Revised Recovery Plan

for

Hawaiian Forest Birds

Original plans completed:

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

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

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Regional Director, U.S. Fish and Wildlife Service

Date: September 22nd, 2006

Dedication

To the naturalists and scientists

who have contributed to our understanding

of the biology and ecology of Hawaiian forest birds.

GUIDE TO RECOVERY PLAN ORGANIZATION

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

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

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

DISCLAIMER

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

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

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

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EXECUTIVE SUMMARY

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

Most of the species covered in this plan are now found only in upper elevation rain forests above 1,200 meters (4,000 feet) on the islands of Hawai`i, Maui, and Kaua`i. Two exceptions are the palila, which is limited to dry upland forests on Mauna Kea volcano on Hawai`i, and the O`ahu `elepaio, which occurs in native and nonnative forests on O`ahu at elevations as low as 100 meters (330

feet). Subfossil records and observations by early naturalists in the Hawaiian Islands indicate that most of the species once had much larger distributions and occurred at lower elevations.

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

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

The primary threats to Hawaiian forest birds are: habitat loss and degradation due to agriculture, urbanization, cattle grazing, browsing by feral ungulate species, timber harvesting, and invasion of nonnative plant species into native-dominated plant communities; predation by alien mammals; and diseases carried by alien mosquitoes. The periodic die-back of native plant species due to natural or alien-species-induced processes is a threat in some areas. The majority of recovery actions therefore address threats to habitat (factor A) and disease and

predation (factor C). The direct overutilization of Hawaiian forest birds for commercial, recreational, scientific, or educational purposes (factor B) and the inadequacies of existing regulatory mechanisms (factor D) are not considered significant current threats. Several Hawaiian forest birds now occur in such low numbers and in such restricted ranges that they are threatened by natural processes, such as inbreeding depression and demographic stochasticity, and by natural and manmade factors such as hurricanes, wildfires, and periodic vegetation die-back (factor E). Impacts of alien birds are not well understood (factor E), but include aggressive behavior towards native bird species, possible competition for food, nest sites, and roosting sites, and possibly supporting elevated predator population levels.

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

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

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

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

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

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

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

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

support suitable forest habitat. An effort was made to incorporate naturally occurring habitat heterogeneity that can shape local adaptation and that is consistent with the conditions under which particular species evolved and that likely are needed for recovery and to maintain demographic and population stability.

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

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

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

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

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

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

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

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

Those actions that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 actions: $102,450,000

All other actions necessary to meet recovery objectives.

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I. INTRODUCTION

A. Overview

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

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

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

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

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

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

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

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

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

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

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

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

resulting in lower population density in degraded forests (VanderWerf 2004) and limiting their ability to respond adaptively to novel resources available in introduced forests.

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

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

This recovery plan addresses some of our most difficult recovery challenges. Several of the species covered have not been sighted for years, and their status is uncertain. The po`ouli may have become extinct since the draft of this plan was written; one bird taken into captivity died of old age in November 2004, before a mate could be obtained. The last two known individuals have not

been seen since. Another species, the O`ahu `elepaio, exists entirely within the range of introduced mosquitoes and pathogens (VanderWerf *et al.* in press). Most of the remaining species are restricted to remote areas of forest at elevations above 1,500 meters (5,000 feet; Scott *et al.* 1986).

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

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

Earnest efforts to eliminate rats, cats, and other nonnative predators and competitors have begun more recently. Predator control efforts thus far generally have not been conducted over areas large enough to result in significant improvement in the status of a species or subspecies. However, studies of the O`ahu `elepaio demonstrate that rat control can result in significant increases in reproductive success and survival of adult females (VanderWerf 2001c,

VanderWerf and Smith 2002). Increases in the number of `akiapōlā`au have been documented on Kamehameha Schools land above Hawai`i Volcanoes National Park after control efforts for rats and cats were implemented (T. Casey, Kamehameha Schools, pers. comm.), although alternative hypotheses for the increase were not evaluated. Introduced species of insects and birds have been considered competitors for food and other resources. Nonnative wasps and the Japanese white-eye (*Zosterops japonicus*) are two of the most frequently cited species (Banko and Banko 1976, Pimm and Pimm 1982, Moulton and Pimm 1983, Mountainspring and Scott 1985, Banko *et al.* 2001), but evidence of actual competition is scarce. There currently are no efforts to control competing species within the recovery areas of endangered forest birds.

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

Several restoration projects point a way to recovery. Kamehameha Schools pioneered restoration of native plant species with their koa (*Acacia koa*) reforestation project at Keauhou Ranch on the island of Hawai`i. Plantings of koa trees at Keauhou Ranch in 1977 and since have resulted in encouraging increases in `akiapōlā`au and native Cerambycid beetles after only 25 years (Pejchar 2004; T. Casey, pers. comm.). This bodes well for the value of reforestation efforts at Hakalau Forest National Wildlife Refuge, where over 350,000 koa and other trees have been planted since 1987. It is also known that koa reforestation facilitates regeneration of `ōhi`a (*Metrosideros polymorpha*), a dominant canopy tree used for foraging by the Hawai`i creeper, Hawai`i `ākepa, and several non-endangered forest bird species. Elimination of feral ungulates has resulted in recovery of native plants in many areas of forest bird habitat (Stone 1985, Scowcroft and Conrad 1992, Cabin *et al.* 2000), and has been particularly effective in the dry māmane (*Sophora chrysophylla*) forests on Mauna Kea, home to the endangered

palila (Scowcroft and Hobdy 1986). The vision of restoring high elevation koa/`ōhi`a forest as a hedge against changes in climatic conditions (Scott *et al.* 1986) and as a refugium from avian pox and avian malaria is still alive, but greater incentives to private landowners are needed to make it happen in some areas. Safe harbor agreements and habitat conservation plans under section 10 of the Endangered Species Act are tools by which this might be accomplished. Artificial nesting boxes have been used successfully on a small scale by the Hawai`i `ākepa, and may be a promising technique to increase the quality of younger forests for Hawai`i `ākepa, as well as to replace natural cavities lost by tree-fall in old-growth forest (Freed 2001).

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

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

public and private partnerships, which will require creative incentives for private landowners and increased public support for endangered species recovery.

B. Recovery Planning for Hawaiian Forest Birds

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

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

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

C. Implementation Participants

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

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

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

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

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

Figure 1. The Main Hawaiian Islands and Major Cities

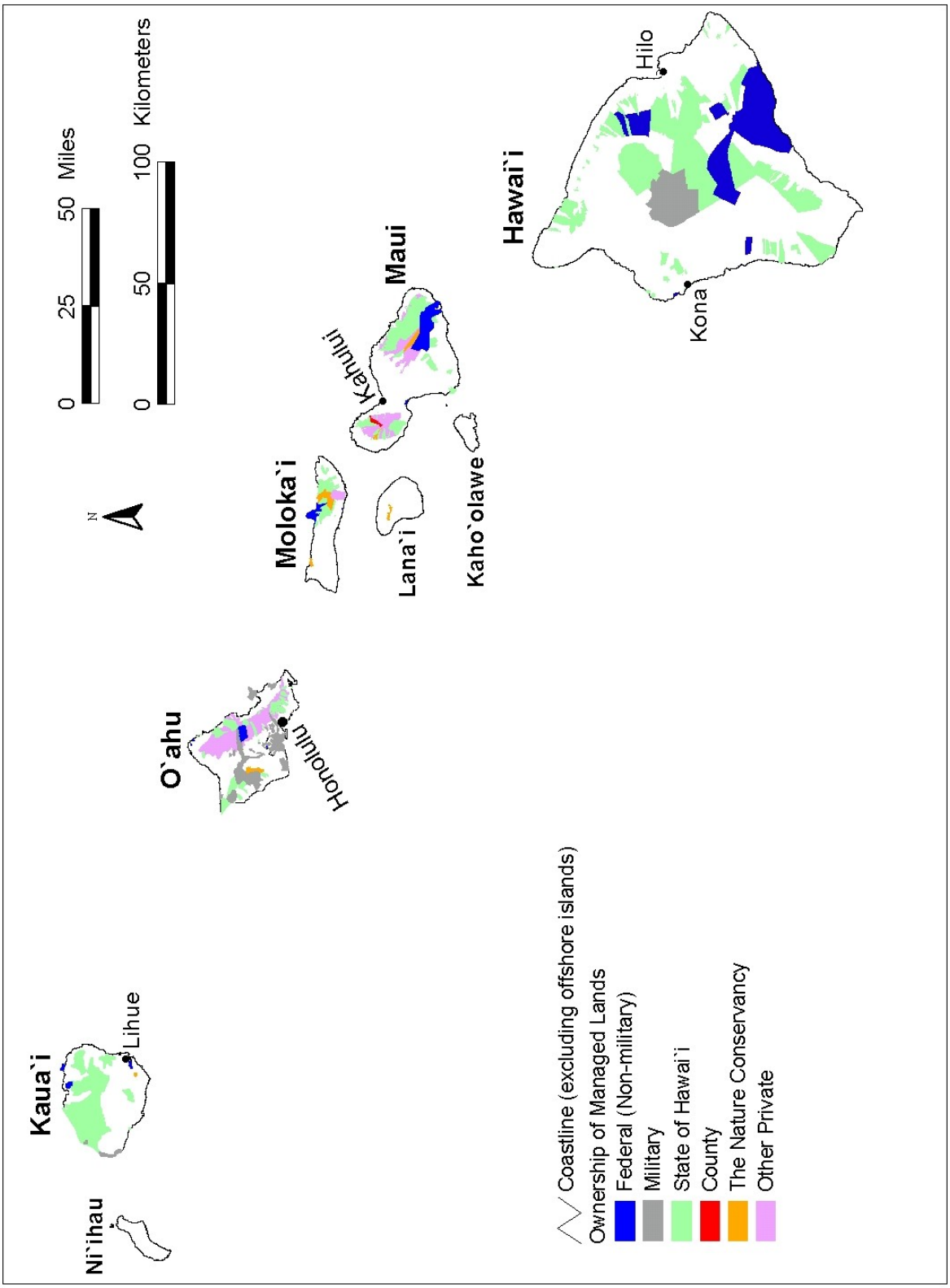

Figure 2. Locations of land parcels on the island of Hawai`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

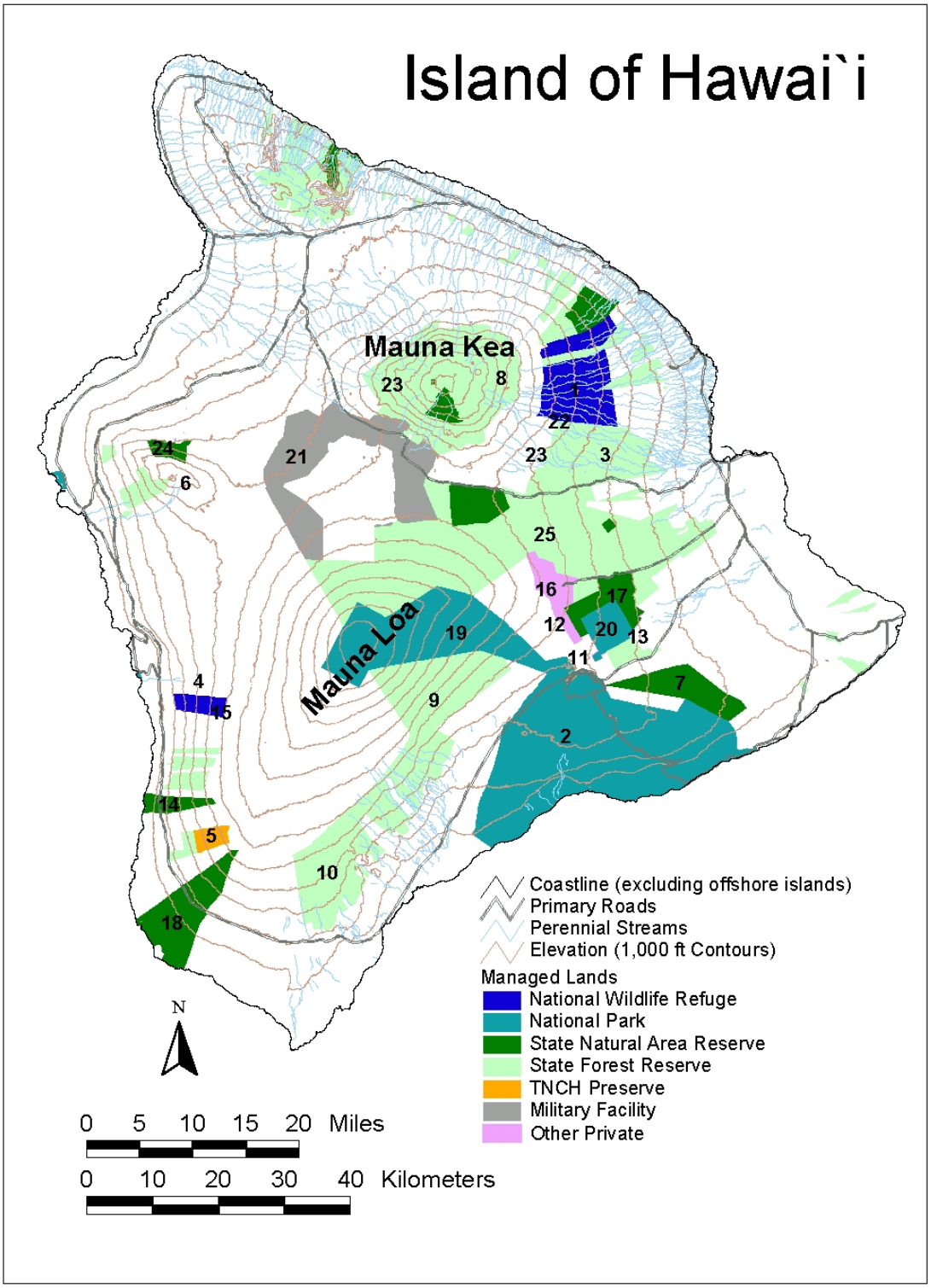

Figure 3. Locations of land parcels on the islands of Maui and Moloka`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

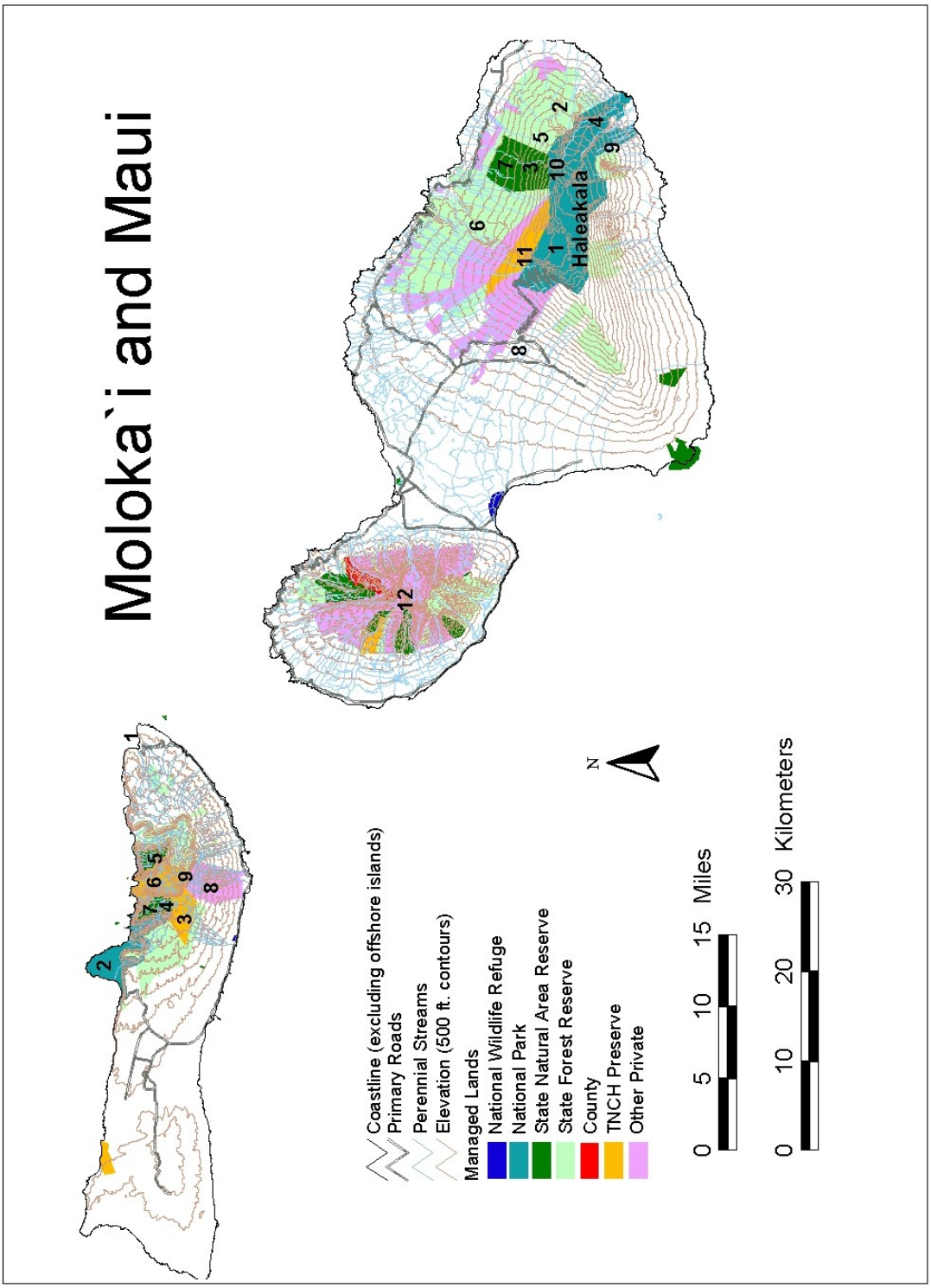

Figure 4. Locations of land parcels on the island of O`ahu that are referred to in this recovery plan (see Gazetteer of place names in Table 3).

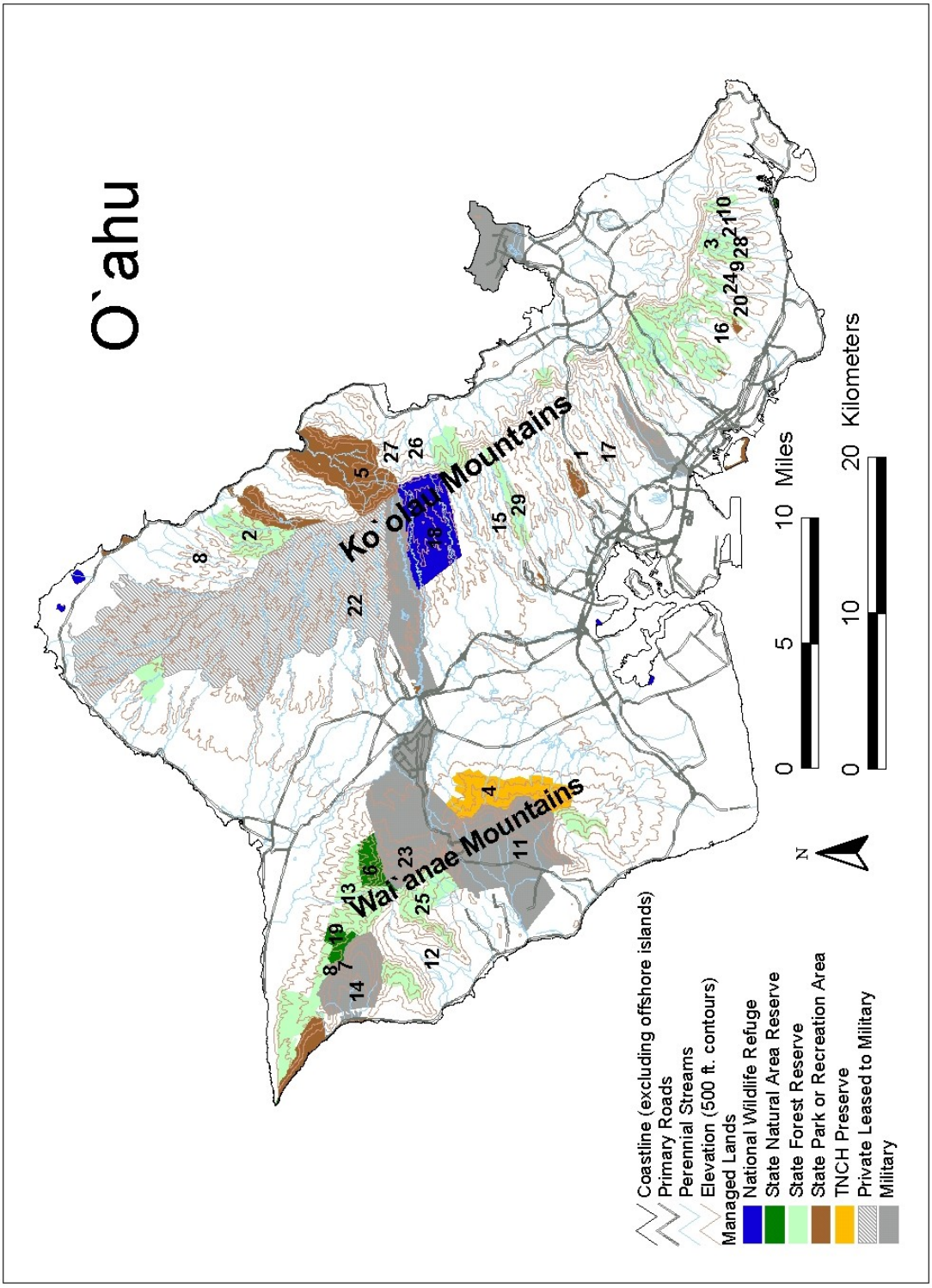
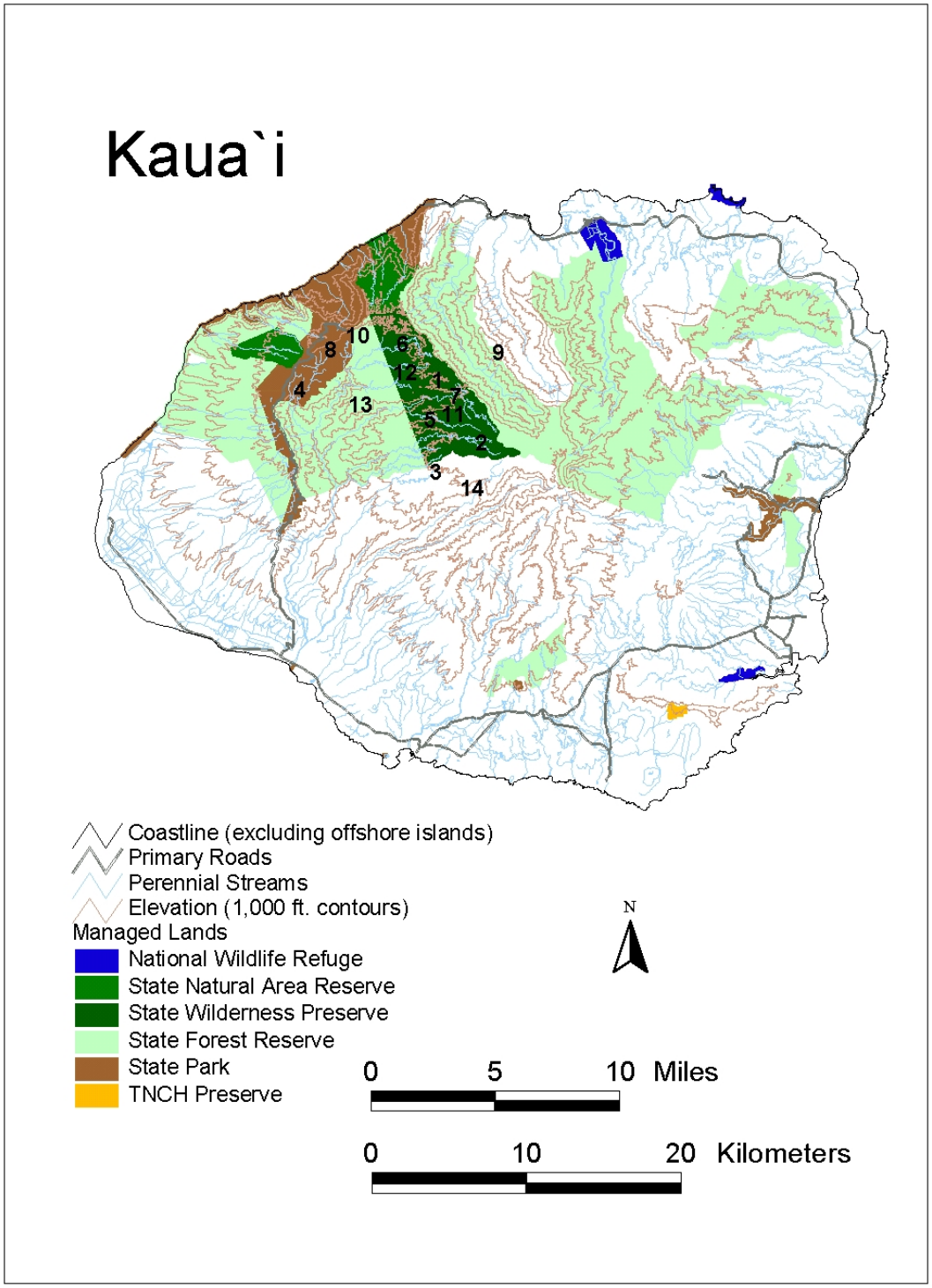
Figure 5. Locations of land parcels on the island of Kaua`i that are referred to in this recovery plan (see Gazetteer of place names in Table 3).