record for parrotbills at either location, the habitat closely resembles occupied habitat on Haleakalā, and there is fossil evidence that the species inhabited Moloka`i.

- Moloka`i: It will be necessary to reestablish the birds on West Maui or Moloka`i. The indicated area, from 2,500 feet (750 meters) to the respective summits, encompasses all remaining forest habitat sufficient for forest bird inhabitation on West Maui and Moloka`i. A population situated on West Maui could provide the second geographically disjunct population where vegetation condition is currently almost pristine and managed for conservation. There is little disease- and vector-free habitat on Moloka`i or West Maui.

<u>Po`ouli</u>

- Currently there is only one population of three birds, on the windward side of Haleakalā. Additional habitat is needed to achieve at least two populations or a metapopulation for Maui Nui.

- The Hawai`i Forest Bird Survey of 1980 found only 0.08 birds per hectare (0.03 birds per acre), and only three birds are currently known to exist on windward Haleakalā. Essentially the entire population on Haleakalā must be rebuilt. Since habitat requirements for the po`ouli remain poorly understood, it must be assumed that habitat needs of this species will be met by the recovery habitat for Maui parrotbill, which the fossil evidence suggests probably encompassed the full range of native forest bird habitat on windward, leeward, and Kula slopes of East Maui. Therefore, to increase the Haleakalā population, additional habitat must be restored on the leeward slopes from 4,000 to 7,000 feet (1,210 to 2,120 meters) and from 5,000 to 7,000 feet (1,515 to 2.120 meters) on the Kula slopes.

- To attain two or more populations or a metapopulation to allow downlisting would require birds to occupy all of current Haleakal• forest habitat, currently unoccupied historical habitat, habitat needing restoration on the Leeward and Kula slopes of Haleakal•, and other Maui Nui areas as well. It will be necessary to reestablish the birds on West Maui to attain downlisting and delisting criteria. The indicated area, from 2,500 feet (750 meters) to the summit, encompasses all remaining forest habitat sufficient for forest bird inhabitation on West Maui. A population situated on West Maui could provide the second geographically disjunct population where vegetation condition is currently almost pristine and managed for conservation, and resembles current po`ouli habitat on Haleakal•. There is little disease- and vector-free habitat on West Maui.

4. O`ahu Recovery Habitat

O`ahu `Elepaio

- Recovery habitat includes all areas that are currently occupied by the O`ahu `elepaio, excluding one very small, isolated area at Hau`ula that contains only a single male (Figure 17).

- 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 habitat units 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 currently is occupied by O`ahu `elepaio.

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

5. Kaua`i Recovery Habitat

Puaiohi

- Puaiohi exist at a density of about 16 birds/square kilometer (16 birds/0.39 square mile) in the core of their range (i.e., best remaining habitat; Snetsinger *et al.* in prep.). We estimate that there is, at best, roughly about 100 square kilometers (38 square miles) of suitable or restorable habitat remaining. Therefore, it would be unreasonable to expect to achieve a total population size of puaiohi of more than 2,000 birds. Furthermore, surrounding lowland habitats are too degraded to consider as possible habitat and are outside consideration until methods for dealing with avian disease have been developed. The lack of suitable habitat elsewhere on the island makes it functionally impossible to establish a second population isolated from the Alaka`i population.

- We used 1977 and 1978 aerial photographs to delineate the boundaries of the wet and mesic montane forest habitat, and this formed the basis for the inclusion of:

    - All known current and historical range that is restorable;

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

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

‘Akikiki

- Recovery habitat includes:

    - All known current and historical range that is restorable;

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

    - Portions of montane mesic forest/scrub (especially in Kōke`e State Park), Lā`au Ridge, and Nāmolokama Peak, based on historical distribution and documentation by J. Sincock. However, Lā`au and Nāmolokama are small, isolated areas and therefore are unlikely to sustain viable populations separate from the main population in the Alaka`i; and

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

- At current densities, `akikiki recovery will require protecting and managing as much of the remaining habitat as possible. Two separate, self-sustaining populations (i.e., one outside of the Alaka`i) will not be possible.

<u>Other Endangered Kaua`i Forest Birds</u>

There have been no confirmed sightings of the Kaua`i `Akialoa, Kaua`i nuku pu`u, Kaua`i `ō`ō, kāma`o, and `ō`ū for many years. In recent history, all five of these species were last extant within the boundaries of puaiohi recovery habitat, and 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., nuku pu`u) originally were more widespread than puaiohi, existing in lower-elevation koa forests. Presumably the Alaka`i was a last refuge from disease but not necessarily the preferred/optimal habitat for these species.

D. Rare Bird Discovery Protocol

1. Background and Justification

Currently, the majority of the 30 species and subspecies of Hawaiian birds listed as endangered are forest birds. While a number of extensive surveys of forest birds have taken place since 1976, the majority of these surveys have focused on determining 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 for information before informed management strategies can be developed and implemented. Moreover, given the magnitude of the threats to Hawaiian forest birds, immediate management measures directed at recovery of the population should be undertaken whenever possible. In October 1993, personnel of the U.S. Fish and Wildlife Service formed a field team (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 Memo, 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 are 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 field 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 by the public agencies or the private citizenry of a species that is considered to be possibly "extinct": (5) maximize data collection efforts; (6)

facilitate communication and decisions between collaborating individuals, agencies, and U.S. Fish and Wildlife Service appointed 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 less than 50 individuals and/or have not been seen for 10 years or longer, include:

Psittirostra psittacea, \`ō\`ū
Melamprosops phaeosoma, po\`ouli
Hemignatus lucidus affinus, Maui nuku pu\`u
Loxops coccineus ochraceus, Maui \`ākepa
Moho bishopi, Bishop's \`ō\`ō
Myadestes lanaiensis rutha, oloma\`o (Moloka\`i thrush)
Paroreomyza flammea, kākāwahie (Moloka\`i creeper)
Paroeomyza maculata, O\`ahu \`alauahio (O\`ahu creeper)
Hemignathus procerus, Kaua\`i \`akialoa
Hemignathus lucidus Hanapepe, Kaua\`i nuku pu'u
Moho braccatus, Kaua\`i \`ō\`ō
Myadestes myadestinus, kāma\`o (large Kaua\`i thrush)

3. Protocol

The following is an outline of 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, propagation managers).

   The designation of "potentially extinct" should be based on the number of years since last observed, evaluation of rate and cause of decline, general condition of preferred habitat, accessibility of wild population, natural history/seasonality, and the joint recommendations of the participating biologists of the U.S. Fish and Wildlife Service, Division of Forestry and Wildlife, and U.S. Geological Survey.

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

Once the target species is located, an intensive search of the surrounding vicinity by U.S. Fish and Wildlife Service and/or Division of Forestry and Wildlife should be made over a period of approximately 3 weeks to study the target species and determine:

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

b) Immediate threat(s) to the population (e.g., predators, disease, human presence, 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, propagation managers, U.S. Fish and Wildlife Service, Division of Forestry and Wildlife, U.S. Geological Survey).

After the target species has been initially observed and its situation documented, the U.S. Fish and Wildlife Service and/or Division of Forestry and Wildlife, in consultation with the Hawaiian Forest Bird Recovery Team, Captive Propagation Working Group, and the captive propagation managers, will consider some or all of the following invasive 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.

b) Blood-samples for genetics, sexing, and veterinary evaluation.

c) Installation of transmitter(s) on some or all individuals.

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

g) Removal from the wild of individuals and nestlings and/or eggs for transferal to one of the captive propagation facilities for propagation and/or hand-rearing prior to management 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.

iv. Initiate intervention if necessary (Hawaiian Forest Bird Recovery Team, propagation managers, U.S. Fish and Wildlife Service, Division of Forestry and Wildlife, U.S. Geological Survey).

Each management strategy selected will require participation by various combinations of agencies, personnel and/or facilities managers. Each action step will require population specific protocols, which should be developed by all entities involved just 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 ACTION NARRATIVE

The recovery action narrative is organized into six broad categories of recovery actions: 1) Protect Ecosystems for Recovery of Native 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 habitat, reducing or eliminating the detrimental effects of alien plants within ecosystems, reducing or eliminating the detrimental effects of ungulates on vegetation within forest ecosystems, reducing or eliminating the detrimental effects of alien mammalian 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 do not have priority numbers for implementation, but each specific recovery action was assigned an implementation priority number (see Table 20, 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.

1. Protect Ecosystems for Recovery of Native Forest Birds.

    1.1 Describe and delineate recovery habitat. (Priority 1)

    Recovery habitat maps have been created for each island and for species with known current distributions (Figures 7, 8, 9, 11, 12, 13, 14, 17, 18, and 20).

    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 Groups Mission/Purpose is to revive Hawaiian Home Lands beneficiary involvement in management of the 3,030 hectares (7,500 acres) 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 ahupuaa 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 core (100,000 acres) 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 in the strategy increased public hunting, and fencing.

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

1.2.5 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.

1.2.6 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 habitat areas through conservation easement, partnership agreement, safe harbor agreement, and change in land use designation, lease, or purchase from willing seller.
Table 7 lists, by island, recovery habitat areas requiring protection. Habitat management plans should be written for all protected areas, and protection could be implemented through conservation easements, partnerships, or, if necessary, land exchange, changes in land use designation, or purchase from willing seller. 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 when ever possible. Several watershed partnerships are in effect across the State, and 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 should be considered for purchase by private and public conservation organizations when owners are interested in selling and when 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 as recovery habitat 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 habitat in need 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 `akialoau; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nuku pu`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 for landowner and partnership abbreviations.

Table 7					
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 State, 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 State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest. By lease, conservation easement, 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 State, DLNR, DOFAW. Currently the Laupāhoehoe Section of Hilo Forest reserve Area. By conservation easement or change in land use designation to conservation protective subzone. A mid-elevation forest with intact native tree canopy vulnerable to destruction by continued sustained yield pig hunting.	2
1.3.4	H	Hilo Forest Reserve, Pīhā	AKIP HCRE	Hawai`i State, DLNR, DOFAW. Contains important wet and mesic	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		Section, 333001004	AKEP OU	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. A mid-elevation forest with intact native tree canopy vulnerable to destruction by sustained yield pig hunting.	
1.3.5	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i State, 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 State, DHHL. Restorable. A vital link between wet and dry forest communities. Currently leased by Nobrega Ranch for cattle grazing. By lease, conservation easement, cooperative agreement, or partnership.	1
1.3.7	H	Humu`ula, Portions of 338001007	AKEP AKIP HCRE PALI	Hawai`i State, 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	Lamaia Section, 326018002	AKIP HCRE AKEP	Hawai`i State, 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
1.3.9	H	Pu`u `ō`ō Ranch, 326018001	AKIP HCRE AKEP	Hawai`i State, DLNR, State Land Division. Leased to Pu`u `ō`ō Ranch for cattle grazing. Important mesic and wet koa/`ōhi`a forest remnants, vital link between wet and dry forest	1

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
				communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.	
1.3.10	H	Ka`ohe Lease, 344015002	AKIP PALI	Hawai`i State, DLNR, State Land Division, currently leased for cattle grazing. A vital 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. Contains remnant mesic koa and `ōhi`a forest. By lease, conservation easement. Currently a new member of the Olaa-Kilauea Parnership.	2
1.3.12	H	Kapāpala Ranch, Portions of 398001010	AKIP HCRE AKEP	Hawai`i State, DLNR, State Land Division, Kapāpala Ranch, currently leased for cattle grazing. Restorable. A link between forest communities to the east and west. By lease, conservation easement, change of jurisdiction, 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. Protects 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	Hawai`i Volcanoes National Park. Valuable wet and mesic forest habitat that links Ka`ū Forest and South Kona Forest. Restorable.	2
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 agreement, change in land use designation, or purchase	3

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
				from willing seller.	
1.3.17	H	Pāpā, 388001001	AKIP HCRE AKEP	Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.	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	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
1.3.21	H	Waiea Tract, 386001003	AKIP HCRE AKEP	Hawai`i DLNR. Land Division. Protects 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	Kamehameha Schools. By lease, conservation easement, partnership	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
			AKEP	agreement, change in land use designation, or purchase from willing seller.	
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. 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
1.3.25	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
1.3.26	H	Pu`u Lehua, Portions of 378001003 378001007 372002001 378001001	AKIP PALI HCRE	Kamehameha Schools. Provide 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,	AKOH, MAPA,	J. Haili. Small parcel at lower edge of recovery habitat. By partnership	3

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		Kukui`ula, 216001007	POOU	with EMWP.	
1.3.29	MA	Kīpahulu Forest Reserve, Kukui`ula, 216001006	AKOH MAPA POOU	Kalalau, Cleveland. Small parcel at lower edge of recovery habitat. By partnership with EMWP.	3
1.3.30	MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006 218001007	AKOH MAPA POOU	Hawai`i State. Isolated; secure access for management needed. By partnership with EMWP or lease.	1
1.3.31	MA	Kīpahulu Forest Reserve, 217001032	AKOH MAPA POOU	A. Kaapana et al. Small parcel at lower edge of recovery habitat. By partnership with EMWP.	3
1.3.32	MA	Kīpahulu Forest Reserve, 217001024	AKOH MAPA POOU	Kaupō Ranch Ltd. Small parcel at lower edge of recovery habitat. By partnership with EMWP.	3
1.3.33	MA	Nu`u, 218001001	AKOH MAPA POOU	Kaupō Ranch Ltd. Degraded former forest land in need of active management. By partnership with EMWP. Acquisition being negotiated by NPS. By safe harbor agreement, easement, change of land use designation, or purchase from willing seller.	3
1.3.34	MA	Nu`u, 218001002	AKOH MAPA POOU	James Campbell Est. Degraded former forest land in need of active management. By partnership with EMWP, conservation easement, or purchase from willing seller.	3
1.3.35	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i State. Isolated; secure better access for management. Degraded former forest land in need of active management. By partnership with EMWP or lease.	1
1.3.36	MA	Kahikinui Homelands, 219001003 219001007 219001008	AKOH MAPA POOU	Hawai`i State, DHHL. Degraded former forest land in active forest stewardship program with FWS. By partnership with EMWP.	1

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		219001011			
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 partnership with EMWP. By conservation easement, safe harbor agreement, change in land use designation, or purchase from willing seller.	2
1.3.38	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i State. By partnership with EMWP. 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 EMWP, 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 partnership with EMWP, 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 partnership with EMWP, 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 EMWP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.	2
1.3.43	MA	Kamehame	AKOH	R. G. Von Tempsky Jr. Trust.	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		Nui/Kealahou, 223005002	MAPA POOU	Degraded former forest in need of active management. By partnership with EMWP, conservation easement, safe harbor agreement, change of land use designation, or purchase from willing seller.	
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 partnership with EMWP, 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
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,	AKOH MAPA	American Factors (Amfac)/JMB Hawai`i Co. In WMWP. By	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		Pu`u Kī/Haakea, 245022002 245022004	POOU	conservation easement, safe harbor agreement, or purchase from willing seller.	
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
1.3.59	MO	Moloka`i Forest Reserve, Laeokapuna,	AKOH MAPA POOU	P. Hodgins. By easement, safe harbor agreement, or purchase from willing seller.	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		257005027			
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
1.3.69	MO	Moloka`i Forest Reserve, Kawela,	AKOH MAPA POOU	Kawela Plantation Homes Association. By easement or purchase from willing seller. In	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		254003001 254003028		EMOWP.	
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 partnership 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 partnership 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 may be needed to ensure protection of large `elepaio population. By easement, partnership 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, partnership 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, partnership in KMWP, or purchase from willing seller.	2
1.3.76	O	Kapālama, 14015009	OAEL	Julius Chung Trust. Small parcel. By partnership in KMWP.	3
1.3.77	O	Moanalua Valley,	OAEL	Damon Estate. In KMWP, but additional measures may be needed	2

Table 7					
Recovery Action #	Island	Land Parcel, Tax Map Key (TMK)	Species Targeted	Landowner/Comments	Priority
		11013001		to ensure protection of large `elepaio population. By easement or purchase from willing seller.	
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 or purchase from willing seller.	2
1.3.79	O	Wai Kāne Valley, 48014005	OAEL	SMF Enterprises. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement or purchase from willing seller.	1
1.3.80	O	Waianu Valley, 48014003 48013014	OAEL	Waiahole Irrigation Co. Ltd. In KMWP, but additional measures may be needed to ensure protection of large `elepaio population. By easement 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
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.	3

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

2.1 Reforest areas of recovery habitat that no longer contain necessary constituent elements for species recovery. (Priority 1-3)
Recovery of most 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 habitat 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 `akialoau; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nuku pu`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 for landowner and partnership abbreviations.

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
2.1.1	H	Northeastern Slope of Mauna Kea, Portions of 344014002 344014003 343010002 343010008	AKIP PALI	Hawai`i State, DLNR, State 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 State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats. Restore upper pasturelands.	1
2.1.3	H	Hilo Forest Reserve, Laupāhoehoe Section, 337001004	AKIP HCRE AKEP OU	Hawai`i State, DLNR, Division of Forestry and Wildlife. 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 State, DLNR, Division of Forestry and Wildlife. Remove alien trees. Restore transition forest from wet `ōhi`a to mesic koa. Facilitate understory regeneration.	3

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
2.1.5	H	Hakalau Forest NWR, 337001010 329005005 333001007 329005003	AKIP HCRE AKEP	U.S. Fish and Wildlife Service. Currently managed forest bird habitat. Remove alien trees and continue forest restoration program.	1
2.1.6	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i State, DHHL, leased by DOFAW. Facilitate canopy tree and understory regeneration.	3
2.1.7	H	Humu`ula, 338001002	AKIP HCRE AKEP PALI	Hawai`i State, DHHL. Restorable. A vital link between wet and dry forest communities. 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 State, DHHL, leased to Parker Ranch. Reforest pasturelands to native montane dryland habitat.	2
2.1.9	H	Lamaia Section, 326018002	AKIP HCRE AKEP	Hawai`i State, 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 State, DLNR, State 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 State, DLNR, State Land Division. Protect and reforest.	2
2.1.12	H	Mauna Kea Forest Reserve, 344015001	AKIP PALI	Hawai`i State, 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,	AKIP HCRE AKEP	Hawai`i Volcanoes National Park. Continue dryland forest restoration.	3

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
		399001002			
2.1.15	H	Kapāpala Ranch, 398001004	AKIP HCRE AKEP	Hawai`i State, DLNR, State Land Division, Kapāpala Ranch. A link between forest communities to the east and west. Protect parcel, remove alien trees and restore montane dryland 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
2.1.17	H	Ka`ū Forest Reserve, Portions of 397001006 397001005	AKIP HCRE AKEP	Kamehameha Schools. Protect and facilitate natural regeneration.	3
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	Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. Protect and 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 State.	2
2.1.23	H	Yee Hop Ranch, Portions of 388001003 388001004 387012001 392001005	AKIP HCRE AKEP	Yee Hop Ranch Ltd. Provides links between State owned 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.	3

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
		387012003 387012004 387001007 387001006 387001011 387001004			
2.1.24	H	Kona Forest NWR, 386001001	AKIP HCRE AKEP	U.S. Fish and Wildlife Service. Restore montane mesic koa forest.	1
2.1.25	H	`Alae Ranch, Portions of 387001014	AKIP HCRE AKEP	Hawai`i State, DLNR, State 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 State, DLNR, State 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. Protects contiguous forest habitat in South Kona from development, and 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

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
2.1.31	H	Pu`u Wa`awa`a, 371001001 371001006	HCRE AKEP	Hawai`i State, 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.	2
2.1.33	MA	Haleakalā National Park, 218001007	AKOH MAPA POOU	National Park Service. Restore montane mesic forest in Kaupō Gap.	1
2.1.34	MA	Kīpahulu Forest Reserve, 217004006	AKOH MAPA POOU	Hawai`i State. Restore montane mesic forest along cliff lines and head of Manawainui Valley.	1
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 State. Restore montane mesic forest and shrubland.	1
2.1.38	MA	Kahikinui Homelands, 219001003 219001007 219001008 219001011	AKOH MAPA POOU	Hawai`i State, 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 State. 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

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
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
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	R. G. Von Tempsky Jr. Trust. 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 elevations. Replace nonnative trees.	1
2.1.48	MA	Makawao Forest Reserve, 224016001 224016002	AKOH MAPA POOU	Hawai`i State. Restore montane mesic forest and shrubland. Replace nonnative trees.	1
2.1.49	MA	West Maui NAR, Kahakuloa, 231006001	AKOH MAPA POOU	Hawai`i State. Restore montane wet forest and shrubland.	2
2.1.50	MA	West Maui Forest Reserve, Kaheawa, 248001001	AKOH MAPA POOU	Hawai`i State. 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 State. Restore montane wet forest and shrubland.	2

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
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 State. 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
2.1.55	MO	Moloka`i Forest Reserve, Kahanui, 261001004	AKOH MAPA POOU	Hawai`i State. 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 State. 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

Table 8					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Landowner/Comments	Priority
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 State, 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. 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 habitat 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 `akialoau; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nuku pu`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 for landowner and partnership abbreviations.

Table 9					
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 State, DLNR, State Land Division.	2
2.2.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats. Currently under lease for cattle grazing. Needs fencing and ungulate control.	1
2.2.3	H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001004 333001004	AKIP HCRE AKEP	Hawai`i State, DLNR, DOFAW. Currently managed for game hunting. Needs fencing and ungulate control.	2
2.2.4	H	Hakalau Forest NWR, 337001010 333001007 329005005 329005003	AKIP HCRE AKEP	U.S. Fish and Wildlife Service. Currently managed forest bird habitat. Ungulate control under way. Construct additional fences and control ungulates in unmanaged areas.	1
2.2.5	H	326018002	AKIP HCRE AKEP	Hawai`i State, DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Encourage fencing and ungulate removal.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.6	H	Pu`u `ō`ō Ranch, 326018001	AKIP HCRE AKEP	Hawai`i State, DLNR, State 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 State, DHHL. Encourage fencing and ungulate removal.	2
2.2.8	H	Ka`ohe, 344015002	AKIP PALI	Hawai`i State, DLNR, State Land Division. Suspend lease. Fence and remove ungulates.	2
2.2.9	H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	AKIP PALI	Hawai`i State, DLNR. Palila critical habitat. Continue to remove ungulates.	1
2.2.10	H	Waiākea Forest Reserve, Upper Portion, 324008001	AKIP AKEP HCRE	Hawai`i State, DLNR, DOFAW. Fence and remove ungulates.	2
2.2.11	H	Waiākea Forest Reserve, Lower Portion, 324008001	OU	Hawai`i State, DLNR, 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 State, DLNR, State Land Division, Kapāpala Forest Reserve. Fencing and ungulate control.	2
2.2.14	H	Ka`ū Forest Reserve, 397001001	AKIP HCRE AKEP OU	Hawai`i State, DLNR, DOFAW, Ka`ū Forest Reserve. Fencing and ungulate control.	3

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.15	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Samuel M. Damon Trust. Purchase by NPS, fence and remove ungulates.	3
2.2.16	H	Manukā NAR, Upper portions of 391001002	AKIP HCRE AKEP	Hawai`i State, DLNR, DOFAW. Fencing and ungulate control.	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	U.S. Fish and Wildlife Service. Fence and remove ungulates.	2
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 State, DLNR, State 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

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
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 State, DLNR. 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 State, DLNR. NAR fencing now 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
2.2.27	MA	Hāna Forest Reserve, 210001001 214001001 215001001	AKOH MAPA POOU	Hawai`i State, 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	National Park Service. Mostly protected by fencing, where 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

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
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 State, 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.	3
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
2.2.36	MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	AKOH MAPA POOU	Hawai`i State. 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 State, 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. Continue to encourage fencing and ungulate removal above 4,000 ft. for bird recovery.	1

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.39	MA	Kula Forest Reserve, 222007001	AKOH MAPA POOU	Hawai`i State, DLNR. Currently a game management area for sustained yield. For portions within forest bird recovery habitat, fence and remove ungulates to encourage 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 habitat, 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 habitat, 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 habitat, manage with Kula Forest Reserve.	2
2.2.43	MA	Waiakoa, 222008001	AKOH MAPA POOU	Lucky Shoji USA Inc. et al. Fence and remove ungulates within forest bird recovery habitat, manage with Kula Forest Reserve.	2
2.2.44	MA	Kamehame Nui/Kealahou, 223005002	AKOH MAPA POOU	R. G. Von Tempsky Jr. Trust. Fence and remove ungulates within forest bird recovery habitat.	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 habitat.	1
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 State, DLNR. Public hunting currently permitted. Fence and remove ungulates within forest bird recovery habitat.	1

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.48	MA	West Maui NAR, Kahakuloa, 231006001	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.49	MA	West Maui Forest Reserve, Waihe`e, 232014001	AKOH MAPA POOU	Maui Board of Water Supply. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.50	MA	West Maui Forest Reserve, Kou, 232014002	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.51	MA	West Maui Forest Reserve, Wailuku, 233003003 235003001 236003001	AKOH MAPA POOU	Wailuku Agriculture. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.52	MA	West Maui Forest Reserve, `Īao, 233003004,	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.53	MA	West Maui Forest Reserve, Kealaloloa, 236001014	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.54	MA	West Maui Forest Reserve, Manawainui Plant Reserve, 236001052 248001010	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.55	MA	West Maui Forest Reserve, Kaheawa, 248001001	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.56	MA	West Maui Forest Reserve, Ukumehame/ Olowalu, West Maui NAR,	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		Līhau, 248001002			
2.2.57	MA	West Maui Forest Reserve, Launiupoko, 247001002	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.58	MA	West Maui Forest Reserve, Pūehuehu, 247001004	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.59	MA	West Maui Forest Reserve, Kaua`ula, 246025001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.60	MA	West Maui Forest Reserve, Pana`ewa, 246025002	AKOH MAPA POOU	Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.61	MA	West Maui Forest Reserve, Kahoma, 245022001	AKOH MAPA POOU	Kamehameha Schools. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.62	MA	West Maui Forest Reserve, Kahoma, 245022005	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	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. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.64	MA	West Maui Forest Reserve, Wahikuli, 245022003	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.65	MA	Kapunakea Preserve, Amfac/JMB, TNCH, 244007001	AKOH MAPA POOU	American Factors (Amfac)/JMB Hawai`i Co., TNCH. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.66	MA	West Maui Forest Reserve, Kapāloa, 244007007	AKOH MAPA, POOU	Unknown. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.67	MA	West Maui NAR, Honokōwai, 244007004	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.68	MA	Pu`u Kukui Watershed Management Area, 242001001, 241001017	AKOH MAPA POOU	Maui Land and Pineapple. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.69	MO	Moloka`i Forest Reserve, Kalama`ula, 252014003	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.70	MO	Moloka`i Forest Reserve, Kahanui, 252014001	AKOH MAPA POOU	R. W. Myer Ltd., et al. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.71	MO	Moloka`i Forest Reserve, Kahanui, 261001004	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.72	MO	Moloka`i Forest Reserve, Waikolu, 261001002	AKOH MAPA POOU	Hawai`i State. Ungulate control currently ongoing at Pu`u Ali`i NAR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	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. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.74	MO	Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe,	AKOH MAPA POOU	Wm. Hitchcock, *et al*. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		259008017			
2.2.75	MO	Moloka`i Forest Reserve, Pelekunu Valley, 254003032	AKOH MAPA POOU	The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.76	MO	Oloku`i NAR, Moloka`i Forest Reserve, Wailau Valley, 259006002	AKOH MAPA POOU	Hawai`i State. Oloku`i NAR is naturally isolated but vulnerable to incursion. Ungulate control currently ongoing. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.77	MO	Moloka`i Forest Reserve, Wailau Valley and Oloku`i, 259006004	AKOH MAPA POOU	G. Brown III, *et al*. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.78	MO	Moloka`i Forest Reserve, Laeokapuna, 257005027	AKOH MAPA POOU	P. Hodgins. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.79	MO	Moloka`i Forest Reserve, Keanakoholua, 257005001	AKOH MAPA POOU	M. Hustice Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.80	MO	Moloka`i Forest Reserve, `Uala`pue, 256006026	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.81	MO	Moloka`i Forest Reserve, Kahananui, 256006014	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.82	MO	Moloka`i Forest Reserve, Manawai, 256006013	AKOH MAPA POOU	P. Petro Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		256006013		recovery habitat.	
2.2.83	MO	Moloka`i Forest Reserve, eastern `Ōhi`a Gulch, 256006011	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.84	MO	Moloka`i Forest Reserve, West `Ōhi`a Gulch, 256006010	AKOH MAPA POOU	E. Wond Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.85	MO	Moloka`i Forest Reserve, Keawa Nui, 256006007	AKOH MAPA POOU	Kamehameha Schools. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.86	MO	Moloka`i Forest Reserve, Puaahala, 256006002	AKOH MAPA POOU	K&H Horizons Hawai`i. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	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 doing animal removal. Continue with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.88	MO	Moloka`i Forest Reserve, Kamalō, 255001016 255001006 255001017	AKOH MAPA POOU	Kamehameha Schools. In EMOWP; currently fencing portions and doing animal removal. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.89	MO	Moloka`i Forest Reserve, Mākolelau, 255001015	AKOH MAPA POOU	Ashton Pitts Jr. Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
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. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.91	MO	Moloka`i Forest Reserve, Kawela, 254003001	AKOH MAPA POOU	Kawela Plantation Homes Association. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.92	MO	Moloka`i Forest Reserve, Kamiloloa/ Makakupa`ia, 254003025	AKOH MAPA POOU	Hawai`i State. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	2
2.2.93	MO	Moloka`i Forest Reserve, Kaunakakai, 253003005	AKOH MAPA POOU	Moloka`i Ranch Ltd. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.	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 2nd 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.	1
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

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
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.	1
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
2.2.101	K	Halehaha, Halepaakai and Koai`e drainages, Alaka`i Wilderness Preserve, Portions of 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i State, DLNR, Division of Forestry and Wildlife. Fencing of at least a 4 km square area in the Halepaakai 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

Table 9					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
2.2.102	K	Upper Mōhihi and upper Waiakoali drainages, Alaka`i Wilderness Preserve, Portions of 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i State, DLNR, Division of Forestry and Wildlife. Recommend fencing as much of the core population of puaiohi as possible, e.g., upper Mōhihi drainage. 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 State, DLNR, Division of Forestry and Wildlife. 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; management for release of captive-bred puaiohi. Fencing and ungulate control may be needed in preparation for aerial broadcast of rodenticides.	3

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

Habitat degradation resulting from the invasion of nonnative weeds is a long-term, pervasive threat in many areas of recovery habitat. 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. List of alien plant taxa known or suspected to pose a significant threat to forest bird recovery habitat 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 habitat. At higher taxonimic levels, all known naturalized taxa from five genera and four families pose significant threats to forest bird recovery habitat. Urgency of the need for management of each taxon is represented by a code: 1 = high; 2 = moderate; 3 = low.

Table 10					
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
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

Table 10					
Scientific Name	**Common Name**	**Hawai`i**	**Maui Nui**	**O`ahu**	**Kaua`i**
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, mongoose) 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 silvestris*). The black rat (*Rattus rattus*) is thought to have been a major cause of the declines in native bird populations in the early 1900's (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 in press). 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 1999b, Hodges and Nagata 2001, Hu *et al.* 2001), but its limited climbing ability makes it a lesser threat than rats and feral cats to forest birds. 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.

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 habitat 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 `akialoau; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nuku pu`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 for landowner and partnership abbreviations.

Table 11					
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 State, DLNR, State Land Division.	2
2.4.1.2	H	Kanakaleonui Corridor, 338001009	AKIP HCRE AKEP PALI	Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats. 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	AKIP HCRE AKEP	Hawai`i State, DLNR, DOFAW. Currently managed for game hunting.	2

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		333001004			
2.4.1.4	H	Hakalau Forest NWR, 337001010 333001007 329005005 329005003	AKIP HCRE AKEP	Currently managed forest bird habitat. Ungulate control under way. Predator control needed to protect core populations of three listed species.	1
2.4.1.5	H	326018002	AKIP HCRE AKEP	Hawai`i State 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 State, DLNR, State Land Division, Pu`u `ō`ō Ranch lease.	2
2.4.1.7	H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	AKIP HCRE AKEP	Hawai`i State, DHHL.	2
2.4.1.8	H	Ka`ohe, 344015002	AKIP PALI	Hawai`i State, DLNR, State Land Division. Suspend lease.	2
2.4.1.9	H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	AKIP PALI	Hawai`i State, DLNR. 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 State, DLNR, DOFAW.	2
2.4.1.11	H	Waiākea Forest Reserve, lower portion, 324008001	OU	Hawai`i State, DLNR, DOFAW.	1
2.4.1.12	H	`Ōla`a/Kīlauea Partnership, 324008009 399001007 399001004 324008025	AKIP HCRE AKEP	Kamehameha Schools, Keauhou Ranch. Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP.	1

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		319001001 319001007			
2.4.1.13	H	Kapāpala Forest Reserve, Portions of 398001004	AKIP HCRE AKEP	Hawai`i State, DLNR, State 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 State, DLNR, Division of Forestry and Wildlife, Ka`ū Forest Reserve. Predator control needed to protect large populations of three listed species.	3
2.4.1.15	H	Kahuku Ranch, Portions of 392001002	AKIP HCRE AKEP	Samuel M. Damon Trust. Purchase by NPS.	3
2.4.1.16	H	Manukā NAR, Upper portions of 391001002	AKIP HCRE AKEP	Hawai`i State, DLNR, DOFAW.	2
2.4.1.17	H	TNCH, Honomalino, 389001001	AKIP HCRE AKEP	The Nature Conservancy of Hawai`i.	3
2.4.1.18	H	Yee Hop Ranch, 392001005	AKIP HCRE AKEP	Yee Hop Ranch Ltd.	3
2.4.1.19	H	Kona Forest NWR, 386001001	AKIP HCRE AKEP	U.S. Fish and Wildlife Service. Predator control needed to protect last wild `alala and other listed species.	2
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

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
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 breeding habitat for endangered species, priority #1, remaining portions, priority #2.	1
2.4.1.26	MA	Ko`olau Forest Reserve, 211002002 212004005 229014001 211001050 211001044	AKOH MAPA POOU	Hawai`i State. Portions providing breeding habitat for endangered species, priority #1; remaining portions, priority #2 and tier #2.	1
2.4.1.27	MA	Hanawī NAR and Ko`olau Forest Reserve, 212004007	AKOH MAPA POOU	Hawai`i State. Portions providing breeding habitat for endangered species, priority #1, remaining portions, priority #2 and tier #2.	1
2.4.1.28	MA	Hāna Forest Reserve, 210001001 214001001 215001001	AKOH MAPA POOU	Hawai`i State. Portions providing breeding habitat for endangered species, priority #1, remaining portions, priority #2 and tier #2.	1
2.4.1.29	MA	Haleakalā National Park, 213001003 216001002 216001001	AKOH MAPA POOU	National Park Service. Portions providing breeding habitat for endangered species, priority #1, remaining portions, priority #2 and tier #2.	1

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		216001003 217004016 216010001 218001007			
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
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 breeding 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	AKOH	Hawai`i State. Potential long-term	3

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		NAR, Līhau, 248001002	MAPA POOU	site for reintroduction.	
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
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 starting in 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	OAEL	U.S. Navy. Rodent control initiated	1

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
		Magazine, 88001001		in 2002 using diphacinone bait stations and snap traps, should be continued and expanded, using aerial broadcast if possible.	
2.4.1.48	O	Schofield Barracks West Range, 77001001	OAEL	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
2.4.1.49	O	Honolulu Watershed Forest Reserve (Wailupe), 36004004	OAEL	Hawai`i DOFAW. Rodent control conducted starting 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
2.4.1.52	O	Wai Kāne 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 State. 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 State. Rodent control conducted in 1999 using bait stations. Currently few `elepaio, but aerial broadcast would help prepare site for reintroduction/augmentation.	2
2.4.1.56	O	Kahanahāiki Valley, 81001012	OAEL	U.S. Army. Rodent and mongoose control conducted starting in 1998 using snap traps, bait stations, and live traps. Currently few `elepaio,	2

Table 11					
Recovery Action #	Island	Land Parcel, TMKs	Species Targeted	Current Landowner/Comments	Priority
				aerial broadcast would help prepare site for reintroduction/augmentation.	
2.4.1.57	O	O`ahu Forest NWR, 95004001 76001001	OAEL	U.S. Fish and Wildlife Service. Currently no `elepaio, rodent control would help prepare site for reintroduction.	3
2.4.1.58	O	Lower Ka`ala NAR, 67003025	OAEL	Hawai`i State. Currently few `elepaio, predator control would help prepare site for reintroduction/augmentation.	3
2.4.1.59	K	Halehaha, Halepaakai, and Koai`e drainages, Alaka`i Wilderness Preserve, 414001003	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i State, DLNR, Division of Forestry and Wildlife. Recommend aerial broadcast of rodenticide in Halehaha and Halepaakai drainages, and a tributary of Koai`e Stream.	1
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 State, DLNR, DOFAW. Pending study of threat posed by rats to core puaiohi population, recommend aerial broadcast of rodenticides in upper Mōhihi and Waiakoali drainages. Ground-based protection of active nest-sites.	2
2.4.1.61	K	Upper Kawaikōī, Alaka`i Wilderness Preserve, 459001001	PUAI KACR KAMO KAAK OO OU KANU	Hawai`i State, DLNR, Division of Forestry and Wildlife. 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.	3

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 in the 1800's, and the introduction of avian malaria (*Plasmodium relictum*) in the early 1900's 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, Atkinson *et al*. 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 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. (Priority 1)

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 2)

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. (Priority 1)

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 habitats and areas outside forest bird recovery habitat. (Priority 1)

Because of their close proximity to areas of human habitation, areas outside forest bird recovery habitats 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 who work regularly in both forest bird recovery habitat and areas outside forest bird recovery habitats 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.

2.5.2 Prevent movement of diseases and disease vectors between islands. (Priority 1)
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. (Priority 1)
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. (Priority 1)

Culex quinquefasciatus is a domesticated 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. 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 suitable buffer areas around recovery habitat where management actions can be taken to reduce numbers of mosquitoes.

2.5.3.1.1 Survey recovery habitat 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.

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
2.5.3.1.1.1	Hawai`i	Portions of parcels between the 2,000 and 5,000 foot contour lines on Mauna Loa and Kīlauea Volcanoes that include recovery habitat	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	Hawai`i	Portions of parcels between the 3,400 and 5,000 foot contour lines on Mauna Kea Volcano that include recovery habitat	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	Hawai`i	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 habitat	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
2.5.3.1.1.4	Hawai`i	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 km of recovery habitat	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	2

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
			habitat makes them lower priority.	
2.5.3.1.1.5	Hawai`i	Portions of parcels on Kīlauea Volcano that are adjacent to or within 3 kilometers of recovery habitat	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 habitat 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	Hawai`i	Portions of parcels on Hualālai Volcano that are adjacent to or within 3 kilometers of recovery habitat	Surveys for adult and larval mosquitoes have not been conducted in these areas. Their close proximity to recovery habitat on Hualālai and role as potential sources of dispersing adult mosquitoes give them high priority for surveys.	2
2.5.3.1.1.7	East Maui	Multiple land parcels in recovery habitat 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 habitat in this elevation zone are needed to prioritize mosquito control efforts.	1
2.5.3.1.1.8	East Maui	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	2

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
			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 habitat.	
2.5.3.1.1.9	East Maui	217004006	Manawainui Valley incursion into recovery habitat, 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	East Maui	215001001	Waiho`i Valley incursion into recovery habitat, from 2,500 to 2,000 feet.	1
2.5.3.1.1.11	East Maui	216001002	Kīpahulu Valley incursion into recovery habitat, from 2,500 to 1,600 feet.	1
2.5.3.1.1.12	East Maui	211002002	Ke`anae Valley incursion into recovery habitat, from 1,800 to 2,500 feet.	1
2.5.3.1.1.13	East Maui	Multiple parcels below and within 3 kilometers 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 habitat has been restored.	3
2.5.3.1.1.14	West Maui	Multiple land parcels in recovery habitat 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	West Maui	233003003, 235003001, 233003004, and multiple smaller parcels within `Īao Valley	`Īao Valley incursion into recovery habitat, 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

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
2.5.3.1.1.16	West Maui	232014001, 233003003	Waiehu Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.17	West Maui	232014001	Waihe`e Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.18	West Maui	231006001	Kahahuloa Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.19	West Maui	241001017	Honokōhau Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.20	West Maui	236003001, 235003001	Waikapū Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.21	West Maui	241001017	Honolua Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.22	West Maui	242001001	Honokahua Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.23	West Maui	242001001	Kahana Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.24	West Maui	244007004, 244007011, 244007001, 244007005	Honokōwai Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.25	West Maui	245022001	Kahoma Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.26	West Maui	246025002	Kanahā Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.27	West Maui	246025001, 247001002	Mākila Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.28	West Maui	248001002	Olowalu Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.29	West Maui	248001002	Ukumehame Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.30	West Maui	236003001	Pōhākea Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.31	West Maui	245022003	Waihikuli Valley incursion into recovery habitat, from 2,500 to 600 feet.	2
2.5.3.1.1.32	West Maui	245022004	Hanakea Valley incursion into recovery habitat, from 2,500 to	2

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
			600 feet.	
2.5.3.1.1.33	West Maui	Multiple parcels below and up to 3 kilometers 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 Lāhainā. Priority for surveying these areas is lower because of their distance from recovery habitat.	3
2.5.3.1.1.34	Moloka`i	Multiple land parcels in recovery habitat	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
2.5.3.1.1.35	Moloka`i	261001002, 259006011, 259006002 and smaller windward parcels in Waihanuu, Wai`ale`ia, Waikolu, Pelekunu, and Wailau Valleys that are adjacent to or within 3 kilometers of recovery habitat	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	Moloka`i	Parcels in Kaunakakai Gulch	Kaunakakai Gulch may act as a natural corridor for dispersal of mosquitoes from urban/suburban Moloka`i directly into recovery habitat.	2
2.5.3.1.1.37	Moloka`i	Portions of parcels 252014003, 253003005, 254003025, 254003001, 255001006 and others that are adjacent to or within 3 kilometers of the southern and eastern boundaries of recovery habitat on leeward Moloka`i	Surveys for adult and larval mosquitoes have not been conducted in these areas. Since the area is deeply dissected by numerous stream valleys that could funnel mosquitoes into recovery habitat, vector surveys should ideally extend from the lower boundary of recovery habitat to the coastline, particularly in areas with rural agricultural development.	2
2.5.3.1.1.38	O`ahu	Portions of parcels that include recovery habitat	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`ahu	Portions of parcels that are adjacent to or within 3 kilometers of recovery	Detailed surveys for adult and larval mosquitoes have not been	2

Table 12				
Recovery Action #	Island	Land Parcel, TMKs	Current Landowner/Comments	Priority
		habitat	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 habitat, but this needs to be documented.	
2.5.3.1.1.40	Kaua`i	Portions of parcels 414001020, 414001014, 414001013, 459001016, 459001001, 414001003, 417001001, 458001001 and others that include recovery habitat	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. Areas in recovery habitat need additional detailed surveys 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	Kaua`i	Portions of parcels 459001001, 458001001, 458002002, 459001003, 459001002 that are adjacent to or within 3 kilometers of recovery habitat	Surveys for adult and larval mosquitoes have not been conducted in windward valleys of the Akaka`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	Kaua`i	Portions of parcels 414001014, 414001020, 414002040, 414001003, 417001001 that are adjacent to or within 3 kilometers of recovery habitat	Surveys for adult and larval mosquitoes have not been conducted in leeward valleys and slopes of the Akaka`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 habitat 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 habitat or within 3 kilometers (1.9 miles) of the lower, windward boundaries of recovery habitat 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 habitat 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* 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 habitats 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 habitats.

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 habitat; coordinate efforts with the State Department of Health. (Priority 1)

In locations where human development is close to recovery habitat (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 epiootics 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 around residential and agricultural areas near recovery habitat. (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 habitats 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 areas in recovery habitat at elevations 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 and their relative roles as larval habitats in both forest bird recovery habitat and areas outside forest bird 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. (Priority 2)

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 (Ewald 1984, 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 recovery forest bird habitats. (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 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. (Priority 2) 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 here are necessary to conserve and recover Hawaiian forest birds.

2.6.1 Prevent introductions of new detrimental species. (Priority 2) 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 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 Hawai'i Department of Agriculture with obtaining an enforcement branch to pursue smuggling and release violations. (Priority 2)

2.6.1.4 Encourage U.S. Fish and Wildlife Service to adopt State injurious species lists as part of Federal injurious wildlife listed under the Lacey Act. (Priority 2)

2.6.1.5 Encourage 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. (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 mainland. (Priority 2)

2.6.1.9 Prevent inter-island expansion of established vertebrates of restricted range. (Priority 2)

2.6.2 Eradicate all incipient populations of new *Tetrapoda* (non-native vertebrate species). (Priority 1)

2.6.2.1 Prevent spread of *Eleutherodactylus* frogs to new areas. (Priority 1)

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 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, 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. 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.

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 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.), 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 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 the 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. Priorities for the use of facilities take into account considerations based on taxonomic uniqueness, urgency/degree of threat, cause of decline, available knowledge of natural history, status of current research and habitat management, population size, distribution (fragmentation), practical considerations (funding, labor, facilities etc.), avicultural difficulty, release difficulty, availability and accessibility of release sites, value as an ecosystem component, cultural value, educational value, Service policies, and International Union for the Conservation of Nature recommendations. Refer to Appendix B for more detailed discussion.

Table 13. Captive propagation program strategies and priorities for facilities use and recovery. Captive Propagation Program Strategies are defined 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. 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) Species for which captive breeding development is to be used as surrogates to aid the development of techniques for other species.

Table 13		
Species	Captive Propagation Program Strategies	Captive Breeding Priorities
"On the Brink Species" (Po`ouli, Kāma`o, etc.)	3	1
Puaiohi	4	1
`Alalā	5, 6	1
`Akiapōlā`au	8, 4	2
Palila	8, 4	2
Nēnē	4	2
Nihoa Millerbird	8, 2, 4	2
Kaua`i Creeper	8, 4	2
Maui parrotbill	8, 4	2
O`ahu `Elepaio	1, 2, 3	3
Hawai`i `Ākepa	8, 3, 4	3
Hawai`i Creeper	8, 3, 4	3
`Ākohekohe	8, 2, 3	3
Laysan Finch	1, 2	3
Hawai`i `Elepaio	8	4
`I`iwi	8	4
`Ōma`o	3	4

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

veterinary requirements, mate selection, and proper socialization of captive-reared birds. Aviculture and release technology is 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 twelve species of Hawaiian forest birds has been established 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 nuku pu`u, Maui `ākepa, oloma`o, po`ouli, O`ahu creeper, kāma`o, Kaua`i nuku pu`u, Kaua`i `akialoa, and Kaua`i `ō`ō if nests can be located and eggs collected. Captive management of the Hawai`i `elepaio will provide propagation and release techniques required for future work with the endangered O`ahu `elepaio. Development of translocation methods for the `ākohekohe should continue, and captive breeding technology should be developed if translocaton efforts fail. The appropriate captive propagation strategy for each species should be evaluated and implemented through the development of annual Work Plans and 5 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 nuku pu`u, Maui `ākepa, oloma`o, O`ahu creeper, kāma`o, Kaua`i nuku pu`u, Kaua`i `akialoa, and Kaua`i `ō`ō.

For these species, which are 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 managed habitat in the future. (Priority 1)

3.2.2 Po`ouli.

Continue habitat management, attempt to promote pairing and reproduction, in captivity if necessary, and collect eggs for captive propagation and future reintroduction into managed habitat. (Priority 1)

3.2.3 Puaiohi.

Maintain a captive breeding flock of whose progeny will be used for reintroduction into managed habitat. (Priority 1) 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.

Collect eggs for incubation and captive rearing to establish a captive breeding flock whose progeny will be used for reintroduction into managed habitat. (Priority 2) 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.

3.2.5.1 Collect eggs of Maui parrotbill 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 no longer known to 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 no longer known to 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 wild 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 <90 percent), collect wild eggs. (Priority 1)

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.

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.
Collect the eggs of Hawai`i `elepaio to serve as a surrogate. (Priority 3).
The Hawai`i subspecies is the most appropriate surrogate to develop the 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. 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 (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, edaphics, 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, 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 logistic 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 habitat 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 1)

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 1)

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 provide funding to construct and operate the captive breeding facilities, supplemented by private sector funding. Funding needs and availability will be considered in Annual Workplans and 5 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

might well 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 2000) and the non-endangered O`ahu `Amakihi (*Hemignathus chloris*) (Shehata *et al*. 2001) and Hawai`i `Akakihi (*Hemignathus* var. *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 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 differences 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, 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 2)
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 micro-habitat, size, dimension, and exact location of the hacking aviary; location and positioning of supplemental food stations; locations of field observations; and the 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, it is important to establish demographic goals for captive propagation program, for example, how many birds to produce using which demographic strategy over what period of time and released into how many sites. (Priority 2)
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 out-placement 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, or species which are in the captive program but for which there is not a high priority to continue to enlarge the captive inventory through breeding, and for 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 actions proposed to deal with these threats require research and management to 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 development of methods to control identified threats and evaluation of the effectiveness of those control methods. In addition, populations may be vulnerable 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, and for determining the effectiveness of implemented actions.

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 of forest bird recovery habitat. (Priority 1)

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 in press) and mongooses (Keith *et al.* 1989, Stone *et al*. 1994, Smith *et al*. 2001). Current registration requires a very labor-intensive application using bait stations, limiting effective use of this tool to small areas. For effective control of predators over a spatial scale that is meaningful for recovery of endangered forest birds, additional experimentation and 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 also is 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 study/control. (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 study/control. (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 study/control. (Priority 2)
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 study/control. (Priority 1)

4.2.6 Ungulate study/control. (Priority 1)

4.2.6.1 Experimental test of alternative methods of feral pig control. (Priority 2)

4.2.7 Weed study/control. (Priority 2)

4.2.8 Yellow jacket wasp study/control. (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/control. (Priority 2)
Study barn owls and pueo in forest bird habitats to determine densities and predatory impacts on native forest birds.

4.2.10 Avian competitor study/control. (Priority 2)
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 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*) and white-rumped shama (*Copsychus malabaricus*). (Priority 2)

4.2.10.3 Investigate role of Japanese white-eye (*Zosterops* japonicus) and Japanese bush-warbler (*Cettia diphone*) as competitors and reservoirs of disease for on all islands. (Priority 2)

4.2.11 Determine best ways of 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.

4.3 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 natural history of the 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 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, 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.

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 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 when the surviving individuals maintain a viable population.

4.5.1 Identify geographical variation in behavior and reproduction of forest birds that may make them less susceptible to threats. (Priority 2)

4.5.1.1 Determine if roost site selection and specific mosquito avoidance behaviors (e.g., sleeping 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. (Priority 1)
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 (Ewald 1984, 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 survive pox and malaria infections or to resist them. (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 that confer 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 acute disease and have acquired immunity to reinfection. (Priority 1) Recently developed polymerase chain reaction (Feldman *et al*. 1995) and serological (Atkinson *et al.* 2001) 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. (Priority 2)

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. (Priority 2)

4.6.1.3 Develop effective techniques for restoration of degradaded and deforested lands. (Priority 2)

4.6.2 Document the population structure. (Priority 2)
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 populations below carrying capacity. Furthermore, 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 global warming, 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 calculation of lambda as an indicator of stable or increasing populations. The Nature Conservancy Population Viability Handbook specifies additional analyses that can be used to assess population viability within a single population or a metapopulation.

4.6.3.1 Conduct trend analysis using count data. (Priority 2)

4.6.3.2 Use demographic data for estimating lambda. (Priority 2)

4.7 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 or for supplementing a small population or for genetic management.

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. (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 involved. In addition, this 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 1)
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 areas where residential and agricultural areas are located next to recovery habitats. 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 habitat. These factors may be particularly important for the design of safe, disease-free corridors to link recovery habitats at different elevations or geographic areas 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 development of malarial parasites in the mosquito vector and increasing the duration of the gonotrophic cycle of *Culex* makes it likely that global warming 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 this 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 habitat 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 1)

Research on experimental vaccines for control of pox and malaria transmission, methods for their delivery to wild free-ranging passerines, and their effects on host-parasite coevolutionary adaptations should be supported. 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.

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 habitat. (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. Geologicl Survey unpubl. data), but where larval *Culex* have rarely been found. In these situations, 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 transfer of virus to offspring in situations where one or more parent birds 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 recovery forest bird habitats. (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 effectiveness of management actions and for determining how complex interactions between abiotic and biotic environmental factors, anthropogenic factors, native and non-native 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 `akialoau; KACR = Kaua`i creeper; KAMO = kāma`o; KANU = Kaua`i nuku pu`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						
Recovery Action #	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
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	KACR PUAI	K	Alaka`i Wilderness Area	Examine factors that determine abundance and distribution, including	2

Table 14						
Recovery Action #	Category of Research (Recovery action narrative general action number)	Species	Island	Area	Research Description	Priority
	in density (4.1)				elevational range.	
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 (4.3.1)	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 (4.3.1)	MAPA AKOH POOU	MA	Maui	Determine population response to predator control efforts.	2
4.10.9	Evaluate the effectiveness of threat management actions; determine response of bird population to removal or reduction of a threat (4.3.1)	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 (4.3.1)	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.	2
4.10.11	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3.2)	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 (4.3.2)	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	MAPA AKOH	MA	Maui	Determine population response to forest regeneration and restoration efforts.	2

Table 14						
Recovery Action #	Category of Research (Recovery action narrative general action number)	Species	Island	Area	Research Description	Priority
	populations to habitat restoration (4.3.2)					
4.10.14	Evaluate the effectiveness of threat management actions; examine response of populations to habitat restoration (4.3.2)	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 treats; 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.	1
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
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	AKIP	H	Hawai`i	Determine the basis of variation in size of home range in areas of different density of the bird and in	2

Table 14						
Recovery Action #	Category of Research (Recovery action narrative general action number)	Species	Island	Area	Research Description	Priority
	structure along gradients in density, particularly elevational gradients (4.6.2.3)				areas with different forest structure.	
4.10.20	Document population structure; determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations (4.6.2.5)	AKEP HCRE AKIP	H	Mauan Kea, Mauan 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 (4.6.2.5)	OAEL	O	O`ahu	Determine morphological, genetic, behavioral, ecological, and vocal variation among core populations.	2
4.10.22	Document population structure; determine patterns of dispersal by age and sex (4.6.2.6)	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)	AKIP 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, plus additional transects established on O`ahu to adequately survey all recovery habitat 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 intrinsic growth rate (lambda) 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 1970's, 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 habitat.

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.

Table 15. Areas of recovery habitat requiring avian monitoring surveys 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 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	Annually/biannually	2
5.2.9	MA	Hanawī NAR	Annual survey	2

Table 15				
Recovery Action #	Island	Study Area	Survey Need/ Comments	Priority
5.2.10	MA	Waikamoi Preserve	Annual survey	2
5.2.11	MA	Kīpuhulu 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

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.

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. (Priority 2)

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. Hawai`i'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 visitor 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 Fund the planning and development of scenic overlooks and trails with interpretative signs along roadsides and in native forest areas (see Table 16).
Expanding visitor outdoor experiences by developing scenic overlooks and trails with interpretative signs along public roadways within native habitats where available, will lead to a greater connection between the public and natural environments.

Table 16. Sites where scenic overlooks and interpretive displays are needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 16				
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 points out native forest birds found in the kīpuka and their forest habitat.	3
6.1.1.2	H	Hawai`i Volcanoes National Park, Mauna Loa Strip Road	Develop several overlooks, parking areas, short loop trails, and interpretive displays along the Mauna Loa Strip Road.	3
6.1.1.3	MA	Polipoli State Park	The parking area needs an interpretive kiosk to point out four local species of honeycreepers.	3
6.1.1.4	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
6.1.1.5	K	Kōke`e State Park, Kalalau and Pu`u O Kila lookouts	Both lookouts need interpretive kiosks or signage to point out common native forest birds and recovery efforts being conducted for the endangered puaiohi.	3

6.1.2 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 the 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 17).

Table 17. Sites where new trails with interpretive displays should be developed or where existing trails need enhancement with interpretive displays. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 17				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.2.1	H	Saddle Road, Pu`u `ō`ō Trail	Trailhead access and parking area need improvement and interpretive displays should be installed to bring attention to native forest birds.	3
6.1.2.2	H	Hawai`i, Hawai`i Volcanoes National Park, Mauna Loa Strip Road.	Develop several short loop trails, parking lots, and interpretive displays along the Mauna Loa Strip Road.	3
6.1.2.3	H	Hakalau Forest NWR	Expand visitor use with a loop trail and interpretive displays.	2
6.1.2.4	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
6.1.2.5	H	`Ainapō Trail	Work with Na Ala Hele to add a bird component to their brochure and interpretive signs at parking areas.	3
6.1.2.6	H	Pu`u Wa`awa`a Forest Bird Sanctuary	Develop a system of trails with interpretive signs.	3
6.1.2.7	H	NARs Pu`u Maka`ala	Develop a system of trails with interpretive signs.	3

Table 17				
Recovery Action #	Island	Area	Development Needed	Priority
		Laupāhoehoe Kīpāhoehoe Manukā Pu`u `Umi		
6.1.2.8	MA	Haleakalā National Park, Hosmer Grove	Develop a new bird trail, overlook, and interpretive signs.	3
6.1.2.9	MA	Polipoli State Park	Develop interpretive signs and brochures for the Waiakoa Loop Trail, and include a bird component.	3
6.1.2.10	MA	Pu`u Kukui, Maui Land and Pineapple	Develop access, trails, and interpretive signs for the Pu`u Kukui Trail.	3
6.1.2.11	MA	Waihe`e Ridge Trail	Develop an interpretive display at the top of the trail.	3
6.1.2.12	MA	Kahakuloa NAR.	At top of Po`elua Road, develop trail and interpretation on birds and other native biota.	3
6.1.2.13	MO	Hanalilolilo Trail	Develop an interpretive trail to rim of Pēpē`ōpae Bog.	3
6.1.2.14	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
6.1.2.15	K	Kōke`e State Park	Develop interpretive signs and brochures for all Kōke`e State Park Trails focusing on native forest birds.	2

6.1.3 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 18).

Table 18. Sites where increased access and interpretation are needed. Island codes: H = Hawai`i; K = Kaua`i; MA = Maui; MO = Moloka`i; O = O`ahu.

Table 18				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.3.1	H	Hakalau Forest NWR, Hakalau and Kona Forest Units	Conduct open houses on a basis regular basis and develop open public access opportunities.	3
6.1.3.2	H	Pu`u Wa`a Wa`a Wildlife Sanctuary	Improve public access and interpretation.	3
6.1.3.3	MA	Waikamoi Preserve The Nature Conservancy	Expand public access opportunities into areas with native forest birds.	3
6.1.3.4	MA	Makawao Forest Reserve	Develop public access and interpretation of the Idyllwild entrance to the reservoir on the 4,300 foot contour road.	3
6.1.3.5	MA	Hanawī NAR	Increase limited public access for bird study and permitted public access.	3
6.1.3.6	MA	Haleakalā National Park	Increase public access opportunities for bird viewing in the Kaupō koa forest and in the Hosmer Grove area.	3
6.1.3.7	MO	Kamakou Preserve, The Nature Conservancy	Improve public access by connecting the preserve with Hanalilolilo trail.	3
6.1.3.8	O	Barber's Point	Develop interpretive displays and sponsor regular trips to sinkholes at Barber's Point to see fossil bird bones.	3
6.1.3.9	O	Honouliuli Preserve, The Nature Conservancy	Support public education through the Project Stewardship program run by The Nature Conservancy of Hawai`i.	3

6.1.4 Expand visitor awareness with development of visitor centers, displays, facilities, and public interpretive programs (see Table 19).

Table 19. 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 19				
Recovery Action #	Island	Area	Development Needed	Priority
6.1.4.1	H	Hakalau Forest National Wildlife Refuge	Develop a visitor center with interpretive displays and docents promoting refuge programs to protect Hawai`i's endangered flora, fauna, and ecosystems.	2
6.1.4.2	MA	Haleakalā National Park	Construct an interpretive display in the cabin at Palikū providing information on programs by the NP and State for Maui parrotbill, `ākohekohe and other native forest birds.	2
6.1.4.3	O	Honolulu Zoo	Provide support for developing a Hawai`i forest bird display at Honolulu Zoo.	2

6.1.5 Promote the opening of State Forest Reserve trails to the general public for nature walks and birding on all islands. (Priority 2)

6.1.6 Support the Na Ala Hele Trail System. (Priority 2)

6.2 Fund, support, and promote programs that inform teachers and educate children, lawmakers, local public, and visitors.
Most people in Hawai`i are unfamiliar with Hawai`i'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 tarsier education programs that promote native species issues. (Priority 2)
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 Hawai`i's native species for elementary and high school teacher education programs. (Priority 1)

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. (Priority 2)

6.2.1.4.1 Develop forest bird posters for schools, emphasizing each of the native forest birds and keyed to each islands 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. (Priority 2) 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 program.

6.2.2.1 Fund and support programs for school children on each island that provide 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 Hawai`i'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 Malama 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. (Priority 2)
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. (Priority 2)
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 Hawai`i's ecosystems and economy.

6.2.4.1 Initiate and fund public outreach efforts about the effect of rats and cats as vectors for human disease, agricultural pests, and predation on native species. Provide film and video footage of the harmful effects rats and cats have on native species and humans. (Priority 2)

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 2)

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 (TV, Radio, Internet, newspapers, advertising, 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, TV, 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 TV and radio about native species and their habitat. (Priority 2)

6.3.2.1 Assist in the development of public service announcements about native species by providing local TV 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, TV 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 TV 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 TV program about Hawai`i'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. (Priority 3)

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. (Priority 3)

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 Hawai`i's natural and cultural resources. (Priority 2)
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. (Priority 2)

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 Hawai`i'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)

6.4.1.3.1 Develop volunteer programs for banding O`ahu `Amakihi at Lyon Arboretum and O`ahu `elepaio in Wailupe Valley. (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 programs with other conservation agencies, native Hawaiian groups, and private landowners. (Priority 3)

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 Association, and other non-governmental organizations to promote environmental awareness. (Priority 3)

V. IMPLEMENTATION SCHEDULE

Recovery actions in the Implementation Schedule have been prioritized in a two-part ranking system. First, each action was assigned a “priority number” from 1 (highest priority) to 3 (lowest priority). Second, within each priority number, actions were further 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. These priority tiers were applied only to actions in Tables 7, 8, 9, and 11 (recovery habitat parcels in need of protection, reforestation, fencing and ungulate control, and predator control, respectively) because it would be difficult to prioritize the large number of actions in these categories without the greater resolution provided by the recovery tier. The recovery tier rankings were 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 were 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 land owners and land managers who may wish to see a complete list by parcel of recovery actions for their lands. Recovery actions in Appendix A are from Tables 7, 8, 9, and 11 of the recovery action narrative.

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.

Threat Categories. We consider five major threats to species in order to list, delist, or reclassify a species:

A – Present or threatened destruction, modification or curtailment of habitat or range;

B – Over-utilization for commercial, recreational, scientific, or educational purposes;

C – Disease or predation;

D – Inadequacy of existing regulatory mechanisms; and

E – Other natural or man-made factors affecting the continued existence of a species.

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 recovery criteria of creating viable populations or meta-populations and management of recovery habitat (see Recovery Criteria section). The majority of recovery actions in this plan address threats to habitat (threat A) and disease and predation (threat C). The over-utilization of Hawaiian forest birds for commercial, recreational, scientific, or educational purposes (threat B) is not currently a concern. The `akikiki, a candidate species for listing, is threatened by inadequacies of existing regulatory mechanisms (threat D) because it is not on the Federal list of threatened and endangered species. In addition, in some cases listed species may be threatened by zoning regulations that are inadequate to ensure protection of their habitat. 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, effects of threats on populations, and measure population response to management.

Definitions of Action Durations:

Continual – An action that will be implemented on a routine basis once begun.

Ongoing – An action that is currently being implemented and will continue until the action is no longer necessary.

Unknown – Action duration is not known at this time or action is not being implemented currently.

Complete – Action has been completed.

Responsible Parties for Action Implementation:

We have the statutory responsibility for implementing this recovery plan. Only Federal agencies are mandated to take part in the effort. Recovery actions identified in this plan imply no legal obligations of State and local government agencies or private landowners. However, in most cases complete recovery of listed species included in this plan will require the involvement and cooperation of the 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 responsible for implementing recovery actions and conservation groups, partnerships, and private landowners that also may wish to be involved in recovery implementation. An asterisk (*) identifies lead partners for implementing recovery actions.

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.

<u>Secure Recovery Habitat</u>: Costs to secure recovery habitat 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.

<u>Reforestation and Restoration</u>: Cost for each action number equals total acreage in the recovery habitat parcel(s) to be reforested or restored multiplied by cost per acre for reforestation or restoration. Cost/acre for reforestation = $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.

<u>Fencing and Feral Ungulate Removal</u>: Cost for each action number equals total acreage in the recovery habitat parcel(s) requiring fencing multiplied by cost per acre for fencing added to the total acreage in the recovery habitat 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 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 percent. One-way gates and other means of reducing numbers of ungulates in fenced areas are included in the cost for fencing designs.

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.

<u>Predator Control</u>: The cost for each action number equals total acreage in the recovery habitat 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. However, 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. It is not possible to determine the cost of predator control for many parcels at this time because the cost will depend on the methodology approved by the Environmental Protection Agency for aerial broadcast application of diphacinone rodenticide for conservation purposes in Hawai`i.

<u>Captive Propagation</u>: 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 $100 million for all

activities under the general heading of captive propagation and related recovery strategies, or $2 million per year for a 50-year period.

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 30 years. Recovery of other species will require substantial habitat restoration, which could take more than 30 years. We have estimated on average that we can expect all the species in this plan with current populations of greater than 300 individuals to be recovered in 50 years. For actions that are continual, total costs reflect annual costs summed over 50 years.

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
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
MFBRP – Maui Forest Bird Recovery Program
MWP – Maui Watershed Partnership
NAPS – Natural Areas Partnership
NAR – Natural Area Reserve

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 20. Implementation Schedule for the Hawaiian Forest Birds Recovery Plan.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
1	1	1.1	A	Describe and delineate recovery habitat	Complete	*USFWS, *HFBRT						
1	1	1.3.2	A	Secure recovery habitat areas: Kanakaleonui Corridor, TMK 338001009	Unknown	*DHHL	TBD[1]					Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest. By lease, conservation easement, or partnership. Remove grazing and enhance natural communities.
1	1	1.3.6	A	Secure recovery habitat areas: Humu`ula, TMK 338001002	Unknown	*DHHL, Nobrega Ranch	TBD[1]					Hawai`i State, DHHL. Restorable. A vital link between wet and dry forest communities. Currently leased to Nobrega Ranch for cattle grazing. By lease, conservation easement, cooperative agreement, or partnership.
1	1	1.3.8	A	Secure recovery habitat areas: TMK 326018002	Unknown	*DHHL	TBD[1]					Hawai`i State, 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	1	1.3.9	A	Secure recovery habitat areas: TMK 326018001	Unknown	*DLNR, State Land Division, Pu`u Ō`ō Ranch	TBD[1]					Hawai`i State, DLNR, State Land Division. Leased to Pu`u `Ō`ō Ranch for cattle

Table 20												
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												grazing. Important mesic and wet koa/`ōhi`a forest remnants, and vital link between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
1	1	1.3.10	A	Secure recovery habitat areas: TMK 344015002	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i State, DLNR, State Land Division, currently leased for cattle grazing to various lessees. Restorable. A vital link between wet and dry forest communities. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
1	1	1.3.27	A	Secure recovery habitat areas: 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, or purchase from willing seller.
1	2	1.3.30	A	Secure recovery habitat areas: Kīpahulu Forest Reserve, TMKs 216001005	Unknown	*DLNR, *EMWP	TBD[1]					Hawai`i State. Isolated; secure access for management. Habitat in need of active management.

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				217001033 217002035 217004006 218001007								By partnership with EMWP or lease.
1	3	1.3.35	A	Secure recovery habitat areas: Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Unknown	*DLNR, *EMWP	TBD[1]					Hawai`i State. Isolated; secure better access for management. Degraded former forest land in need of active management. By partnership with EMWP or lease.
1	3	1.3.36	A	Secure recovery habitat areas: Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	Unknown	*DHHL, USFWS, *EMWP	TBD[1]					Hawai`i State, DHHL. Degraded former forest land in active forest stewardship program with FWS. By partnership with EMWP.
1	2	1.3.44	A	Secure recovery habitat areas: Haleakalā Ranch (Pūlehu Nui /Kalialinui), TMK 223005003	Unknown	*Haleakalā Ranch Co., *EMWP	TBD[1]					Haleakalā Ranch Co. Degraded former forest land in need of active management. By partnership with EMWP. By conservation easement, safe-harbor agreement, change of land use designation, or purchase from willing seller.
1	1	1.3.45	A	Secure recovery habitat areas: 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

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												management by TNCH, or by purchase from willing seller.
1	1	1.3.71	A	Secure recovery habitat areas: Pia Valley, TMKs 37003073 37003033	Unknown	*Benjamin Casiday, *James Pflueger, *KMWP	TBD[1]					Benjamin Cassiday, James Pflueger. By easement, partnership, or purchase from willing seller. Upper valley (Pflueger, 37003003) in KMWP, but additional measures may be needed to ensure protection of forest habitat supporting large `elepaio population. Lower valley is zoned conservation, but no other protection.
1	1	1.3.72	A	Secure recovery habitat areas: Lower Wailupe Valley, TMK 36004001	Unknown	*City and County of Honolulu	TBD[1]					City and County of Honolulu. Currently zoned urban. By easement, change in land use designation, or purchase from willing seller.
1	1	1.3.73	A	Secure recovery habitat areas: Kūpaua Valley, TMKs 37004001 37004002	Unknown	*Hawai`i Humane Society, *KMWP	TBD[1]					Hawai`i Humane Society. By easement, partnership, or purchase from willing seller. Upper valley (37004002) in KMWP, but additional measures may be needed to ensure protection of forest habitat supporting large `elepaio population. Lower valley is zoned conservation, but no other protection.
1	1	1.3.74	A	Secure recovery habitat	Unknown	*Joseph Paiko	TBD[1]					Joseph Paiko Trust owns

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				areas: Kuli`ou`ou Valley, TMK 38013001		Trust, *KMWP						west half of lower valley. By easement, partnership, or purchase from willing seller. Not in KMWP, no current protection.
1	1	1.3.79	A	Secure recovery habitat areas: Wai Kāne Valley, TMK 48014005	Unknown	*SMF Enterprises, *KMWP	TBD[1]					SMF Enterprises. By easement, partnership, or purchase from willing seller. In KMWP, additional measures may be needed to ensure protection of forest habitat supporting large `elepaio population.
1	1	1.3.81	A	Secure recovery habitat areas: Southern Alaka1i Plateau, Portion of TMK 417001001	Unknown	*Robinson Family Partners	TBD[1]					Robinson Family Partners. Develop cooperative management agreement or purchase from willing seller.
1	1	2.1.2	A	Reforest areas of the Kanakaleonui Corridor, TMK 338001009	Unknown	*DHHL	15.1					Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats. Restore upper pasturelands.
1	1	2.1.5	A	Reforest areas of Hakalau Forest NWR, TMKs 337001010 329005005 333001007 329005003	Ongoing	*USFWS	33.7					USFWS. Currently managed forest bird habitat. Remove alien trees and continue forest restoration program.
1	1	2.1.12	A	Reforest areas of Mauna Kea Forest Reserve, TMK 344015002	Unknown	*DLNR	3.9					Hawai`i State, DLNR, Mauna Kea Forest Reserve. Restore montane dry māmane/naio forest.

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
1	1	2.1.24	A	Reforest areas of Kona Forest NWR, TMK 386001001	Unknown	*USFWS	2.0					USFWS, Kona Forest NWR. Restore montane mesic koa forest.
1	1	2.1.33	A	Reforest areas of Haleakalā National Park, TMK 218001007	Unknown	*NPS	8.8					NPS. Restore montane mesic forest in Kaupō Gap.
1	1	2.1.34	A	Reforest areas of Kīpahulu Forest Reserve, TMK 217004006	Unknown	*DLNR, *DOFAW	0.2					Hawai`i State. Restore montane mesic forest along cliff lines and head of Manawainui Valley.
1	3	2.1.37	A	Reforest areas of Kahikinui Forest Reserve, TMKs 218001006 218001005 218001009	Unknown	*DLNR, *DOFAW	2.8					Hawai`i State. Restore montane mesic forest and shrubland.
1	3	2.1.38	A	Reforest areas of Kahikinu Homelands, TMKs 219001003 219001007 219001008 219001011	Unknown	*DHHL	21.1					Hawai`i State, DHHL. Support ongoing restoration of 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	1	2.1.47	A	Reforest areas of Waikamoi Preserve, TMK 223005004	Unknown	*Haleakalā Ranch Co., *THCH	29.8					Haleakalā Ranch Co., TNCH. Restore montane mesic forest and shrubland at high elevations, replace non-native trees.
1	2	2.1.48	A	Reforest areas of Makawao Forest Reserve, TMK	Unknown	*DLNR	6.9					Hawai`i State. Restore montane mesic forest and shrubland, replace non-

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				224016001 224016002								native trees.
1	1	2.2.2	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kanakaleonui Corridor, TMK 338001009	3 years	*DHHL	18.1					Hawai`i State, DHHL. Provides a vital link between mesic koa forest and dry māmane forest habitats. Currently under lease for cattle grazing. Needs fencing and ungulate control.
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	3 years	*USFWS	61.9					Currently managed forest bird habitat. Ungulate control under way. Construct additional fences and control ungulates in unmanaged areas.
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	3 years	*DLNR, *DOFAW	69.1					Hawai`i State, DLNR, palila critical habitat. Continue to remove ungulates.
1	1	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	3 years	*DLNR, *DOFAW	124.3					Hawai`i State, DLNR, DOFAW. Fence and remove ungulates.
1	1	2.2.12	A, C	Reduce or eliminate the	3 years	*KS, Keauhou	90.9					Kamehameha Schools,

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				detrimental effects of ungulates on vegetation within `Ōla`a/ Kīlauea Partnership, TMKs 324008009 399001007 399001004 324008025 319001001 319001007		Ranch, Kūlani Correctional Facility, *Maka`ala NAR, *HVNP						Keauhou Ranch, Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP. Continue to 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	3 years	*Alexander and Baldwin, *East Maui Irrigation, EMWP, TNCH	50.0[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	3 years	*DLNR, *EMWP	50.0[2]					Hawai`i State, DLNR. EMWP fencing underway, protecting forest above 3600 ft. Remove ungulates above fence, additional fencing and ungulate control needed for unprotected areas below fence.
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,	3 years	*DLNR	100.0[2]					Hawai`i State, DLNR. Fenced area of NAR above 5,400 ft. now ungulate-free. Fence and remove ungulates from remaining

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				TMK 212004007								portions of NAR above 2,500 ft.
1	1	2.2.27	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Hāna Forest Reserve, TMK 210001001 214001001 215001001	3 years	*DLNR	81.5					Hawai`i State, 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	3 years	*NPS	50.0[2]					NPS. Mostly protected by fencing, but ungulate removal not completed in some areas. Fence and remove ungulates from remaining areas, e.g., Ka`āpahu.
1	2	2.2.31	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMKs 216001005 217001033 217002035 217004006	3 years	*DLNR	15.5					Hawai`i State. Fence and remove ungulates.
1	3	2.2.36	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahikinui Forest Reserve, TMKs	3 years	*DLNR	50.0[2]					Hawai`i State, DLNR. Fencing of portion underway. Complete fencing and ungulate removal from Forest

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				218001006 218001005 218001009								Reserve above 4,000 ft.
1	3	2.2.37	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahikinui Homelands, TMKs 219001003 219001007 219001008 219001011	3 years	*DHHL	50.0[2]					Hawai`i State, DHHL. Fencing of portions underway. Continue fencing through partnership programs. Ungulate removal above 4,000 ft.
1	3	2.2.38	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Upper Auwahi, TMKs 219001006 221009001 222001001 222001034	3 years	*`Ulupalakua Ranch Inc.	50.0[2]					`Ulupalakua Ranch Inc. Some exclosures for plant protection in place or underway. Continue to encourage fencing and ungulate removal above 4,000 ft.
1	3	2.2.45	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Haleakalā Ranch (Pūlehu Nui/Kalialinui), TMK 223005003	3 years	*Haleakalā Ranch Co.	9.3					Haleakalā Ranch Co. The ranch is formulating a conservation reforestation plan. Fence and remove ungulates within forest bird recovery habitat.
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.	20.0[2]					Haleakalā Ranch Co., The Nature Conservancy of Hawai`i. Strategic fencing and ungulate control protects the Preserve. Additional protection from deer may be warranted.
1	2	2.2.47	A, C	Reduce or eliminate the	3 years	*DLNR	15.6					Hawai`i State, DLNR.

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				detrimental effects of ungulates on vegetation within Makawao Forest Reserve, TMKs 224016001 224016002								Public hunting currently permitted. Fence and remove ungulates within forest bird recovery habitat.
1	1	2.2.94	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Honouliuli Preserve, TMK 92005013	3 years	*James Campbell Est., *TNCH	21.4					James Campbell Est., managed by The Nature Conservancy of Hawai`i. 40 acre and 100 acre exclosures completed. More, larger fences needed to exclude ungulates from as much of the preserve as possible.
1	1	2.2.95	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lualualei Naval Magazine, TMK 88001001	3 years	*U.S. Navy	9.3					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.
1	1	2.2.96	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Schofield Barracks West Range, TMK 77001001	3 years	*U.S. Army	11.0					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	1	2.2.97	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation	3 years	*DLNR	3.9					Hawai`i State, DLNR. Fencing and ungulate eradication to protect forest,

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				within Pahole NAR, TMK 68001002								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.
1	1	2.2.101	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Halehaha, Halepaakai, and Koai`e drainages, Alaka`i Wilderness Preserve, Portions of TMK 414001003	3 years	*DLNR, *DOFAW	5.9					Hawai`i State, DLNR, DOFAW. Fencing of at least a 4 km square area in the Halepaakai and Koai`e Stream drainage and eradication of pigs is needed to protect key habitat. Fencing and ungulate control may be needed in preparation for aerial broadcast of rodenticides.
1	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]					Individual priority numbers have not been assigned to parcels in recovery habitat.
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	Ongoing	*USFWS	674.0	13.5	13.5	13.5	13.5	Currently managed forest bird habitat. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				329005003								
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	406.8	8.1	8.1	8.1	8.1	Hawai`i State DLNR. Palila critical habitat. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	2,288.7	45.8	45.8	45.8	45.8	Kamehameha Schools, Keauhou Ranch, Kūlani Correctional Facility, Pu`u Maka`ala NAR, HVNP. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	730.3	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	2.4.1.26	C	Control alien mammalian predators by trapping, poisoning and other means in Ko`olau Forest	Continual	*DLNR, *DOFAW	819.0	16.4	16.4	16.4	16.4	Hawai`i State, DLNR, DOFAW. Portions supporting breeding habitat for endangered species,

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Reserve, TMKs 211002002 212004005 229014001 211001050 211001044								priority #1, remaining portions, priority #2 and tier #2. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	588.6	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	714.6	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	Continual	*NPS	829.9	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				217004016 216010001 218001007								
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	595.4	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	290	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	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	125	2.5	2.5	2.5	2.5	U.S. Navy. Control rodents using diphacinone bait stations, or by aerial broadcast if possible. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
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	150	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	80	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	2.4.1.50	C	Control alien mammalian predators by trapping, poisoning and other means in North Hālawa Valley, TMK 99011002	Continual	*KS	10	0.2	0.2	0.2	0.2	Kamehameha Schools. Rodent control needed to protect core `elepaio population. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	2.4.1.51	C	Control alien mammalian predators by trapping, poisoning and other means in Control alien	Continual	*Damon Estate	20	0.4	0.4	0.4	0.4	Damon Estate. Rodent control needed to protect core `elepaio population. Total cost based on

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				mammalian predators by trapping, poisoning and other means in Moanalua Valley, TMKs 11013001 and 11013002								continuous implementation for 50 years (estimated time to delisting).
1	1	2.4.1.52	C	Control alien mammalian predators by trapping, poisoning and other means in Waikāne Valley, TMK 48014005	Unknown	*SMF Enterprises	30	0.6	0.6	0.6	0.6	SMF Enterprises. Rodent control needed to protect core `elepaio population. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	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	30	0.6	0.6	0.6	0.6	Hawai`i State. Rodent control needed to protect core `elepaio population. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	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	10	0.2	0.2	0.2	0.2	City and County of Honolulu. Rodent control needed to protect core `elepaio population. Total cost based on continuous implementation for 50 years (estimated time to delisting).
1	1	2.4.1.59	C	Control alien mammalian predators by trapping, poisoning and other means in Halehaha, Halepaakai, and Koai`e drainages, Alaka`i Wilderness Preserve, TMK 414001003	Continual	*DLNR, *DOFAW	80	1.6	1.6	1.6	1.6	Hawai`i State, DLNR, DOFAW. Recommend aerial broadcast of rodenticide in Halehaha and Halepaakai drainages, and a tributary to Koai`e Stream.

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
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	50.0	1.0	1.0	1.0	1.0	Total cost based on equivalent of one additional enforcement officer per year for 50 years.
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	100.0	2.0	2.0	2.0	2.0	Total cost based on annual cost for 50 years.
1	1	2.5.1.3.2	C	Respond to and determine causes of avian disease outbreaks in forest bird recovery habitats and areas outside forest bird recovery habitat	Continual	*ADWG	100.0	2.0	2.0	2.0	2.0	Total cost based on annual cost for 50 years.
1	1	2.5.2.1	C	Initiate inspection programs for all interisland vessels,	Continual	*State and Federal Departments of	50.0	1.0	1.0	1.0	1.0	Total cost based on annual cost for 50 years.

Table 20

Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				including ships, airplanes, and barges and their cargos to intercept and kill mosquito larvae and adults		Agriculture, ADWG						
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	50.0	1.0	1.0	1.0	1.0	Total cost based on annual cost for 50 years.
1	1	2.5.3.1.1.2	C	Mosquito surveys on Hawai`i between the 3,400 and 5,000 ft. contour lines on Mauna Kea Volcano that include recovery habitat	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	
1	1	2.5.3.1.1.3	C	Mosquito surveys between the 3,400 and 5,000 ft. contour lines on Hualālai Volcano that include recovery habitat, portions of TMKs 371001001, 372002001, 374002008, 374001003, 374002007, 374001002	1 year	*USGS, USFWS, DOFAW	2.5	2.5				
1	1	2.5.3.1.1.7	C	Mosquito surveys: between 2,500 and 5,000 ft. contour lines on Haleakalā Volcano that include recovery habitat	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	East Maui Recovery habitat below the 5,000 ft. contour line.
1	2	2.5.3.1.1.9	C	Mosquito surveys, TMK 215001001	1 year	*USGS, USFWS, DOFAW	2.5	2.5				East Maui Waiho`i Valley incursion into recovery habitat, below 2,500 ft. contour line.
1	2	2.5.3.1.1.10	C	Mosquito surveys, TMK	1 year	*USGS,	2.5	2.5				East Maui Kīpahulu Valley

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				216001002		USFWS, DOFAW						incursion into recovery habitat, below 2,500 ft. contour line.
1	2	2.5.3.1.1.11	C	Mosquito surveys, TMK 211002002	1 year	*USGS, USFWS, DOFAW	2.5	2.5				East Maui Ke`anae Valley incursion into recovery habitat, below 2,500 ft. contour line.
1	2	2.5.3.1.1.12	C	Mosquito surveys on the northern slope of Haleakalā between the 2,500 ft. contour line and Hāna Highway	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	East Maui land parcels between the lower elevational limits of recovery habitat and the Hāna Highway.
1	1	2.5.3.1.1.14	C	Mosquito surveys of West Maui in recovery habitat 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.
1	1	2.5.3.1.1.34	C	Mosquito surveys in multiple parcels that include recovery habitat on Moloka`i	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			
1	1	2.5.3.1.1.38	C	Mosquito surveys of parcels on O`ahu that include recovery habitat	4 years	*USGS, USFWS, DOFAW, DOD	10.0	2.5	2.5	2.5	2.5	
1	1	2.5.3.1.1.40	C	Mosquito surveys on Kaua`i that include recovery habitat, 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.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
1	1	2.5.3.1.2	C	Eliminate or treat mosquito breeding sites in recovery habitat 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.
1	3	2.5.3.1.3.1	C	Eliminate or treat cattle troughs and stock ponds	Ongoing	*Land Managers, State Departments of Health and Education	25	0.5	0.5	0.5	0.5	Use findings from vector surveys to identify and prioritize areas for treatment.
1	3	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	5	0.1	0.1	0.1	0.1	Use findings from vector surveys to identify and prioritize areas for treatment.
1	2	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 areas near recovery habitat	Ongoing	*Land Managers, *State Depa rtments of Health and Education	20.0					Use findings from vector surveys to identify and prioritize areas for treatment.

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
1	1	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		
1	1	2.5.3.1.4.1	C	Identify and fence priority areas in recovery habitat 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.
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.
1	1	2.6.2	A	Eradicate all incipient populations of new tetrapoda	4 years	*APHIS, USFWS, DLNR	80.0	20.0	20.0	20.0	20.0	
1	1	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	1	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	
1	1	3	E	Develop captive propagation,	Ongoing	*ZSSD, *USFWS,	1,000.0	20.0	20.0	20.0	20.0	Annual and total costs for captive propagation

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 03	FY 04	FY 05	FY 06	Comments/Notes
				translocation and related recovery strategies		USGS, *DOFAW, HFBRT						program, which would implement all related recovery strategies. Total cost based on annual cost for 50 years.
1	1	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	1	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, *DOFAW, HFBRT	TBD[4]					\`ō\`ū, Maui nuku pu\`u, Maui \`ākepa, oloma\`o, O\`ahu creeper, kāma\`o, Kaua\`i nuku pu\`u, \`akialoa, and Kaua\`i \`ō\`ō.
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	Ongoing	*ZSSD, *USFWS, USGS, *DOFAW, HFBRT	TBD[4]					Po\`ouli.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				managed habitat								
1	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.
1	1	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.
1	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, *DOFAW, HFBRT	TBD[4]					Puaiohi.
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]					
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	1	3.11.1	E	Establish a cryogenic cell culture of germplasm of the endangered Hawaiian avifauna at two partner	Unknown	*ZSSD, ADWG, VC, *USFWS, USGS,	5.0					

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				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		DOFAW						
1	1	4.2.1.1	C	Continue efforts to register hand and aerial broadcast methods for dispersing diphacinone toxicants for controlling predators	Ongoing	Research Institutions, UH, *USFWS, USGS, *DOFAW	6.0	1.5	1.5	1.5	1.5	
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	Ongoing	*Research Institutions, *UH, *USFWS, USGS, *DOFAW	10.0	2.5	2.5	2.5	2.5	
1	1	4.2.2	C	Rat study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	10.0	2.5	2.5	2.5	2.5	
1	1	4.2.3	C	Feral cat study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	6.0	1.5	1.5	1.5	1.5	
1	1	4.2.5	C	Mosquito study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	10.0	2.5	2.5	2.5	2.5	

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
1	1	4.2.6	A	Ungulate study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	12.0	3.0	3.0	3.0	3.0	
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, *DOFAW	6.0	2.0	2.0	2.0		
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	1	4.5.2.2	C	Refine diagnostic methods for identifying individuals who have survived acute disease and who have acquired immunity to reinfection	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	8.0	2.0	2.0	2.0	2.0	
1	1	4.8.1	C	Special research considerations for	Ongoing	*Research Institutions,	2.0	1.0	1.0			

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				disease and parasitism: Determine the effects of land use changes on disease transmission		*UH, USFWS, *USGS, DOFAW						
1	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		
1	1	4.8.5	C	Determine dispersal distances of adult mosquitoes from point sources outside of recovery habitat	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			
1	1	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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.5	1.5			Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
1	1	4.10.16	C	Determine if tolerance or resistance to malaria and pox virus is evolving in any of the fragmented populations	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	3.0	1.5	1.5			O`ahu. Species: O`ahu `elepaio
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	Ongoing	UH, *USFWS, *USGS, *DOFAW	60.0	1.2	1.2	1.2	1.2	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 03	FY 04	FY 05	FY 06	Comments/Notes
				distribution and population size of all native and non-native forest birds								
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, *DOFAW	35.0	0.7	0.7	0.7	0.7	
1	1	6.2.1.1	E	Institute core curriculum at the university level emphasizing Hawai`i's native species for elementary and high school education programs	Ongoing	*UH	100.0	2.0	2.0	2.0	2.0	
2	1	1.2	A	Continue existing and develop new partnerships	Ongoing	*All Land Owners, Land Managers, and Other Parties	TBD[1]					
2	2	1.3.1	A	Secure recovery habitat areas: Portions of TMKs 344014002 344014003 343010002 343010008	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i State, DLNR, State Land Division, currently leased for cattle grazing to various lessees. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
2	2	1.3.3	A	Secure recovery habitat areas: Hilo Forest Reserve, Laupāhoehoe Section, TMK	Unknown	*DLNR, *DOFAW	TBD[1]					Hawai`i State, DLNR, DOFAW. By conservation easement or change in land use designation to

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				337001004								protective subzone. A mid-elevation forest with intact native tree canopy vulnerable to destruction by continued sustained yield pig hunting.
2	1	1.3.4	A	Secure recovery habitat areas: Hilo Forest Reserve, Pīhā Section, TMK 333001004	Unknown	*DLNR, *DOFAW	TBD[1]					Hawai`i State, DLNR, DOFAW. Contains important wet and mesic forest remnants. Bounded on both sides by Hakalau Forest National Wildlife Refuge. By conservation easement or change in land use designation to protective subzone. A mid-elevation forest with intact native tree canopy vulnerable to destruction by sustained yield pig hunting.
2	2	1.3.5	A	Secure recovery habitat areas: Kīpuka `Āinahou Nēnē Sanctuary, TMK 338001008	Unknown	*DHHL, *DOFAW	TBD[1]					Hawai`i State, DHHL, leased by DOFAW and currently under annual lease. A long-term lease should be negotiated.
2	1	1.3.7	A	Secure recovery habitat areas: Humu`ula, Portions of TMK 338001007	Unknown	*DHHL	TBD[1]					Hawai`i State, 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	2	1.3.11	A	Secure recovery habitat	Unknown	*KS	TBD[1]					Kamehameha Schools.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				areas: TMK 399001004								Contains remnant mesic koa and \`ōhi\`a forest. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	2	1.3.12	A	Secure recovery habitat areas: Kapāpala Ranch, Portions of TMK 398001010	Unknown	*DLNR, State Land Division, Kapāpala Ranch	TBD[1]					Hawai\`i State, DLNR, State Land Division, Kapāpala Ranch, currently leased for cattle grazing. Restorable. A link between forest communities to the east and west. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
2	3	1.3.13	A	Secure recovery habitat areas: Ka\`ū Forest Reserve, TMK 397001007	Unknown	*Mauna Kea Agribusiness	TBD[1]					Mauna Kea Agribusiness. Protect wet forest habitat from development. By purchase, lease, conservation easement, partnership agreement, or change in land use designation.
2	3	1.3.14	A	Secure recovery habitat areas: Ka\`ū Forest Reserve, Portions of TMKs 397001006 397001005	Unknown	*KS	TBD[1]					Kamehameha Schools. Protect wet forest habitat from development. By lease, conservation easement, partnership agreement, or purchase from willing seller.
2	2	1.3.15	A	Secure recovery habitat	Unknown	*Samuel M.	TBD[1]					Samuel M. Damon Trust.

Table 20

Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				areas: Portions of TMK 392001002		Damon Trust, Kahuku Ranch						Valuable wet and mesic forest habitat and a link between Ka`ū Forest and the South Kona Forests. Restorable. Approximately 25,000 acre Kahuku Ranch Cooperative Nēnē Sanctuary included in parcel. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	3	1.3.17	A	Secure recovery habitat areas: Papa, TMK 388001001	Unknown	*Koa Aina Ventures	TBD[1]					Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
2	2	1.3.18	A	Secure recovery habitat areas: 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 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	1.3.20	A	Secure recovery habitat areas: McCandless Ranch, Portions of TMKs 392001003 386001001	Unknown	*McCandless Ranch	TBD[1]					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	1.3.21	A	Secure recovery habitat areas: Waiea Tract, TMK 386001003	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i State, DLNR, State Land Division. Protects contiguous forest habitat in South Kona from continued degradation. Currently leased for cattle grazing. By lease, conservation easement, change of jurisdiction, or change in land use designation to protective subzone.
2	1	1.3.22	A	Secure recovery habitat areas: 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 habitat areas: 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.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	1.3.24	A	Secure recovery habitat areas: Keālia Ranch, Portions of TMK 385001002	Unknown	*Elizabeth Stack et al.	TBD[1]					Elizabeth Stack et al. 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	1.3.26	A	Secure recovery habitat areas: Pu`u Lehua, Portions of TMKs 378001003 378001007 372002001 378001001	Unknown	*KS	TBD[1]					Kamehameha Schools. 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	3	1.3.37	A	Secure recovery habitat areas: Upper Auwahi, TMKs 219001006 221009001 222001001 222001034	Unknown	*`Ulupalakua Ranch Inc., DOI, NHPS, *EMWP	TBD[1]					`Ulupalakua Ranch Inc. Pasture with ongoing restoration at selective sites in partnership with DOI and NHPS. By partnership with EMWP. By conservation easement, safe-harbor agreement, change in land use designation, or purchase from willing seller.
2	3	1.3.38	A	Secure recovery habitat areas: Kula Forest Reserve, TMK 222007001	Unknown	*DLNR, *EMWP	TBD[1]					Hawai`i State. By partnership with EMWP. Degraded, forest predominated by alien species. Resolve conflicting management as

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												game management area.
2	3	1.3.39	A	Secure recovery habitat areas: Kēōkea, TMK 222004033	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest land in need of active management. By partnership with EMWP. By conservation easement, safe-harbor agreement, change in land use designation, or purchase from willing seller.
2	3	1.3.40	A	Secure recovery habitat areas: Waiohuli, TMK 222005052	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest land in need of active management. By partnership with EMWP. By conservation easement, safe-harbor agreement, change in land use designation, or purchase from willing seller.
2	3	1.3.41	A	Secure recovery habitat areas: 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 land in need of active management. By partnership with EMWP. By conservation easement, safe harbor agreement, or purchase from willing seller.
2	3	1.3.42	A	Secure recovery habitat areas: Waiakoa, TMK 222008001	Unknown	*Lucky Shoji USA Inc., *EMWP	TBD[1]					Lucky Shoji USA Inc. et al. Degraded former forest land in need of active management. By partnership with EMWP.

Table 20												
Pritty Nmbr	Pritty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												By conservation easement, safe-harbor agreement, change of land use designation, or purchase from willing seller.
2	3	1.3.43	A	Secure recovery habitat areas: Kamehame Nui/Kealahou, TMK 223005002	Unknown	*R. G. Von Tempsky Jr. Trust, *EMWP	TBD[1]					R. G. Von Tempsky Jr. Trust. Degraded former forest land in need of active management. By partnership with EMWP. By conservation easement, safe-harbor agreement, change of land use designation, or purchase from willing seller.
2	3	1.3.46	A	Secure recovery habitat areas: West Maui Forest Reserve, Wailuku, TMKs 233003003 235003001 236003001	Unknown	*Wailuku Agriculture, *WMWP	TBD[1]					Wailuku Agriculture. Native forest or shrubland. In West Maui Watershed Partnership (WMWP). By conservation easement or purchase from willing seller.
2	3	1.3.47	A	Secure recovery habitat areas: West Maui Forest Reserve, Launiupoko, TMK 247001002	Unknown	*Amfac/JMB Hawai`i Co., *WMWP	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. Native forest or shrubland. In WMWP. By conservation easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.48	A	Secure recovery habitat areas: West Maui Forest Reserve, Kaua`ula, TMK 246025001	Unknown	*Amfac/JMB Hawai1i Co., *WMWP	TBD[1]					American Factors (Amfac)/JMB Hawai`i Co. Native forest or shrubland. In WMWP. By conservation easement or

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												purchase from willing seller.
2	3	1.3.49	A	Secure recovery habitat areas: West Maui Forest Reserve, Kahoma, TMK 245022001	Unknown	*KS, *WMWP	TBD[1]					Kamehameha Schools. Native forest or shrubland. In WMWP. By conservation easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.50	A	Secure recovery habitat areas: 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. Native forest or shrubland. In WMWP. By conservation easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.51	A	Secure recovery habitat areas: 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., TNCH. Native forest or shrubland. In WMWP and NAPS. In conservation easement. By purchase from willing seller.
2	3	1.3.52	A	Secure recovery habitat areas: West Maui Forest Reserve, Kapāloa, TMK 244007007	Unknown	*WMWP	TBD[1]					Unknown. Native forest or shrubland. By WMWP. By conservation easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.53	A	Secure recovery habitat areas: Pu`u Kukui Watershed Management Area, TMKs 242001001 241001017	Unknown	*Maui Land and Pineapple, *WMWP, NAPS	TBD[1]					Maui Land and Pineapple. Native forest or shrubland. By WMWP and NAPS. Support continued management by Maui Land

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												and Pine, or by purchase from willing seller.
2	2	1.3.54	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Kahanui, TMK 252014001	Unknown	*R. W. Myer Ltd., et al.	TBD[1]					R. W. Myer Ltd., et al. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.55	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Pelekunu Valley, TMK 259006011	Unknown	*TNCH	TBD[1]					The Nature Conservancy of Hawai`i. Native forest or shrubland. Support continued management by TNCH, or by purchase from willing seller.
2	3	1.3.56	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Pelekunu Valley, Wawaeolepe, TMK 259008017	Unknown	*William Hitchcock, et al.	TBD[1]					Wm. Hitchcock et al. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.57	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Pelekunu Valley, TMK 254003032	Unknown	*TNCH	TBD[1]					The Nature Conservancy of Hawai`i. Native forest or shrubland. Support continued management by TNCH, or by purchase from willing seller.
2	3	1.3.58	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Wailau Valley and Oloku`i, TMK 259006004	Unknown	*G. Brown III, et al.	TBD[1]					G. Brown III et al. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.59	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Laeokapuna, TMK 257005027	Unknown	*P. Hodgins	TBD[1]					P. Hodgins. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.60	A	Secure recovery habitat	Unknown	*M. Hustice	TBD[1]					M. Hustice Trust. Native

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				areas: Moloka`i Forest Reserve, Keanakoholua, TMK 257005001		Trust						forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.61	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Manawai, TMK 256006013	Unknown	*P. Petro Trust	TBD[1]					P. Petro Trust. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.62	A	Secure recovery habitat areas: Moloka`i Forest Reserve, West `Ōhi`a Gulch, TMK 256006010	Unknown	*E. Wond Trust	TBD[1]					E. Wond Trust. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.63	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Keawa Nui, TMK 256006007	Unknown	*KS	TBD[1]					Kamehameha Schools. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller. In EMOWP.
2	3	1.3.64	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Pua`ahala, TMK 256006002	Unknown	*K&H Horizons Hawai`i	TBD[1]					K&H Horizons Hawai`i. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller. In EMOWP.
2	3	1.3.65	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Kumu`eli, TMK 256006001	Unknown	*D. Fairbanks III Trust	TBD[1]					D. Fairbanks III Trust. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller. In EMOWP.
2	3	1.3.66	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Kamalō, TMKs	Unknown	*KS	TBD[1]					Kamehameha Schools. Native forest or shrubland. By easement, safe-harbor

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				255001016 255001006 255001017								agreement, or purchase from willing seller. In EMOWP.
2	2	1.3.67	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Mākolelau, TMK 255001015	Unknown	*Ashton Pitts Jr. Trust	TBD[1]					Ashton Pitts Jr. Trust. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	3	1.3.68	A	Secure recovery habitat areas: Kamakou Preserve, Kawela, TMK 2540003026	Unknown	*Moloka`i Ranch Ltd., TNCH	TBD[1]					Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller. In EMOWP.
2	3	1.3.69	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Kawela, TMKs 254003001 254003028	Unknown	*Kawela Plantation Homes Association	TBD[1]					Kawela Plantation Homes Association. Native forest or shrubland. By easement or purchase from willing seller. In EMOWP.
2	3	1.3.70	A	Secure recovery habitat areas: Moloka`i Forest Reserve, Kaunakakai, TMK 253003005	Unknown	*Moloka`i Ranch Ltd.	TBD[1]					Moloka`i Ranch Ltd. Native forest or shrubland. By easement, safe-harbor agreement, or purchase from willing seller.
2	1	1.3.75	A	Secure recovery habitat areas: Ka`alakei Valley, TMK 39009001	Unknown	*Hawai`i Kai Development Co., *KMWP	TBD[1]					Hawai`i Kai Development Co. By easement, partnership, or purchase from willing seller. Not in KMWP.
2	1	1.3.77	A	Secure recovery habitat areas: Moanalua Valley, TMK 11013001	Unknown	*Amon Estate, *KMWP	TBD[1]					Damon Estate. By easement or partnership. In KMWP, additional measures may be needed to ensure protection of forest

Table 20												
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												habitat supporting large `elepaio population.
2	1	1.3.78	A	Secure recovery habitat areas: South Hālawa Valley, Tripler Ridge, TMK 99011001	Unknown	*Queen's Medical Center, *KMWP	TBD[1]					Queen's Medical Center. By easement or partnership. In KMWP, additional measures may be needed to ensure protection of forest habitat supporting large `elepaio population.
2	1	1.3.80	A	Secure recovery habitat areas: Waianu Valley, TMKs 48014003 48013014	Unknown	*Waiāhole Irrigtaion Co. Ltd., *KMWP	TBD[1]					Waiahole Irrigation Co. Ltd. By easement or partnership. In KMWP, additional measures may be needed to ensure protection of forest habitat supporting large `elepaio population.
2	1	2.1.1	A	Reforest areas of on the Northeast slope of Mauna Kea, Portions of TMKs 344014002 344014003 343010002 343010008	Unknown	*DLNR, State Land Division	31.5					Hawai`i State, DLNR, State Land Division. Reforest and restore pasturelands to dry māmane and mesic koa forest.
2	1	2.1.7	A	Reforest areas of Humu`ula, TMK 338001002	Unknown	*DHHL	29.8					Hawai`i State, DHHL. Restorable. A vital link between wet and dry forest communities. Reforest pasturelands to transition forest from mesic koa to dry māmane.
2	1	2.1.8	A	Reforest areas of Humu`ula Portions of TMK 338001007	Unknown	*DHHL, Parker Ranch	71.6					Hawai`i State, DHHL, leased to Parker Ranch. Reforest pasturelands to native montane dryland

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												habitat.
2	1	2.1.9	A	Reforest areas of Lamaia Section, TMK 326018002	Unknown	*DHHL	14.3					Hawai`i State, 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	1	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 State DLNR, State 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	1	2.1.11	A	Reforest areas of recovery habitat: Ka`ohe, TMK 344015002	Unknown	*DLNR, State Land Division	0.9					Hawai`i State, DLNR, State Land Division. Protect and reforest.
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 State, DLNR, State Land Division, Kapāpala Ranch. A link between forest communities to the east and west. Protect parcel, remove alien trees and restore montane dryland koa, `ōhi`a, and māmane forest.
2	2	2.1.18	A	Reforest areas of recovery habitat, 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

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												Ka`ū Forest and the South Kona Forest.
2	2	2.1.22	A	Reforest areas of Honomalino Forest Reserve, TMK 389001002	Unknown	*DLNR	1.3					Hawai`i State, DLNR.
2	1	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					McCandless Ranch and E. Stack et al. Protects contiguous forest habitat in South Kona from development. Protect and restore pasture to mesic koa and dry māmane/naio forest.
2	2	2.1.27	A	Reforest areas of Waiea Tract, TMK 386001003	Unknown	*DLNR, State Land Division	1.9					Hawai`i State, DLNR, State Land Division. Protects contiguous forest habitat in South Kona. Protect reforest mesic koa forest.
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. Protect and reforest mesic koa forest and dry māmane/naio forest.
2	2	2.1.30	A	Reforest areas of Pu`u Lehua, Portions of TMKs 378001003 378001007 378001002 378001001	Unknown	*KS	145.8					Kamehameha Schools. Protect 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	Unknown	*DOFAW	34.3					Pu`u Wa`awa`a Forest Bird Sanctuary. Restore montane mesic koa and

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				371001001 371001006								māmane/naio forest habitat.
2	2	2.1.32	A	Reforest areas of Hualālai Ranch, TMK 372002001	Unknown	*KS	11.8					Kamehameha Schools.
2	3	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 State. Restore montane mesic forest and shrubland, replace non-native 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 non-native trees.
2	3	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 non-native trees.
2	3	2.1.49	A	Reforest areas of West Maui NAR, Kahakuloa, TMK 231006001	Unknown	*DLNR	5.8					Hawai`i State. 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 State. Restore montane wet forest and shrubland, replace non-native trees.
2	3	2.1.51	A	Reforest areas of West Maui Forest Reserve, Ukumehame/ Olowalu, West Maui NAR, Līhau,	Unknown	*DLNR	18.4					Hawai`i State. Restore montane wet forest and shrubland.

Table 20												
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				TMK 248001002								
2	3	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 non-native trees.
2	3	2.1.53	A	Reforest areas of Moloka`i Forest Reserve, Kalamāula, TMK 252014003	Unknown	*DLNR	1.6					Hawai`i State. Restore montane wet forest and shrubland, replace non-native trees.
2	3	2.1.54	A	Reforest areas of Moloka`i Forest Reserve, Kahanui, TMK 252014001	Unknown	*R. W. Myer Ltd.	3.4					R. W. Myer Ltd., et al. Restore montane wet forest and shrubland, replace non-native trees.
2	3	2.1.55	A	Reforest areas of Moloka`i Forest Reserve, Kahanui, TMK 261001004	Unknown	*DLNR	0.05					Hawai`i State. Restore montane wet forest and shrubland, replace non-native 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.
2	3	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 non-native trees.
2	3	2.1.60	A	Reforest areas of Moloka`i Forest Reserve, Kamiloloa/Makakupaīa, TMK 254003025	Unknown	*DLNR	5.3					Hawai`i State. Restore montane mesic forest and shrubland, replace non-native trees.
2	1	2.2.1	A, C	Reduce or eliminate the detrimental effects of	3 years	*DLNR, State Land Division	26.4					Hawai`i State, DLNR, State Land Division.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation on the northeast slopes of Mauna Kea, Portions of TMKs 344014002 344014003 343010002 343010008								
2	1	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	3 years	*DLNR, *DOFAW	34.1					Hawai`i State, DLNR, DOFAW. Currently managed for game hunting. Needs fencing and ungulate control.
2	1	2.2.5	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lamaia Section, TMK 326018002	3 years	*DHHL	24.0					Hawai`i State, DHHL. Adjacent to Hakalau Forest National Wildlife Refuge. Encourage fencing and ungulate removal.
2	1	2.2.6	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pu`u `Ō`ō Ranch, TMK 326018001	3 years	*DLNR, State Land Division, Pu`u `Ō`ō Ranch	19.9					Hawai`i State, DLNR, State Land Division, leased to Pu`u `Ō`ō Ranch. 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	3 years	*DHHL	29.8					Hawai`i State, DHHL. Encourage fencing and ungulate removal.
2	1	2.2.8	A, C	Reduce or eliminate the detrimental effects of	3 years	*DLNR, State Land Division	1.5					Hawai`i State, DLNR, State Land Division. Suspend

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation within Ka`ohe, TMK 344015002								lease. Fence and remove ungulates.
2	2	2.2.13	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kapāpala Forest Reserve, Portions of TMK 398001004	3 years	*DLNR, State Land Division	49.7					Hawai`i State, DLNR, State Land Division, Kapāpala Forest Reserve. Fencing and ungulate control.
2	1	2.2.16	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Manukā NAR, Upper Portions of TMK 391001002	3 years	*DLNR, *DOFAW	11.5					Hawai`i State, DLNR, DOFAW. Fencing and ungulate control.
2	1	2.2.19	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kona Forest NWR, TMK 386001001	3 years	*USFWS	13.3					USFWS, Kona Forest NWR. Fence and remove ungulates.
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	3 years	*McCandless Ranch and E. Stack et al.	49.9					McCandless Ranch and E. Stack et al. Fence and remove ungulates.
2	1	2.2.21	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiea Tract, TMK 386001003	3 years	*DLNR, State Land Division	3.2					Hawai`i State, DLNR, State Land Division. Fence and remove ungulates.
2	1	2.2.22	A, C	Reduce or eliminate the detrimental effects of	3 years	*KS	50.0[2]					Kamehameha Schools. Fence and remove

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation within Hōnaunau Forest, TMKs 384001001 384001002 383001001 383001002								ungulates.
2	2	2.2.23	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Pu`u Lehua, Portion of TMKs 378001003 378001007 372002001 378001001	3 years	*KS	73.1					Kamehameha Schools. Fence and remove ungulates.
2	3	2.2.39	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kula Forest Reserve, TMK 222007001	3 years	*DLNR	26.8					Hawai`i State, DLNR. Currently a sustained yield game management area. Fence and remove ungulates from portions within forest bird recovery habitat to encourage regeneration of native forest.
2	3	2.2.40	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kēōkea, TMK 222004033	3 years	*James Campbell Est.	1.2					James Campbell Est. Fence and remove ungulates within forest bird recovery habitat, manage with Kula Forest Reserve.
2	3	2.2.41	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Waiohuli, TMK 222005052	3 years	*James Campbell Est.	4.0					James Campbell Est. Fence and remove ungulates within forest bird recovery habitat, manage with Kula Forest Reserve.

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	3	2.2.42	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ka`ono`ulu, TMKs 222007002 222006009 222007010 222006032	3 years	*Ka`ono`ulu Ranch Co. Ltd.	8.1					Ka`ono`ulu Ranch Co. Ltd. Fence and remove ungulates within forest bird recovery habitat, 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	3 years	*Lucky Shoji USA Inc. et al.	1.6					Lucky Shoji USA Inc. et al. Fence and remove ungulates within forest bird recovery habitat, manage with Kula Forest Reserve.
2	3	2.2.44	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kamehame Nui/Kealahou, TMK 223005002	3 years	*R. G. Von Tempsky Jr. Trust	7.6					R. G. Von Tempsky Jr. Trust. Fence and remove ungulates within forest bird recovery habitat.
2	3	2.2.48	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui NAR, Kahakuloa, TMK 231006001	3 years	*DLNR	13.3					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.49	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Waihe`e, TMK 232014001	3 years	*Maui Board of Water Supply	24.2					Maui Board of Water Supply. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.50	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest	3 years	*DLNR	0.65					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Reserve, Kou, TMK 232014002								recovery habitat.
2	3	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	3 years	*Wailuku Agriculture	45.6					Wailuku Agriculture. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	0.64					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	3.1					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	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	3 years	*DLNR	0.51					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.55	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest	3 years	*DLNR	1.3					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Reserve, Kaheawa, TMK 248001001								recovery habitat.
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	3 years	*DLNR	42.0					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.57	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Launiupoko, TMK 247001002	3 years	*Amfac/JMB Hawai`i Co.	10.7					American Factors (Amfac)/JMB Hawai`i Co. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	2.0					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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.	2.0					American Factors (Amfac)/JMB Hawai`i Co. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	9.2					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.61	A, C	Reduce or eliminate the	3 years	*KS	8.0					Kamehameha Schools.

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				detrimental effects of ungulates on vegetation within West Maui Forest Reserve, Kahoma, TMK 245022001								Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	0.20					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	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	3 years	*Amfac/JMB Hawai`i Co.	1.9					American Factors (Amfac)/JMB Hawai`i Co. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	2.2					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.65	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kapunakea Preserve, Amfac/JMB, TNCH, TMK 244007001	3 years	*Amfac/JMB Hawai`i Co., *TNCH	6.9					American Factors (Amfac)/JMB Hawai`i Co., TNCH. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.66	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui Forest	3 years	UNK	1.6					Unknown. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Reserve, Kapāloa, TMK 244007007								
2	3	2.2.67	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within West Maui NAR, Honokōwai, TMK 244007004	3 years	*DLNR	8.4					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*Maui Land and Pineapple	37.2					Maui Land and Pineapple. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	3.7					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.70	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kahanui, TMK 252014001	3 years	*R. W. Myer, et al.	7.8					R. W. Myer Ltd., et al. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	0.11					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.72	A, C	Reduce or eliminate the	3 years	*DLNR	16.5					Hawai`i State, DLNR.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Waikolu and Pu`u Ali`i NAR, TMK 261001002								Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.73	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pelekunu Valley, TMK 259006011	3 years	*TNCH	12.0					The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*William Hitchcock, et al.	0.14					Wm. Hitchcock, et al. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.75	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Pelekunu Valley, TMK 254003032	3 years	*TNCH	1.0					The Nature Conservancy of Hawai`i. Ungulate control currently ongoing. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	19.5					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.77	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest	3 years	*G. Brown III, et al.	0.40					G. Brown III, et al. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Reserve, Wailau Valley and Oloku`i, TMK 259006004								
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	3 years	*P. Hodgins	1.1					P. Hodgins. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*M. Hustice Trust	3.3					M. Hustice Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	0.89					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	0.83					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*P. Petro Trust	1.2					P. Petro Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.83	A, C	Reduce or eliminate the detrimental effects of	3 years	*DLNR	1.5					Hawai`i State, DLNR. Protect with strategic

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation within Moloka`i Forest Reserve, east `Ōhi`a Gulch, TMK 256006011								fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*E. Wond Trust	0.74					E. Wond Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*KS	0.88					Kamehameha Schools. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*K&H Horizons Hawai`i	0.62					K&H Horizons Hawai`i. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*D. Fairbanks III Trust, EMOWP	50.0[2]					D. Fairbanks III Trust (Austin Estate?) In EMOWP; currently fencing portions and doing animal removal. Continue with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.88	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kamalō, TMKs	3 years	*KS, *EMOWP	50.0[2]					Kamehameha Schools. In EMOWP; currently fencing portions and doing animal removal. Protect with strategic fencing and

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				255001016 255001006 255001017								remove ungulates within forest bird recovery habitat.
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	3 years	*Ashton Pitts Jr. Trust	2.4					Ashton Pitts Jr. Trust. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.90	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kamakou Preserve, Kawela, TMK 2540003026	3 years	*Moloka`i Ranch Ltd., *TNCH, EMOWP	25.3					Moloka`i Ranch Ltd., The Nature Conservancy of Hawai`i. In EMOWP. Ungulate control currently ongoing. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*Kawela Plantation Homes Association	8.6					Kawela Plantation Homes Association. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
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	3 years	*DLNR	11.0					Hawai`i State, DLNR. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.
2	3	2.2.93	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Moloka`i Forest Reserve, Kaunakakai,	3 years	*Moloka`i Ranch Ltd.	0.57					Moloka`i Ranch Ltd. Protect with strategic fencing and remove ungulates within forest bird recovery habitat.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				TMK 253003005								
2	1	2.2.98	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahanahāiki Valley, TMK 81001012	3 years	*U.S. Army	1.5					U.S. Army. Fencing and eradication of pigs to allow aerial broadcast of rodenticide.
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	3 years	*DLNR, *DOFAW	7.7					Hawai`i State, DLNR, DOFAW. Recommend fencing as much of the core population of puaiohi as possible, e.g., upper Mōhihi drainage. Fencing and ungulate control and/or time/area closure to hunting in preparation for aerial broadcast of rodenticide.
2	3	2.2.103	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Alaka`i Wilderness Preserve, TMK 414001003	3 years	*DLNR, *DOFAW	100.0[2]					Hawai`i State, DLNR, DOFAW. Strategic fencing to exclude ungulates from as much of the preserve as practical.
2	1	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	630.5	12.6	12.6	12.6	12.6	Hawai`i State, DLNR, State Land Division. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.2	C	Control alien mammalian predators by trapping, poisoning and other	Continual	*DHHL	302.2	6.0	6.0	6.0	6.0	Hawai`i State, DHHL. Provides a vital link between mesic koa forest

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				means in Kanakaleonui Corridor, TMK 338001009								and dry māmane forest habitats. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	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	54.2	1.1	1.1	1.1	1.1	Hawai`i State, DLNR, DOFAW. Currently managed for game hunting. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.5	C	Control alien mammalian predators by trapping, poisoning and other means in TMK 326018002	Continual	*DHHL	286.6	5.7	5.7	5.7	5.7	Hawai`i State DHHL, adjacent to Hakalau Forest National Wildlife Refuge. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	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	356.1	7.1	7.1	7.1	7.1	Hawai`i State, DLNR, State Land Division, Pu`u Ō`ō Ranch lease. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	356.0	7.1	7.1	7.1	7.1	Hawai`i State, DHHL. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20													
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
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	18.0	0.36	0.36	0.36	0.36	Hawai`i State DLNR, State Land Division. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	2,972.8	59.5	59.5	59.5	59.5	Hawai`i State DLNR, DOFAW. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.13	C	Control alien mammalian predators by trapping, poisoning and other means in Kapāpala Forest Reserver, Portions of TMK 398001004	Continual	*DLNR, State Land Division	237.9	4.8	4.8	4.8	4.8	Hawai`i State DLNR, State Land Division, Kapāpala Forest Reserve. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.16	C	Control alien mammalian predators by trapping, poisoning and other means in Manukā NAR, Upper portions of TMK 391001002	Unknown	*DLNR, *DOFAW	71.3	1.4	1.4	1.4	1.4	Hawai`i State DLNR, DOFAW. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.19	C	Control alien mammalian predators by trapping, poisoning and other means in Kona Forest NWR, TMK 386001001	Continual	*USFWS	142.5	2.9	2.9	2.9	2.9	Kona Forest NWR. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.20	C	Control alien mammalian predators by trapping, poisoning and other means in McCandless Ranch, TMKs	Continual	*McCandless Ranch	257.4	5.1	5.1	5.1	5.1	McCandless Ranch. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				392001003 386001001 385001002								
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	75.5	1.5	1.5	1.5	1.5	Hawai`i State, DLNR, State Land Division. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	957.1	19.1	19.1	19.1	19.1	Kamehameha Schools. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	1,399.5	28.0	28.0	28.0	28.0	Kamehameha Schools. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2		2.4.1.24	C	Control alien mammalian predators by trapping, poisoning and other means in Pu`u Wa`a wa`a Bird Sanctuary, TMKs 371001001 and 371001006	Continual	*DLNR, *DOFAW	686.3	13.7	13.7	13.7	13.7	Hawai`i State, DLNR, DOFAW. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	2	2.4.1.30	C	Control alien mammalian predators by trapping,	Continual	*DLNR, *DOFAW	135.5	2.7	2.7	2.7	2.7	Hawai`i State, DLNR, DOFAW. Adjacent to

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				poisoning and other means in Kīpahulu Forest Reserve, TMKs 216001005 217001033 217002035 217004006								known populations of AKOH and MAPA. Potential for range expansion. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	2	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	177.0	3.5	3.5	3.5	3.5	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	2	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	422.2	8.4	8.4	8.4	8.4	Hawai`i State, DHHL. Potential long-term site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	2	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	137.1	2.7	2.7	2.7	2.7	Hawai`i State, DLNR, DOFAW. Likely site of near-term range expansion for AKOH and MAPA. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	3	2.4.1.37	C	Control alien mammalian predators by trapping,	Continual	*DLNR, *DOFAW	116.6	2.3	2.3	2.3	2.3	Hawai`i State, DLNR, DOFAW. Primary site for

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				poisoning and other means in West Maui NAR, Kahakuloa, TMK 231006001								reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	60.9	1.2	1.2	1.2	1.2	American Factors (Amfac)/JMB Hawai`i Co., TNCH. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	73.2	1.5	1.5	1.5	1.5	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	3	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	326.0	6.5	6.5	6.5	6.5	Maui Land and Pineapple. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	3	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	144.3	2.9	2.9	2.9	2.9	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).

Table 20

Pririty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	3	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	170.8	3.4	3.4	3.4	3.4	Hawai`i State, DLNR, DOFAW. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	3	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	221.9	4.4	4.4	4.4	4.4	Moloka`i Ranch Ltd, TNCH. Primary site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
2	1	2.4.1.55	C	Control alien mammalian predators by trapping, poisoning and other means in Pahole NAR, TMK 68001002	Ongoing	*DLNR, *DOFAW	50	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/augmentatio n. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	20	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/augmentatio

Table 20													
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												n. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	100	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	20.0	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.
2	3	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	Total cost based on annual cost for 50 years.
2	1	2.5.2.3	C	Establish disease monitoring protocols for captive native birds to assess presence of avian disease in captive held	Ongoing	*ZSSD, USFWS, *USGS, DOFAW, ADWG	25.0	0.5	0.5	0.5	0.5	Total cost based on annual cost for 50 years.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				populations and risk of transfer of disease strains between avian captive holding facilities								
2	1	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	1 year	*ZSSD, USFWS, *USGS, DOFAW, *ADWG	5.0	2.5	2.5			
2	1	2.5.3.1.1.4	C	Mosquito surveys of windward Hāmākua between the 3,400 and 2,000 ft. contour lines on Mauna Kea Volcano adjacent to or within 3 km of recovery habitat	4 years	*USGS, USFWS, DOFAW	10.0	2.5	2.5	2.5	2.5	
2	1	2.5.3.1.1.5	C	Mosquito surveys on Kilauea Volcano adjacent to or within 3 kilometers of recovery habitat	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			
2	1	2.5.3.1.1.6	C	Mosquito surveys on Hualālai Volcano adjacent to or within 3 km of recovery habitat	1 year	*USGS, USFWS, DOFAW	2.5	2.5				
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 habitat, below 2,500 ft. contour line.
2	1	2.5.3.1.1.15	C	Mosquito surveys within `Īao Valley, West Maui, TMKs 233003003, 235003001, 233003004,	1 year	*USGS, USFWS, DOFAW	1.0	1.0				`Īao Valley incursion into recovery habitat, between 2,500 ft. and 600 ft. contour lines.

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Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				and multiple smaller parcels								
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.

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Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	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 habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	2.5.3.1.1.32	C	Mosquito surveys of	1 year	*USGS,	1.0	1.0				Hanakea Valley incursion

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				West Maui, TMK 245022004		USFWS, DOFAW						into recovery habitat, between 2,500 ft. and 600 ft. contour lines.
2	1	2.5.3.1.1.35	C	Mosquito surveys in Waihanuu, Wai`ale`ia, Waikolu, Pelekunu, and Wailau Valleys on Moloka`i that are adjacent to or within 3 km of recovery habitat, 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	1	2.5.3.1.1.37	C	Mosquito surveys adjacent to or within 3 km of the southern and eastern boundaries of recovery habitat 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 habitat to the coastline, particularly in areas with rural agricultural development.
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 habitat	4 years	*USGS, USFWS, DOFAW DOD	10.0	2.5	2.5	2.5	2.5	
2	1	2.5.3.1.1.41	C	Mosquito surveys on	1 year	*USGS,	2.5	2.5				Windward parcels that are

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Kaua`i that are adjacent to or within 3 km of recovery habitat, portions of TMKs 459001001, 458001001, 458002002, 459001003, 459001002		USFWS, DOFAW						adjacent to recovery habitat on the Alaka`i Plateau, including Wainiha Valley.
2	2	2.5.3.1.1.42	C	Mosquito surveys on Kaua`i that are adjacent to or within 3 km of recovery habitat, portions of TMKs 414001014, 414001020, 414002040, 414001003, 417001001	1 year	*USGS, USFWS, DOFAW	2.5	2.5				Leeward parcels that are adjacent to recovery habitat on the Alaka`i Plateau, including Waimea Canyon.
2	2	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.
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	150.0	3.0	3.0	3.0	3.0	Total cost based on annual cost for 50 years.
2	1	2.5.5	C	Monitor long-term changes in the prevalence and	Ongoing	*Research Institutions, *UH, USFWS,	125.0	2.5	2.5	2.5	2.5	Identify priority areas for long-term monitoring in areas that will be

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				transmission of avian diseases in recovery forest bird habitats		*USGS, DOFAW, ADWG						intensively managed. Total cost based on annual cost for 50 years.
2	1	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	
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	1	2.6.1.5	A	Encourage HDOA, DLNR, USFWS, and county police departments to develop a task force to pursue smuggling and release violations	Ongoing	*HDOA, APHIS, *USFWS, *DLNR, *County Police Departments	5.0	5.0				
2	1	2.6.1.6	A	Provide single point-of-exit at airports	Unknown	*FAA, *County Airports, HDOA, APHIS, USFWS, DLNR	100.0					
2	1	2.6.1.7	A	Increase the numbers of	Unknown	County Airports,	20.0	5.0	5.0	5.0	5.0	

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				HDOA and USDA inspectors to better cover nursery cargo and passenger baggage/hand-carry		*HDOA, *USDA						
2	1	2.6.1.8	A	Secure congressional approval of USDA quarantine of mainland	Unknown	*USDA, APHIS, USFWS, DLNR	10.0					
2	1	2.6.1.9	A	Prevent inter-island expansion of established vertebrates of restricted range, including brown tree snake	Ongoing	*HDOA, *APHIS, USFWS, DLNR	1,000.0	20.0	20.0	20.0	20.0	Total cost based on annual cost for 50 years.
2	1	2.6.3	A	Reduce or eliminate the detrimental effects of *vespulid* wasps on forest birds within forest ecosystems	Ongoing	*USFWS, DLNR, NPS	125.0	2.5	2.5	2.5	2.5	Total cost based on annual cost for 50 years.
2	1	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, 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, *DOFAW, HFBRT	TBD[4]					Maui parrotbill.
2	1	3.2.5.2	E	Develop rear and release methods for managed native habitat on leeward	Ongoing	*ZSSD, USFWS, USGS,	TBD[4]					Maui parrotbill.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Haleakalā (Kahikinui), West Mai or Moloka`i, when disease is no longer known to be a threat		DOFAW, HFBRT						
2	1	3.2.6.1	E	Continue program to use translocation to West Maui or Moloka`i as recovery strategy	Ongoing	ZSSD, USFWS, USGS, *DOFAW, HFBRT	TBD[4]					`Ākohekohe.
2	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	1	3.2.7.1	E	Collect eggs for incubation and captive rearing	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.
2	1	3.3.1	E	Develop methods of evaluating, selecting, and preparing sites for release of endangered birds to ensure long-term	Ongoing	*ZSSD, *USFWS, USGS, *DOFAW, *HFBRT	TBD[4]					Maui forest birds.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				persistence of birds reintroduced to West Maui and Moloka`i								
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, *DOFAW, HFBRT	TBD[4]					Palila.
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, *DOFAW, HFBRT	TBD[4]					`Akiapōlā`au.
2	1	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	Ongoing	*ZSSD, USFWS, USGS,	TBD[4]					

Table 20													
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				into managed habitat: Develop and refine release (hacking) procedures		DOFAW						
2	1	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, *DOFAW	TBD[4]					
2	1	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, *DOFAW	TBD[4]					
2	1	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]					
2	1	3.10	E	If egg collections fail, develop methods by which to bring nestling birds, juveniles, and/or adults into captivity with	Unknown	*ZSSD, *USFWS, USGS, *DOFAW	TBD[4]					

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				concomitant quarantine procedures								
2	1	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					
2	1	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, DOFAW	21.0	6.0	6.0	6.0	3.0	
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, *DOFAW	10.0	2.5	2.5	2.5	2.5	

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	4.2.4	C	Mongoose study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	1.5	1.5	1.5	1.5	
2	1	4.2.7	E	Yellow-jacket wasp study	Ongoing	*Research Institutions, *UH, USFWS, USGS, *DOFAW	4.0	1.0	1.0	1.0	1.0	
2	1	4.2.8	C	Barn owl and Pueo study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	1.5	0.5	0.5	0.5		
2	1	4.2.9	E	Avian competitor study	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	8.0	2.0	2.0	2.0	2.0	
2	1	4.2.10.1	E	Investigate Red-billed Leiothrix as competitor and reservoir for disease for po`ouli and Maui parrotbill	Ongoing	*Research Institutions, *UH, USFWS, *USGS, 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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, 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	Ongoing	*Research Institutions, *UH, USFWS, USGS, *DOFAW	3.0	1.0	1.0	1.0		

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Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				reservoirs of disease for Hawai`i `ākepa, Hawai`i creeper, and `akiapōlā`au								
2	1	4.2.11	A	Determine best ways of conducting reforestation efforts	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	4.0	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, *DOFAW	40.0					
2	1	4.4	A, C, E	Determine safety of threat management to non-target species	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	12.0	3.0	3.0	3.0	3.0	
2	1	4.5.1.1	C	Determine if sleeping habits may reduce exposure to mosquitoes and predators	1 year	*Research Institutions, *UH, USFWS, *USGS, DOFAW	0.5	0.5				
2	1	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, DOFAW	3.0	1.0	1.0	1.0		
2	1	4.6.1	E	Investigate ways to	Ongoing	*Research	10.0					

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Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				enhance niche characteristics for particular species within existing habitat		Institutions, *UH, USFWS, *USGS, DOFAW						
2	1	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	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	Research Institutions, UH, USFWS, USGS, *DOFAW	1.5	0.5	0.5	0.5		
2	2	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, DOFAW	10.0					
2	2	4.6.1.3	A	Develop effective techniques for restoration of degraded and deforested lands	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	8.0	2.0	2.0	2.0	2.0	
2	2	4.6.2.1	E	Develop a comprehensive library of microsatellite loci	3 years	Research I*nstitutions, ZSSD, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	1	4.6.2.2	E	Document genetic	Ongoing	*Research	6.0	2.0	2.0	2.0		

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				population structure of species with single populations		Institutions, *UH, USFWS, *USGS, DOFAW						
2	1	4.6.2.3	E	Document source/sink metapopulation structure along gradients in density, particularly elevational gradients	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	1	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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	1	4.6.2.5	E	Determine patterns of dispersal by age and sex	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	1	4.6.2.6	E	Determine seasonal patterns of movement by age and sex	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	6.0	2.0	2.0	2.0		
2	1	4.6.3	E	Conduct population and metapopulation viability analyses	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			
2	1	4.6.3.1	E	Conduct trend analysis using count data	Ongoing	*Research Institutions, UH, USFWS,	2.0	1.0	1.0			

Table 20												
Prity Nmbr	Prity Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
						*USGS, DOFAW						
2	1	4.6.3.2	E	Use demographic data for estimating lambda	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			
2	1	4.7.2	E	Determine optimal parameters for translocation efforts	Ongoing	*Research Institutions, UH, *USFWS, *USGS, *DOFAW	3.0	1.0	1.0	1.0		
2	1	4.8.2	C	Special research considerations for disease and parasitism: Determine effects of long-term climate change on disease transmission	Ongoing	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			
2	1	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, DOFAW	4.5	1.5	1.5	1.5		
2	1	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		
2	1	4.8.4.2	C	Determine whether concomitant infections	3 years	*Research Institutions,	4.5	1.5	1.5	1.5		

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Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				with pox and malaria affect virulence and transmissibility		*UH, USFWS, *USGS, DOFAW						
2	1	4.8.6	C	Determine the feasibility of decreasing malarial transmission through genetic manipulation of vector populations	Unknown	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		
2	1	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	Unknown	*Research Institutions, *UH, USFWS, *USGS, DOFAW	2.0	1.0	1.0			
2	1	4.8.8	C	Determine the role that endoparasites such as Coccidea play in demography of birds	Unknown	*Research Institutions, *UH, USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		
2	1	4.8.9	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	4.0	1.0	1.0	1.0	1.0	
2	1	4.9	E	Conduct development and testing of improved survey and monitoring techniques to survey recovery habitat for extremely rare species and species difficult to monitor using standard methods	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	1.0	0.5	0.5			

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							Total	FY 03	FY 04	FY 05	FY 06	
2	1	4.10.1	E	Determine the basis for variation in population density and termination of range	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	3.0	1.0	1.0	1.0		Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	1	4.10.2	E	Determine the basis for low nesting success documented at Honohina Tract (wet habitat) using cameras on nests while documenting rainfall	Unknown	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	2.0	1.0	1.0			Hawai`i; Hakalau Forest NWR, Honohina Tract. Species: Hawai`i creeper
2	1	4.10.3	E	Determine the role of food in timing of breeding, attempts to breed, and breeding success	Unknown	*Research Institutions, *UH, *USFWS, *USGS, 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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *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	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	2.0	1.0	1.0			Kaua`i; Alaka`i Wilderness area. Species: Kaua`i creeper, Puaiohi
2	1	4.10.6	E	Determine the role of food as the basis for different densities of the bird in continuous habitat	Unknown	*Research Institutions, *UH, USFWS, *USGS, *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	Ongoing	*Research Institutions, *UH, *USFWS, *USGS,	2.0	1.0	1.0			Hawai`i; Mauna Kea and Mauna Loa. Species: palila

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Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
						DOFAW						
2	1	4.10.8	C	Determine population response of endangered Maui forest birds to predator control efforts	Ongoing	*Research Institutions, *UH, USFWS, USGS, *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
2	1	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	Unknown	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	4.5	1.5	1.5	1.5		Kaua\`i; Alaka\`i Wilderness area. Species: Kaua\`i creeper, Puaiohi
2	1	4.10.11	A	Determine population response of palila to forest regeneration and restoration efforts	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	1	4.10.12	A	Determine use of regenerating/restored canopy trees as substrates for feeding	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	2.0	1.0	1.0			Hawai\`i. Species: Hawai\`i \`ākepa, Hawai\`i creeper, \`akiapōlā\`au
2	1	4.10.13	A	Determine population response of endangered Maui forest birds to forest regeneration and habitat restoration efforts	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	2.0	1.0	1.0			Maui. Species: \`ākohekohe, Maui parrotbill
2	1	4.10.14	A	Determine population	Ongoing	*Research	2.0	1.0	1.0			Kaua\`i. Species: Kaua\`i

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				response to experimental control of weeds (e.g., ginger)		Institutions, *UH, USFWS, USGS, *DOFAW						creeper, Puaiohi
2	1	4.10.17	E	Document genetic population structure of species with single populations	Ongoing	*Research Institutions, *UH, USFWS, *USGS, *DOFAW	2.0	1.0	1.0			Maui. Species: po`ouli, Maui parrotbill, `ākohekohe
2	1	4.10.18	E	Document source/sink metapopulation structure and dispersal characteristics in populations along lateral and elevational gradients of density	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	2.0	1.0	1.0			Hawai`i. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	1	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	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	2.0	1.0	1.0			Hawai`i. Species: `akiapōlā`au
2	1	4.10.20	E	Determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations.	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, DOFAW	4.0	2.0	2.0			Hawai`i; Mauna Kea and Hualālai. Species: Hawai`i `ākepa, Hawai`i creeper, `akiapōlā`au
2	1	4.10.21	E	Determine genetic as well as morphological, behavioral, ecological, and vocal variation among core populations.	Unknown	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio
2	1	4.10.22	E	Determine patterns of dispersal by age and sex	Unknown	*Research Institutions, *UH, *USFWS,	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
						*USGS, *DOFAW						
2	1	4.10.23	E	Document dispersal and survival of juveniles	Unknown	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	2.0	1.0	1.0			O`ahu. Species: O`ahu `elepaio
2	1	4.10.24	E	Conduct population and metapopulation viability analyses and calculate lambda in populations in different portions of the recovery area	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *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	Ongoing	*Research Institutions, *UH, *USFWS, *USGS, *DOFAW	3.0	1.0	1.0	1.0		Kaua`i. Species: Kaua`i creeper, Puaiohi
2	1	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	10.0	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	10.0	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,	Ongoing	*USFWS, USGS	5.0	0.1	0.1	0.1	0.1	Annual survey.

Table 20														
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Hawai`i, to determine annual and seasonal changes in distribution and population size								
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	12.5	0.5	0	0.5	0	Every 2 years.
2	2	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	5.0	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	5.0	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	5.0	0.1	0.1	0.1	0.1	Annual survey.
2	2	5.2.8	E	Conduct systematic surveys of Mauna Loa Strip, Hawai`i, to determine annual and	Ongoing	USFWS, *USGS, DOFAW, *NPS	5.0	0.1	0.1	0.1	0.1	Annually/biannually.

Table 20													
Pritty Nmbr	Pritty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				seasonal changes in distribution and population size								
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	12.5	0.25	0.25	0.25	0.25	Annual survey.
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	5.0	0.1	0.1	0.1	0.1	Annual survey.
2	1	5.2.11	E	Conduct systematic surveys of Kīpuhulu Valley, Maui, to determine annual and seasonal changes in distribution and population size	Ongoing	USFWS, *USGS, DOFAW, *NPS	5.0	0.1	0.1	0.1	0.1	Annual survey.
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	2.4	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle.
2	1	5.2.13	E	Conduct systematic surveys of Pia Valley, O`ahu, to determine	Ongoing	*USFWS, USGS, *DOFAW	2.4	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				annual and seasonal changes in distribution and population size and to monitor efficacy of predator control								
2	1	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	2.4	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle.
2	1	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	2.4	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle.
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	2.4	0.2	0.2	0.2	0	Annual for 3 years, integrated with 5-year cycle.
2	1	5.2.17	E	Conduct systematic surveys of “core” puaiohi habitat in Alaka`i Wilderness Preserve,	Ongoing	*USFWS, *USGS, *DOFAW	10.0	0.2	0.2	0.2	0.2	Annual survey.

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Kaua`i, to determine annual and seasonal changes in distribution and population size								
2	1	6	E	Inform 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	Ongoing	*USFWS, *DLNR, *DOFAW						Cost broken down into separate actions
2	1	6.1	E	Build alliances with the public through outdoor experience with native forest birds and their forest habitats	Continual	*USFWS, *USGS, *DLNR, *DOFAW	2.0	0.5	0.5	0.5	0.5	
2	1	6.1.2.3	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Hakalau Forest NWR, Hawai`i	2 years	*USFWS	2.0	1.0	1.0			
2	1	6.1.2.4	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Pu`u Lā`au, Mauna Kea, Hawai`i,	2 years	*DLNR, *USGS	2.0	1.0	1.0			

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	6.1.2.14	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Kuli`ou`ou Trail and `Aiea Loop Trail, O`ahu	2 years	*DLNR, *USFWS	2.0	1.0	1.0			
2	1	6.1.2.15	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Kōke`e State Park, Kaua`i	2 years	*DLNR	2.0	1.0	1.0			
2	1	6.1.4.1	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public services interpretive programs: Hawai`i, Hakalau Forest NWR	Ongoing	*USFWS	44.0	10.0	10.0	0.5	0.5	
2	1	6.1.4.2	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public services interpretive programs: Maui, Haleakalā National Park	Ongoing	*NPS	44.0	10.0	10.0	0.5	0.5	
2	1	6.1.4.3	E	Expand visitor awareness with development of visitor centers, displays and facilities, and public	Ongoing	*HZ	44.0	10.0	10.0	0.5	0.5	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				services interpretive programs: O`ahu, Honolulu Zoo								
2	1	6.1.5	E	Promote the opening of State Forest reserve trails to the general public for nature walks and birding on all islands	Ongoing	*DLNR, *DOFAW	50.0	1.0	1.0	1.0	1.0	
2	1	6.1.6	E	Support the Na Ala Hele Trail System	Ongoing	*DLNR, *DOFAW	50.0	1.0	1.0	1.0	1.0	
2	1	6.2.1	E	Fund and support teacher education programs that promote native species issues	Ongoing	TBD	100.0	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	100.0	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	100.0	2.0	2.0	2.0	2.0	
2	1	6.2.1.4.2	E	Fund the development and distribution of educational materials:	4 years	*KS	4.0	1.0	1.0	1.0	1.0	

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Keauhou Ranch/ Kīlauea Forest Reserve. Assist Kamehameha Schools with their ongoing development of environmental learning opportunities								
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 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	Ongoing	*Hawai`i Outdoor Education Centers	150.0	3.0	3.0	3.0	3.0	
2	1	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 Hawai`i’s school children	Ongoing	TBD	50.0	1.0	1.0	1.0	1.0	

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
2	1	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	10.0	0.2	0.2	0.2	0.2	
2	1	6.2.2.3	E	Develop and support programs such as Malama Hawai\`i, that encourage widespread awareness of conservation goals through a diverse coalition of traditional and non-traditional partnerships	Ongoing	TBD	10.0	0.2	0.2	0.2	0.2	
2	1	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	5.0	0.1	0.1	0.1	0.1	
2	1	6.2.4.1	E	Initiate and fund public outreach and information about the effect of rats and cats as vectors for	4 years	*USFWS, *HDPH	6.0	2.0	2.0	1.0	1.0	

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				human disease, agricultural pests, and their threats to native species as predators								
2	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	1	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			
2	1	6.3.2.1	E	Assist in the development of public service announcements	Ongoing	TBD	10.0	0.2	0.2	0.2	0.2	

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				about native species by providing local TV 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								
2	1	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	5.0	0.1	0.1	0.1	0.1	
2	1	6.4.1.1	E	Support conservation outreach organizations to promote conservation at a “grass roots” level	Ongoing	TBD	25.0	0.5	0.5	0.5	0.5	
2	1	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	20.0	0.4	0.4	0.4	0.4	
2	1	6.4.1.3.1	E	Develop program to bring volunteers for banding O`ahu `Amakihi at Lyon Arboretum and `elepaio in Wailupe	Ongoing	*UH, *USFWS	2.5	0.05	0.05	0.05	0.05	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Valley								
3	3	1.3.16	A	Secure recovery habitat areas: Honomalino, TMKs 389006004 389006029	Unknown	*Scott C. Rolles Trust	TBD[1]					Scott C. Rolles Trust. A link between Ka`ū Forest and South Kona Forest. By conservation easement, lease, partnership agreement, change in land use designation, or purchase from willing seller.
3	3	1.3.19	A	Secure recovery habitat areas: Portions of TMK 387001014	Unknown	*DLNR, State Land Division	TBD[1]					Hawai`i State, DLNR, State Land Division, currently leased for cattle grazing. By lease, conservation easement, change of jurisdiction, or change in land use designation to conservation.
3	1	1.3.25	A	Secure recovery habitat areas: Portions of TMK 382001001	Unknown	*Kealakekua Development Corp.	TBD[1]					Protects contiguous forest habitat in South Kona from development and provides habitat for a second palila population. Restorable. By lease, conservation easement, partnership agreement, change in land use designation, or purchase from willing seller.
3	3	1.3.28	A	Secure recovery habitat areas: Kīpahulu Forest Reserve, Kukui`ula, TMK 216001007	Unknown	*J. Haili, *EMWP	TBD[1]					J. Haili. Small parcel at lower edge of recovery habitat. By partnership with EMWP.
3	3	1.3.29	A	Secure recovery habitat areas: Kīpahulu Forest	Unknown	*Kalalau, Cleveland,	TBD[1]					Kalalau, Cleveland. Small parcel at lower edge of

Table 20

Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 03	FY 04	FY 05	FY 06	Comments/Notes
				Reserve, Kukui`ula, TMK 216001006		*EMWP						recovery habitat. By partnership with EMWP.
3	2	1.3.31	A	Secure recovery habitat areas: Kīpahulu Forest Reserve, TMK 217001032	Unknown	*A. Kaapana et al., *EMWP	TBD[1]					A. Kaapana et al. Small parcel at lower edge of recovery habitat. By partnership with EMWP.
3	2	1.3.32	A	Secure recovery habitat areas: Kīpahulu Forest Reserve, TMK 217001024	Unknown	*Kaupō Ranch Ltd., *EMWP	TBD[1]					Kaupō Ranch Ltd. Small parcel at lower edge of recovery habitat. By partnership with EMWP.
3	3	1.3.33	A	Secure recovery habitat areas: 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 partnership with EMWP. Acquisition being negotiated by NPS. By safe-harbor agreement, easement, change of land use designation, or purchase from willing seller.
3	3	1.3.34	A	Secure recovery habitat areas: Nu`u, TMK 218001002	Unknown	*James Campbell Est., *EMWP	TBD[1]					James Campbell Est. Degraded former forest land in need of active management. By partnership with EMWP, conservation easement, or purchase from willing seller.
3	1	1.3.76	A	Secure recovery habitat areas: Kapālama, TMK 14015009	Unknown	*Julius Chung Trust, *KMWP	TBD[1]					Julius Chung Trust. Small parcel not included in KMWP.
3	1	1.3.82	A	Secure recovery habitat areas: Upper Wainiha	Unknown	*Alexander and Baldwin,	TBD[1]					Alexander and Baldwin Hawai`i Inc. Currently

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Pali, Portion of TMK 458001001		Hawai`i Inc., *DLNR						under surrender agreement to DLNR. Area under management of DLNR. Land is extremely remote and without public access. For these reasons area is considered adequately protected at present and for foreseeable future. Any change in this status should be reassessed.
3	1	2.1.3	A	Reforest areas of the Hilo Forest Reserve, Laupāhoehoe Section, TMK 337001004	Unknown	*DLNR, *DOFAW	0.9					Hawai`i State, DLNR, DOFAW. Remove alien trees. Restore transition forest from wet `ōhi`a to mesic koa.
3	3	2.1.4	A	Reforest areas of the Hilo Forest Reserve, Pīhā Section, TMK 333001004	Unknown	*DLNR, *DOFAW	1.4					Hawai`i State, DLNR, DOFAW. Remove alien trees. Restore transition forest from wet `ōhi`a to mesic koa. Facilitate understory regeneration.
3	3	2.1.6	A	Reforest areas of Kīpuka `Āinahou Nēnē Sanctuary, TMK 338001008	Unknown	*DHHL, *DOFAW	17.8					Hawai`i State, DHHL, leased by DOFAW. Facilitate canopy tree and understory regeneration.
3	1	2.1.13	A	Reforest areas of Keauhou Ranch, TMK 399001004	Unknown	*KS, Keauhou Ranch	108.7					Kamehameha Schools, Keauhou Ranch. Reforest transition wet `ōhi`a, mesic koa and dry māmane /sandlewood.
3	3	2.1.14	A	Reforest areas of HVNP, TMK 399001002	Unknown	*HVNP	13.1					Hawai`i Volcanoes National Park. Continue

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												dryland forest restoration.
3	2	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.
3	2	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.
3	2	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					Koa Aina Ventures. A link between Ka`ū Forest and South Kona Forest. Protect and restore montane mesic koa forest.
3	2	2.1.21	A	Reforest areas of Honomalino, TMK 389001001	Unknown	*TNCH	12.0					The Nature Conservancy of Hawai`i. Continue forest restoration program.
3	2	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 owned 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.

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
3	1	2.1.25	A	Reforest areas of `Alae Ranch, Portions of TMK 387001014	Unknown	*DLNR, State Land Division	0.9					Hawai`i State DLNR, State Land Division. Protect and restore wet `ōhi`a forest.
3	1	2.1.29	A	Reforest areas of recovery habitat, Portions of TMK 382012001	Unknown	*Kealakekua Development Corp.	31.9					Kealakekua Development Corp. Protect contiguous forest habitat in South Kona from development and provide habitat for a second palila population. Restore wet `ōhi`a, mesic koa and dry montane māmane forest.
3	3	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	3	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.
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 non-native trees.
3	3	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 non-native trees.
3	3	2.1.45	A	Reforest areas of Kamehame Nui/Kealahou, TMK 223005002	Unknown	*R. G. Von Tempsky Jr. Trust	3.3					R. G. Von Tempsky Jr. Trust. Restore montane mesic forest and shrubland.
3	3	2.1.57	A	Reforest areas of Moloka`i Forest Reserve, Mākolelau, TMK	Unknown	*Ashton Pitts Jr. Trust	1.0					Ashton Pitts Jr. Trust. Restore montane mesic forest and shrubland.

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				255001015								
3	3	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.
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 non-native trees.
3	1	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, needs reforestation.
3	1	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 State, DLNR, Division of State Parks. Additional protection may be needed to secure remaining forested habitat.
3	1	2.2.14	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Ka`ū Forest Reserve, TMK 397001001	3 years	*DLNR, *DOFAW	165.9					Hawai`i State, DLNR, DOFAW, Ka`ū Forest Reserve. Fencing and ungulate control.
3	1	2.2.15	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kahuku Ranch, Portions of TMK 392001002	3 years	*Samuel M. Damon Trust	125.3					Samuel M. Damon Trust. Purchase by NPS, fence and remove ungulates.
3	1	2.2.17	A, C	Reduce or eliminate the detrimental effects of	3 years	*TNCH	0.9					The Nature Conservancy of Hawai`i. Fence and remove

Table 20													
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation within Honomalino, TMK 389001001								ungulates.
3	1	2.2.18	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Yee Hop Ranch, TMK 392001005	3 years	*Yee Hop Ranch Ltd.	20.6					Yee Hop Ranch Ltd. Fence and remove ungulates.
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	3 years	*J. Haili	0.15					J. Haili. Encourage ungulate control and fencing.
3	3	2.2.30	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, Kukui`ula, TMK 216001006	3 years	*Kalalau, Cleveland	0.49					Kalalau, Cleveland. Encourage ungulate control and fencing.
3	2	2.2.32	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMK 217001032	3 years	*A. Kaapana et al.	0.11					A. Kaapana et al. Encourage ungulate control and fencing.
3	3	2.2.33	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Kīpahulu Forest Reserve, TMK 217001024	3 years	*Kaupō Ranch Ltd.	0.12					Kaupō Ranch Ltd. Encourage ungulate control and fencing.
3	3	2.2.34	A, C	Reduce or eliminate the detrimental effects of	3 years	*Kaupō Ranch Ltd.	6.2					Kaupō Ranch Ltd. Encourage ungulate control

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ungulates on vegetation within Nu`u, TMK 218001001								and fencing.
3	3	2.2.35	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Nu`u, TMK 218001002	3 years	*James Campbell Estate	9.9					James. Campbell Est. Encourage ungulate control and fencing.
3	1	2.2.99	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within O`ahu Forest NWR, TMKs 95004001 and 76001001	3 years	*USFWS	38.9					U.S. Fish and Wildlife Service. Currently no `elepaio, but high potential for reintroduction. Fencing and eradication of ungulates and/or time/area closure to hunting may be needed in preparation for aerial broadcast of rodenticides.
3	1	2.2.100	A, C	Reduce or eliminate the detrimental effects of ungulates on vegetation within Lower Ka`ala NAR, TMK 67003025	3 years	*DLNR	6.4					Hawai`i State. Currently few `elepaio, but high potential for augmentation/reintroductio n. Fencing and eradication of ungulates and/or time/area closure to hunting to allow aerial broadcast of rodenticide.
3	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	3 years	*Robinson Family Partners	20.0[2]					Gay and Robinson Partnership with DLNR/DOFAW as part of management for release of captive-bred puaiohi. Fencing and ungulate control may be needed, but area not determined.
3	1	2.4.1.14	C	Control alien mammalian	Continual	*DLNR,	3,967.7	79.4	79.4	79.4	79.4	Hawai`i State DLNR,

Table 20

Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units) Total	FY 03	FY 04	FY 05	FY 06	Comments/Notes
				predators by trapping, poisoning and other means in Ka`ū Forest Reserve, TMK 397001001		*DOFAW						DOFAW, Ka`ū Forest Reserve. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	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	2,247.4	44.9	44.9	44.9	44.9	Samuel M. Damon Trust. Purchase by NPS. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	1	2.4.1.17	C	Control alien mammalian predators by trapping, poisoning and other means in TNCH, Honomalino, TMK 389001001	Continual	*TNCH	240.7	4.8	4.8	4.8	4.8	TNCH. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	1	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.	245.9	4.9	4.9	4.9	4.9	Yee Hop Ranch Ltd. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	234.6	4.7	4.7	4.7	4.7	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	2	2.4.1.34	C	Control alien mammalian predators by trapping, poisoning and other means in Haleakalā Ranch (Pūlehu	Continual	*Haleakalā Ranch Co.	81.4	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. Total cost

Table 20													
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Nui/Kalialinui), TMK 223005003								based on continuous implementation for 50 years (estimated time to delisting).
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	368.4	7.4	7.4	7.4	7.4	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
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	80.5	1.6	1.6	1.6	1.6	Hawai`i State, DLNR, DOFAW. Potential long-term site for reintroduction. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	1	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	500	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. Total cost based on continuous implementation for 50 years (estimated time to delisting).
3	1	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	85	1.7	1.7	1.7	1.7	Hawai`i State. Currently few `elepaio, but aerial broadcast of rodenticide would help prepare site for reintroduction or augmentation. Total cost based on continuous

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
												implementation for 50 years (estimated time to delisting).
3	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	20.0	0.4	0.4	0.4	0.4	Robinson Family Partners, in conjunction with release program for Puaihoi.
3	1	2.5.3.1.1.1	C	Mosquito surveys on Hawai`i between the 2,000 and 5,000 ft. contour lines on Mauna Loa and Kīlauea Volcanoes that include recovery habitat	2 years	*USGS, USFWS, DOFAW	5.0	2.5	2.5			
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 habitat and also in need of extensive restoration.
3	1	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 habitat.
3	1	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	1	3.2.8.2	E	Maintain captive flocks of Hawai`i `ākepa and	Ongoing	*ZSSD, USFWS,	TBD[4]					Hawai`i `ākepa and Hawai`i creeper.

Table 20												
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				Hawai`i creeper whose progeny will be used for reintroduction into managed habitat in the future, or rear and release in managed habitat		USGS, DOFAW, HFBRT						
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.
3	1	4.7.3	E	Evaluate the relative costs of habitat suitability analysis vs. experimental translocation or reintroduction	Ongoing	*Research Institutions, UH, *USFWS, *USGS, *DOFAW	3.0	1.0	1.0	1.0		
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	1	6.1.1.2	E	Develop scenic overlook and interpretive displays at Mauna Loa Strip Road, Hawai`i Volcanoes National Park	2 years	*NPS	2.0	1.0	1.0			
3	1	6.1.1.3	E	Develop scenic overlook and interpretive displays at Polipoli State Park, Maui	2 years	*DLNR	1.0	0.5	0.5			
3	1	6.1.1.4	E	Develop scenic overlook	2 years	*DLNR	1.0	0.5	0.5			

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				and interpretive displays at Pu`u Ali`i NAR, Moloka`i								
3	1	6.1.1.5	E	Develop scenic overlook and interpretive displays at Kalalau and Pu`u O Kila lookouts, Kōke`e State Park, Kaua`i,	2 years	*DLNR	2.0	1.0	1.0			
3	1	6.1.2.1	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Pu`u `Ō`ō Trail, Saddle Road, Hawai`i	2 years	*DLNR	1.0	0.5	0.5			
3	1	6.1.2.2	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Mauna Loa Strip Road, Hawai`i Volcanoes National Park	2 years	*NPS	2.0	1.0	1.0			
3	1	6.1.2.5	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Ainapō Trail, Hawai`i	2 years	*DLNR, *NPS	2.0	1.0	1.0			

Table 20													
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
3	1	6.1.2.6	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Pu`u Wa`awa`a Forest Bird Sanctuary, Hawai`i	2 years	*DLNR	2.0	1.0	1.0			
3	1	6.1.2.7	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Pu`u Maka`ala, Laupāhoehoe, Kīpāhoehoe, Manukā, Pu`u O`umi NARs, Hawai`i	2 years	*DLNR	3.0	1.5	1.5			
3	1	6.1.2.8	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Hosmer Grove, Haleakalā National Park, Maui	2 years	*NPS	2.0	1.0	1.0			
3	1	6.1.2.9	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive	2 years	*DLNR	1.0	0.5	0.5			

Table 20												
Pirty Nmbr	Pirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				displays at Polipoli State Park, Maui								
3	1	6.1.2.10	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Pu`u Kukui, Maui	2 years	*Maui Land and Pineapple Co.	2.0	1.0	1.0			
3	1	6.1.2.11	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Waihe`e Ridge Trail, Maui	2 years	*DLNR	2.0	1.0	1.0			
3	1	6.1.2.12	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Kahakuloa NAR, Maui	2 years	*DLNR	1.0	0.5	0.5			
3	1	6.1.2.13	E	Promote and support native species public awareness and environmental education through improved visitor access and interpretive displays at Hanalilolilo Trail, Maui	2 years	*DLNR	1.0	0.5	0.5			
3	1	6.1.3.1	E	Promote increased access	Ongoing	*USFWS	5.0	0.1	0.1	0.1	0.1	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				and interpretation programs on lands where native species are found: Hawai`i, Hakalau Forest NWR, Hakalau and Kona Forest Units								
3	1	6.1.3.2	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	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.3	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Waikamoi Preserve, The Nature Conservancy	Ongoing	* TNCH	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.4	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Makawao Forest Reserve	Ongoing	*DLNR, *DOFAW	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.5	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Hanawī NAR	Ongoing	*NAR	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.6	E	Promote increased access and interpretation programs on lands where native species are found: Maui, Haleakalā	Ongoing	*NPS	5.0	0.1	0.1	0.1	0.1	

Table 20												
Pririty Nmbr	Pririty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				National Park								
3	1	6.1.3.7	E	Promote increased access and interpretation programs on lands where native species are found: Moloka`i, Kamakou Preserve, The Nature Conservancy	Ongoing	*TNCH	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.8	E	Promote increased access and interpretation programs on lands where native species are found: O`ahu, Barber's Point	Ongoing	*DLNR, *DOFAW	5.0	0.1	0.1	0.1	0.1	
3	1	6.1.3.9	E	Promote increased access and interpretation programs on lands where native species are found: Honouliuli Preserve, The Nature Conservancy.	Ongoing	*DLNR, *DOFAW	5.0	0.1	0.1	0.1	0.1	
3	1	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	1	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	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
3	1	6.3.2.3	E	Promote the use of prize-winning contests, with sponsors, on local radio, TV stations and newspapers to promote native species awareness	Ongoing	TBD	5.0	0.1	0.1	0.1	0.1	
3	1	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 Hawai`i'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	2.5	0.05	0.05	0.05	0.05	
3	1	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	5.0	0.1	0.1	0.1	0.1	
3	1	6.3.2.4.2	E	Develop a weekly radio program provided radio stations on all islands providing information on native species and	Ongoing	TBD	5.0	0.1	0.1	0.1	0.1	

Table 20												
Prirty Nmbr	Prirty Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
				ecosystem issues, with the writing shared by conservation organizations throughout the state								
3	1	6.3.2.4.3	E	Develop a half hour weekly or monthly TV nature program about Hawai`i's native species and their habitat	Ongoing	TBD	20.0	0.4	0.4	0.4	0.4	
3	1	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	
3	1	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	2.5	0.05	0.05	0.05	0.05	
3	1	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	5.0	0.1	0.1	0.1	0.1	

Table 20												
Pritry Nmbr	Pritry Tier	Action Number	List. Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $100,000 units)					Comments/Notes
							Total	FY 03	FY 04	FY 05	FY 06	
3	1	6.4.1.2	E	Develop a "mentor" program, where natural science based professionals provide field opportunities for young people in learning about Hawai`i's native species	Unknown	*UH, *USFWS, *USGS, *DLNR, *DOFAW	10.0	0.2	0.2	0.2	0.2	
3	1	6.4.1.4	E	Support the development of a volunteer "clearinghouse" to provide volunteers for resource management, education, and outreach	Ongoing	TBD	5.0	0.1	0.1	0.1	0.1	
3	1	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	25.0	0.5	0.5	0.5	0.5	
TOTAL							36,273	1,051	1,001	905	855	

[1]Costs to secure recovery habitat 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 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 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 Habitat 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 habitat in need of protection;
2.1._ = Parcels in recovery habitat needing reforestation;
2.2._ = Parcels in recovery habitat needing fencing and ungulate control; and
2.4.1._ = Parcels in recovery habitat 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, NAR = Natural Area Reserve, HVNP = Hawai`i Volcanoes National Park.

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Northeastern slopes of Mauna Kea, portions of 344014002 344014003 343010002 343010008	Hawai`i State, 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 State, 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 State, DLNR, Division of Forestry and Wildlife. Currently the Laupāhoehoe Game Management Area.	1.3.3 (2); 2.1.3 (3);
H	Hilo Forest Reserve, Humu`ula Section,	Hawai`i State, DLNR, Division of Forestry and Wildlife. Currently the Laupāhoehoe Game Management Area.	2.1.3 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	337001004		
H	Hilo Forest Reserve, Pīhā Section, 333001004	Hawai`i State, DLNR, Division of Forestry and Wildlife. 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 State, DLNR, Division of Forestry and Wildlife. Currently the Laupāhoehoe and Pīhā Game Management Areas.	2.2.3 (2);
H	Hilo Forest Reserve, Laupāhoehoe and Pīhā Sections, 337001002 333001004	Hawai`i State, DLNR, Division of Forestry and Wildlife. 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	326018002	Hawai`i State, DHHL, adjacent to Hakalau Forest National Wildlife Refuge.	2.2.5 (2); 2.4.1.5 (2);
H	Kīpuka `Āinahou Nēnē Sanctuary, 338001008	Hawai`i State, DHHL. Leased by Division of Forestry and Wildlife 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 State, DHHL. Currently leased by Nobrega Ranch for cattle grazing.	1.3.6 (1); 2.1.7 (2);
H	Humu`ula, Portions of 338001007	Hawai`i State, DHHL. Parker Ranch, leased for grazing.	1.3.7 (2); 2.1.8 (2);
H	Lamaia Section, 326018002	Hawai`i State, DHHL. Adjacent to Hakalau Forest National Wildlife Refuge.	1.3.8 (1); 2.1.9 (2)
H	Pu`u `ō`ō Ranch, 326018001	Hawai`i State, 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);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Ka`ohe Lease, 344015002	Hawai`i State, 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 State, DLNR.	2.1.12 (1);
H	Mauna Kea Forest Reserve, 344015001 344016003 338001004	Hawai`i State, DLNR.	2.2.9 (1); 2.4.1.9 (1);
H	Waiākea Forest Reserve, Upper Portion, 324008001	Hawai`i State, DLNR, Division of Forestry and Wildlife.	2.2.10 (2); 2.4.1.10 (2);
H	Waiākea Forest Reserve, Lower Portion, 324008001	Hawai`i State, DLNR, Division of Forestry and Wildlife.	2.2.11 (1); 2.4.1.11 (1);
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 State, DLNR, State Land Division. Kapāpala Ranch, currently leased for cattle grazing.	1.3.12 (2);
H	Kapāpala Ranch, Portions of 398001004	Hawai`i State, DLNR, State Land Division. Kapāpala Ranch, currently leased for cattle grazing.	2.1.15 (2);
H	Kapāpala Forest Reserve, Portions of 398001004	Hawai`i State, DLNR, State Land Division.	2.2.13 (2); 2.4.1.13 (2);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
H	Ka`ū Forest Reserve, 397001001	Hawai`i State, DLNR, Division of Forestry and Wildlife.	2.2.14 (3); 2.4.1.14 (3);
H	Ka`ū Forest Reserve, 397001007	Mauna Kea Agribusiness.	1.3.13 (2); 2.1.16 (3);
H	Ka`ū Forest Reserve, Portions of 397001006 397001005	Kamehameha Schools.	1.3.14 (2); 2.1.17 (3);
H	Kahuku Ranch, Portions of 392001002	Samuel M. Damon Trust.	1.3.15 (2); 2.1.18 (2); 2.2.15 (3); 2.4.1.15 (3);
H	Manukā NAR, Upper portions of 391001002	Hawai`i State, DLNR, Division of Forestry and Wildlife.	2.2.16 (2); 2.4.1.16 (2);
H	TNCH, Honomalino, 389001001	The Nature Conservancy of Hawai`i.	2.1.21 (3); 2.2.17 (3); 2.4.1.17 (3);
H	Honomalino, 389006004 389006029	Scott C. Rolles Trust.	1.3.16 (3); 2.1.19 (3);
H	Honomalino Forest Reserve, 389001002	Hawai`i State.	2.1.22 (2);
H	Honomalino, 389001001	The Nature Conservancy of Hawai`i.	2.1.21 (3);
H	Pāpā, 388001001	Koa Aina Ventures.	1.3.17 (2); 2.1.20 (3);
H	Yee Hop Ranch, Portions of 388001003 388001004 387012001 392001005 387012003 387012004 387001007 387001006 387001011	Yee Hop Ranch Ltd.	1.3.18 (2); 2.1.23 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	387001004		
H	Yee Hop Ranch, 392001005	Yee Hop Ranch Ltd.	2.2.18 (3); 2.4.1.18 (3);
H	Kona Forest NWR, 386001001	U.S. Fish and Wildlife Service.	2.1.24 (1); 2.2.19 (2); 2.4.1.19 (2);
H	`Alae Ranch, Portions of 387001014	Hawai`i State, 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, Portions of 392001003 386001001 385001002	McCandless Ranch.	2.1.26 (2); 2.2.20 (2); 2.4.1.20 (2);
H	Waiea Tract, 386001003	Hawai`i State, 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);
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	Kealakekua Development Corp.	1.3.25 (3); 2.1.29 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	Development Corp., Portions of 382001001		
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 State, Pu`u Wa`awa`a Bird Sanctuary.	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);
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 State, DLNR.	2.2.25 (1); 2.4.1.26 (1);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	Hanawī NAR and Ko`olau Forest Reserve, 212004007	Hawai`i State, DLNR.	2.2.26 (1); 2.4.1.27 (1);
MA	Hāna Forest Reserve, 210001001 214001001 215001001	Hawai`i State, 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);
MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006 218001007	Hawai`i State.	1.3.30 (1);
MA	Kīpahulu Forest Reserve, 216001005 217001033 217002035 217004006	Hawai`i State.	2.2.31 (1); 2.4.1.30 (2);
MA	Kīpahulu Forest Reserve, 217004006	Hawai`i State.	2.1.34 (1);
MA	Kīpahulu Forest Reserve, 217001032	A. Kaapana et al. Small parcel at lower edge of recovery habitat.	1.3.31 (3); 2.2.32 (3);
MA	Kīpahulu Forest Reserve, 217001024	Kaupō Ranch Ltd. Small parcel at lower edge of recovery habitat.	1.3.32 (3); 2.2.33 (3);
MA	Nu`u, 218001001	Kaupō Ranch Ltd.	1.3.33 (3); 2.1.35 (3); 2.2.34 (3);
MA	Nu`u,	James Campbell Est.	1.3.34 (3); 2.1.36 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	218001002		2.2.35 (3);
MA	Kahikinui Forest Reserve, 218001006 218001005 218001009	Hawai`i State.	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 State, DHHL.	1.3.36 (1); 2.1.38 (1); 2.2.37 (1); 2.4.1.32 (2);
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 State.	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	R. G. Von Tempsky Jr. Trust.	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 (1); 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);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MA	Makawao Forest Reserve, 224016001 224016002	Hawai`i State.	2.1.48 (1); 2.2.47 (1); 2.4.1.36 (2);
MA	West Maui NAR, Kahakuloa, 2231006001	Hawai`i State.	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 State, 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 State, DLNR.	2.2.52 (2);
MA	West Maui Forest Reserve, Kealaloloa, 236001014	Hawai`i State, DLNR.	2.2.53 (2);
MA	West Maui Forest Reserve, Manawainui Plant Reserve, 236001052 248001010	Hawai`i State, DLNR.	2.2.54 (2);
MA	West Maui Forest Reserve, Kaheawa, 248001001	Hawai`i State.	2.1.50 (2); 2.2.55 (2);
MA	West Maui Forest Reserve, Ukumehame/Olowalu, West Maui NAR, Līhau, 248001002	Hawai`i State.	2.1.51 (2); 2.2.56 (2);
MA	West Maui NAR,	Hawai`i State.	2.4.1.38 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	Līhau, 248001002		
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 State, 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 State, 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 State.	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 State.	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);
MA	West Maui Forest Reserve, Kapāloa, 244007007	Unknown.	1.3.52 (2); 2.2.66 (2);
MA	West Maui NAR,	Hawai`i State.	2.2.67 (2); 2.4.1.41

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	Honokōwai, 244007004		(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 State.	2.4.1.43 (2);
MO	Moloka`i Forest Reserve, Kalamāula, 252014003	Hawai`i State.	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, 252014004	Hawai`i State.	2.1.55 (2); 2.2.71 (2);
MO	Moloka`i Forest Reserve, Waikolu, 261001002	Hawai`i State.	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);
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	Hawai`i State.	2.2.76 (2); 2.4.1.44 (2);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	Reserve, Wailau Valley, 259006002		
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 State.	2.2.80 (2);
MO	Moloka`i Forest Reserve, Kahananui, 256006014	Hawai`i State.	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 State.	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);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
MO	Moloka`i Forest Reserve, Kumu`eli, 256006001	D. Fairbanks III Trust.	1.3.65 (2); 2.2.87 (2);
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 State.	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	Honouluuli 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 (1); 2.4.1.47 (1);
O	Schofield Barracks	U.S. Army.	2.2.96 (1); 2.4.1.48

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	West Range, 77001001		(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 State.	2.2.97 (1); 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 (3);
O	Lower Ka`ala NAR, 67003025	Hawai`i State.	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	Volumes Co. Ltd.	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);
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,	Damon Estate.	1.3.77 (2);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	11013001		
O	Moanalua Valley, 11013001 11013002	Damon Estate.	2.4.1.51 (1);
O	North Hālawa Valley, 99011002	Kamehmeha Schools.	2.4.1.50 (1);
O	South Hālawa Valley, Tripler Ridge, 99011001	Queen's Medical Center.	1.3.78 (2);
O	Wai Kāne Valley, 48014005	SMF Enterprises.	1.3.79 (1); 2.4.1.52 (1);
O	Waianu Valley, 48014003 48013014	Waiahole Irrigation Co. Ltd.	1.3.80 (2);
O	Mākua Military Reservation	U.S. Army.	2.1.62 (3);
K	Halehaha, Halepaakai and Koai\`e drainages, Alaka\`i Wilderness Preserve, 414001003	Hawai\`i State, DLNR, Division of Forestry and Wildlife.	2.2.101 (1); 2.4.1.59 (1);
K	Upper Mōhihi and upper Waiakoali drainages, Alaka\`i Wilderness Preserve, 414001003	State of Hawai\`i, DLNR, Division of Forestry and Wildlife.	2.2.102 (2); 2.4.1.60 (2);
K	Alaka\`i Wilderness Preserve, 4414001003	Hawai\`i State, DLNR, Division of Forestry and Wildlife.	2.2.103 (2);
K	Upper Kawaikōī, Alaka\`i Wilderness Preserve, 459001001	Hawai\`i State, DLNR, Division of Forestry and Wildlife.	2.4.1.61 (2);
K	Kōke\`e State Park,	Hawai\`i State.	2.1.63 (3);

Appendix A			
Island	Land Parcel, TMKs	Landowner	Recovery Actions
	414001013 459001016 414001020 414001014 414001002 and numerous small parcels within		
K	Southern Alaka`i Plateau, Portions of 417001001	Robinson Family Partners	1.3.81 (1); 2.2.104 (3); 2.4.1.62 (3);
K	Upper Wainiha Pali, Portions of 458001001	Alexander and Baldwin Hawai`i Inc.	1.3.82 (3);

APPENDIX B.
Captive Propagation Program Strategies for:
The Hawaiian Endangered Bird Conservation Program Keauhou Bird Conservation Center/Maui Bird Conservation Center 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:

    - 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.

<u>Founder Requirements for Wild Population Genetic Diversity</u>

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, this is a preferable strategy.

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).

   <u>Example Program: \`Ōma\`o</u>
   In 1995, an experimental program was undertaken with 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 (~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 x 85 percent hatchability = 17 chicks hatched
17 chicks x 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.

   <u>Example Program: Puaiohi (1996-1999)</u>
   43 viable wild and captive eggs collected (hatchability =91 percent; survivability of hand-reared chicks = 93 percent)
   43 eggs x 91 percent hatchability = 39 chicks hatched
   39 chicks x 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).

   <u>Example Program: Bali Mynahs</u>
   There are ~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.

   Example Program: Micronesian Kingfishers
   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.

   Example Program: \`Ōma\`o as a surrogate for Puaiohi
   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 x 93 percent hatchability = 27 chicks hatched
27 chicks x 93 percent survivability = 25 chicks hand-reared
25 birds released
(Fancy et al. 2001, Kuehler et al. 2000).

APPENDIX C.

Endangered and Threatened Species Recovery Priority Guidelines (adapted from 48 FR 51985)

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.

Listing Priority System

Threat		Taxonomy	Priority
Magnitude	Immediacy		
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies	6
Low to Moderate	Imminent	Monotypic genus	7
		Species	8
		Subspecies	9
	Non-imminent	Monotypic genus	10
		Species	11
		Subspecies	12