PUU ALII

NATURAL AREA RESERVE

MANAGEMENT PLAN

Natural Area Reserves System Program

Division of Forestry and Wildlife
Department of Land & Natural Resources
State of Hawaii

October 1991

Contents
Puu Alii Natural Area Reserve

EXECUTIVE SUMMARY

This plan describes the management program for the Puu Alii Natural Area Reserve. The 1330-acre reserve, which was established in 1985 by Executive Order 3302, is located in a remote portion of northern Molokai. It is situated on the east Molokai volcanic shield and is surrounded by steep valley walls which drop vertically from all but the south boundary.

The reserve protects five types of wet montane shrublands and forests which provide habitat to native plants, birds, and invertebrates, several of which are considered rare. The reserve's communities make up an important part of Molokai's watershed. The upper half of the reserve contains the most intact communities.

Management efforts will focus on reducing ungulate damage. Pig damage was found throughout the reserve and goats are moving up from the coastal ridges and neighboring Waikolu Valley. Two fencelines have already been constructed to enclose the upper half of the reserve. Ungulate removal will consist of snaring and aerial hunting along the inaccessible slopes and ridges.

Other management programs include: 1) nonnative plant control to limit the spread and where possible eradicate nonnative plant infestations; 2) monitoring to determine the effectiveness of nonnative animal and plant control programs; 3) education and volunteer support to build public understanding and support for the reserve and the Natural Area Reserves System; and 4) access improvement to facilitate management, and educational and volunteer opportunities.

Most of the lands surrounding the reserve are either Forest Reserve or preserves managed by The Nature Conservancy of Hawaii (TNCH). The Kalaupapa National Historical Park has entered into an agreement with the state for cooperative management of the lands within the Puu Alii reserve and the adjacent Forest Reserve. Control of nonnative plants and animals in adjacent areas will help slow their influx into the Puu Alii reserve. Compatible management projects should be coordinated with Kalaupapa National Historical Park and The Nature Conservancy.

For reasons discussed in the Ungulate Control program, public hunting should not be allowed in the reserve. The planned boardwalk trail will facilitate public access through TNCH's Kamakou Preserve up to the edge of Puu Alii reserve. Public access into Puu Alii reserve beyond the boardwalk should not be encouraged due to the rugged terrain and potential adverse impacts of increased human presence, such as nonnative plant introduction. Enforcement needs in this remote reserve should be minimal.

The management programs discussed form an integrated strategy to protect the natural area resources of the reserve. A six year implementation schedule is proposed. Expensive projects such as fence and boardwalk construction during the first three years account for the high average yearly budget. Beginning with year 5, the average yearly budget should be reduced to approximately $27,000.

PUU ALII NATURAL AREA RESERVE MANAGEMENT PLAN

I. INTRODUCTION

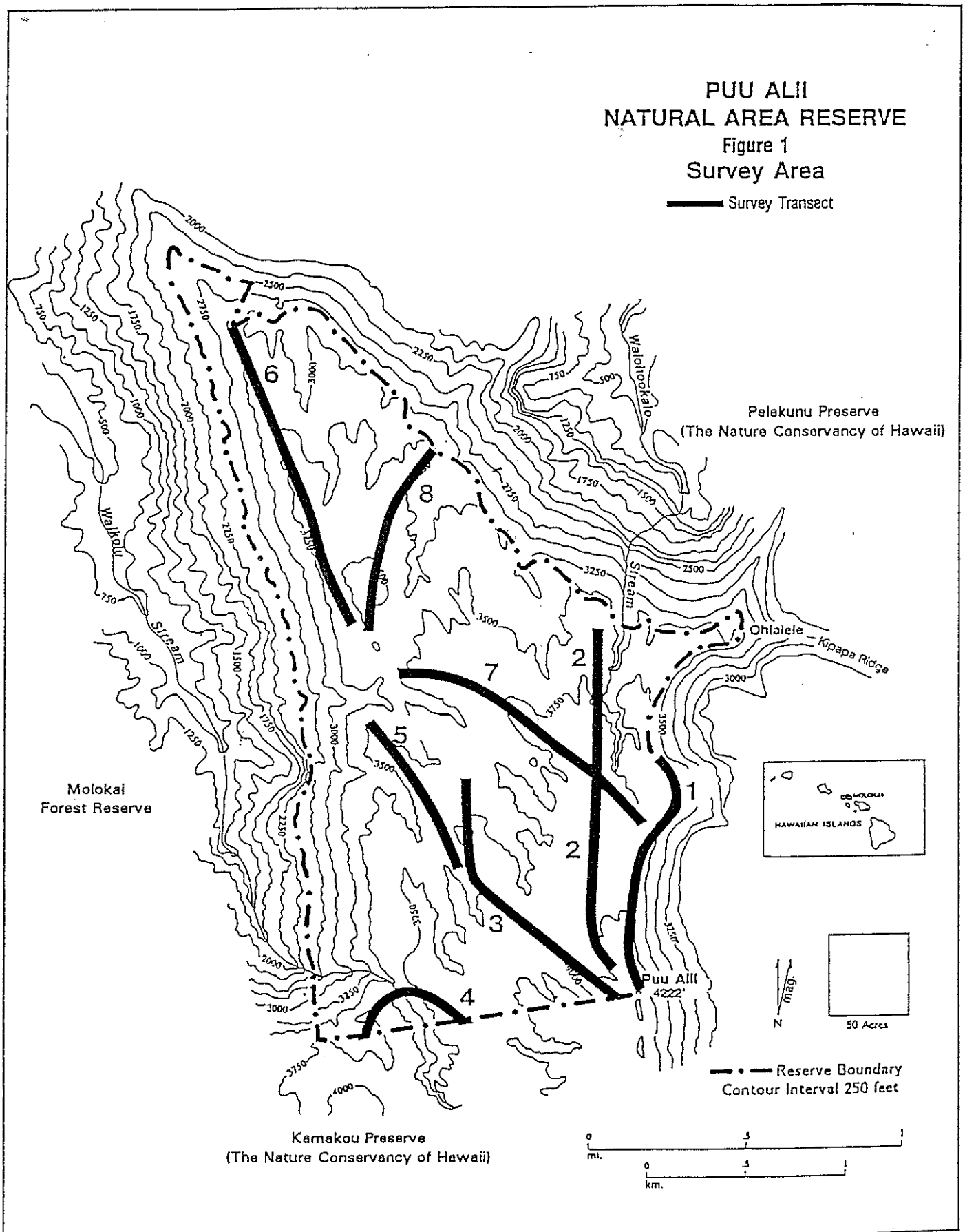
In 1970, Hawaii became one of the first states in the country to recognize the importance of its unique natural resources by establishing the State Natural Area Reserves System (NARS). The NARS was established to "preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawaii" (HRS Section 195-1). To date, there are 19 reserves on 5 islands, occupying more than 109,000 acres of the state's most biologically diverse ecosystems.

This plan describes the management program for the Puu Alii Natural Area Reserve on Molokai. The reserve, which was established in 1985 by Executive Order 3302, protects five types of wet montane shrublands and forests. These communities provide habitat to native plants, birds, and invertebrates, several of which are considered rare. Also, the reserve's communities are part of an important watershed, supplying water to Waikolu Ditch which is diverted for agricultural use. This plan consists of the following:

- a **Resources Summary** describing the reserve's natural resources;
- a **Management** plan describing programs recommended to maintain the reserve's resources with an analysis of alternative actions and impacts;
- a **Budget Summary** indicating the funds necessary to carry out the management plan; and
- **Appendices** with more detailed resource information

Three major sources of information were used to prepare this plan. The first was The Nature Conservancy's Hawaii Heritage database on rare species and unique natural communities. The second was a January 1989 field inventory, specifically designed to collect data relevant to the management of the reserve's natural resources. The third was a review of this plan by managers, planners, and biologists familiar with the area and its management needs.

Survey crews spent 9 field days gathering data along 8 transects, ranging from 2,950 - 5,400 feet in length (Figure 1). Transects were planned to sample the variety of natural vegetation types in the area (Appendix 1) as described by Jacobi (1985). Detailed field forms were completed at sampling


PUU ALII
NATURAL AREA RESERVE
Figure 1
Survey Area
Survey Transect
Pelekunu Preserve
(The Nature Conservancy of Hawaii)
Molokai
Forest Reserve
Kamakou Preserve
(The Nature Conservancy of Hawaii)
Waiolilookalo
Stream
Walkolu
Stream
Ohialele
Kipapa Ridge
Puu Alii
4222'
HAWAIIAN ISLANDS
MOLOKAI
mag.
N
50 Acres
Reserve Boundary
Contour Interval 250 feet
mi.
km.

stations every 165 feet, noting the type of natural community, and the presence of rare plants, native birds, feral ungulates, and nonnative plants (Appendix 2).

The survey was designed to gather management-oriented resource information over a large area in a short time period. It was not intended to be a comprehensive biological inventory. Sampling of small mammals, birds, and invertebrates was incidental rather than systematic. Detailed survey methods are available upon request (NARS 1988). A list of vascular plant species known from the reserve is in Appendix 3; a list of bird species is in Appendix 4.

This plan is intended to establish long-range goals and describe specific programs and activities to be accomplished during the next 6 years. The plan will be updated biannually to incorporate new knowledge and refine management concepts.

II. RESOURCES SUMMARY

A. General Setting

The Puu Alii Natural Area Reserve occupies 1,330 acres in the Kalawao District on the island of Molokai. The reserve is on the stream-dissected east Molokai volcanic shield and is surrounded by steep valley walls that drop vertically from all but the south boundary. Elevations range from 2,250 to 4,222 feet at the summit of Puu Alii. The state owns lands along the western boundary which are designated as Forest Reserve. The Nature Conservancy of Hawaii's Pelekunu and Kamakou preserves border the reserve's eastern and southern boundaries, respectively (Figure 1).

No roads approach or cross the reserve. Jeep roads provide access to The Nature Conservancy's Kamakou Preserve which contains foot trails leading to Puu Alii.

Rainfall averages below 70 inches annually in the lower elevations, increasing to 120 inches in the upper elevations. March is generally the wettest month and June is usually the driest (Giambelluca, Nullet, and Schroeder 1986).

B. Flora

Five natural communities were observed in the Puu Alii Natural Area Reserve during the January 1989 survey (Table 1). Two of the three types of ʻohiʻa forest that dominate the reserve were surveyed by transect: ʻOhiʻa/ʻOlapa Montane Wet Forest and ʻOhiʻa/Mixed Shrub Montane Wet Forest (Appendix 1). ʻOhiʻa/Uluhe Montane Wet Forest (which forms patches within the ʻohiʻa/ʻolapa forest on steep slopes) and two shrubland communities that occupy the steepest slopes of the reserve were not directly surveyed,

and are described here by their typical components. The shrublands (an 'ohi'a-dominated shrubland and a mixed fern/mixed shrub cliff community) extend from the adjacent valley walls onto the reserve's western edge and eastern extension at Ohialele (Figure 2).

TABLE 1
NATURAL COMMUNITIES OF PUU ALII NATURAL AREA RESERVE

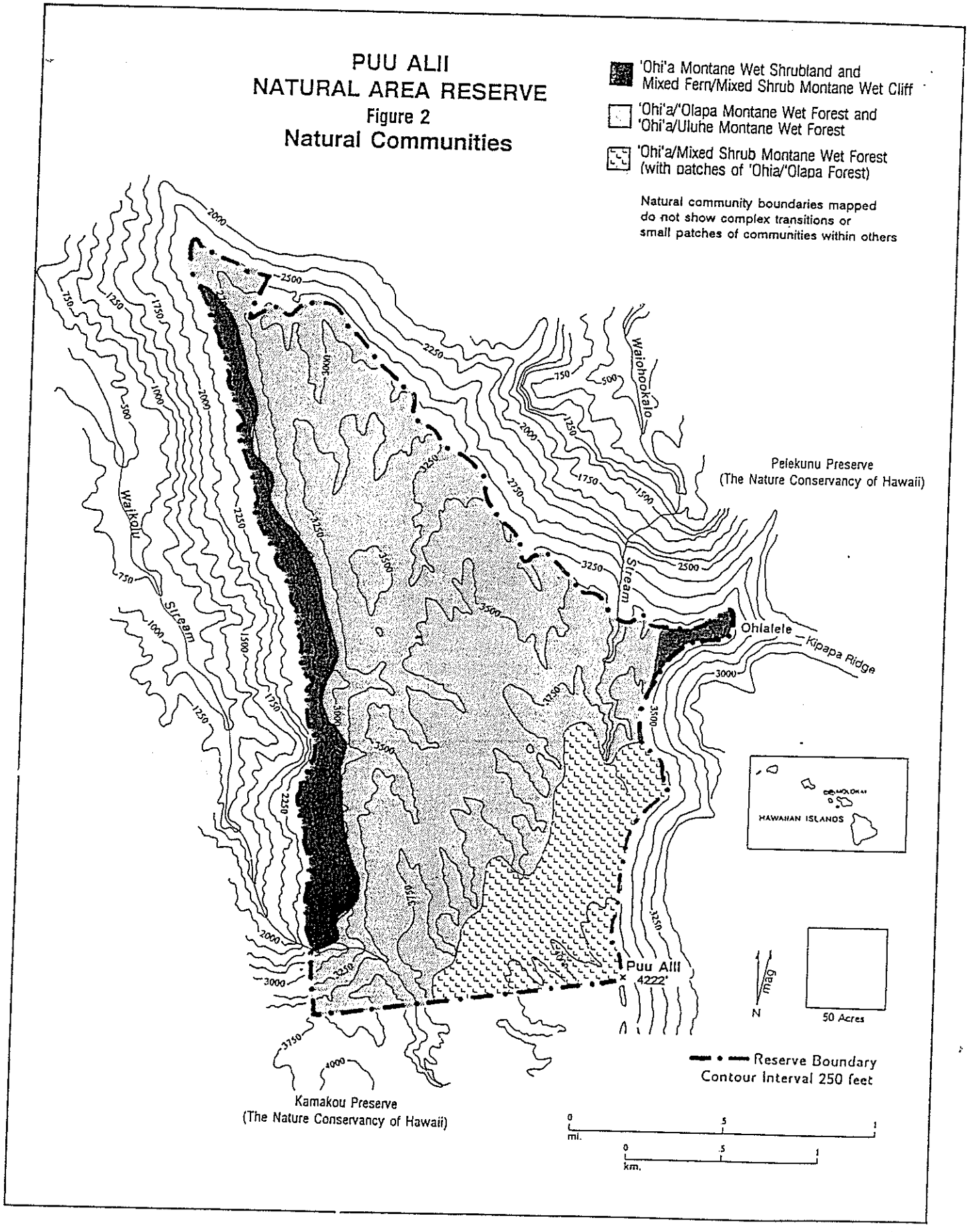
Natural Community	HHP Rank[1]	Acreage[2]
Mixed Fern/Mixed Shrub Montane Wet Cliff	3	234
'Ohi'a/Mixed Shrub Montane Wet Forest	3	238
'Ohi'a Montane Wet Shrubland	3	+
'Ohi'a/'Olapa Montane Wet Forest	3	858
'Ohi'a/Uluhe Montane Wet Forest	3	++

[1] Key to Hawaii Heritage Program rank:
3 = Restricted Range (typically more than 20 occurrences)

[2] Acreages are based on vegetation types mapped in Figure 2. Due to mapping and survey constraints, complex transitions between communities, or small patches of communities within others, are not accounted for.
+ acreage included in mixed fern/mixed shrub wet cliff
++ acreage included in 'ohi'a/ olapa wet forest

Figure 2 shows the general distribution of community types. The map does not reflect complex transitions between communities, or small patches of communities within others. A rare community known from fewer than 20 places worldwide, an 'Ohi'a Mixed Montane Bog, occurs outside the reserve's southeastern corner in the adjacent Kamakou Preserve at 4,050 feet elevation.

In the Puu Alii reserve, a wet forest dominated by 'ohi'a and 'olapa (Cheirodendron trigynum) covers a large portion of the gentle to moderately sloping terrain. 'Ohi'a/'Olapa Montane Wet Forests are generally found above 3,000 feet elevation and are known from the islands of Kauai, Oahu, Molokai, Maui, Lanai and Hawaii. It provides important habitat for rare plants and animals such as forest birds and land snails. In the reserve, 'ohi'a dominates more than 60 percent of the 'ohi'a/'olapa forest canopy. The codominant 'olapa often exceeds 25 percent cover, though rarely attains 40 percent cover. The most common


PUU ALII
NATURAL AREA RESERVE
Figure 2
Natural Communities
'Ohi'a Montane Wet Shrubland and Mixed Fern/Mixed Shrub Montane Wet Cliff
'Ohi'a/'Olapa Montane Wet Forest and 'Ohi'a/Uluhe Montane Wet Forest
'Ohi'a/Mixed Shrub Montane Wet Forest (with patches of 'Ohia/'Olapa Forest)
Natural community boundaries mapped do not show complex transitions or small patches of communities within others
Waiohookalo Stream
Pelekunu Preserve
(The Nature Conservancy of Hawaii)
Waikolu Stream
Ohialele
Kipapa Ridge
HAWAIIAN ISLANDS
Puu Alii
4222'
N
mag
50 Acres
Reserve Boundary
Contour Interval 250 feet
mi.
km.
Kamakou Preserve
(The Nature Conservancy of Hawaii)

trees in the secondary tree layer are kawa'u (Ilex anomala), kolea (Myrsine lessertiana) and kopiko (Psychotria spp.). Hapu'u ferns (mostly Cibotium chamissoi, some C. glaucum) are often prominent.

The diverse native shrub and fern layer in the understory includes shrubs such as kanawao (Broussaisia arguta), 'ohelo kau la'au (Vaccinium calycinum), pilo (Coprosma ochracea), kamakahala (Labordia hedyosmifolia), manono (Hedyotis terminalis) and saplings of 'ohi'a and 'olapa. Native ferns are well represented by ho'i'o (Athyrium sandwichianum), akolea (Athyrium microphyllum), Elaphoglossum spp., wahine noho mauna (Adenophorus spp.), 'ae (Polypodium pellucidum) and Dryopteris spp. Epiphytic filmy ferns, mosses and liverworts are abundant. Where pig damage is minimal, native herbs such as 'ala'ala wai nui (Peperomia macraeana) and pa'iniu (Astelia menziesiana) are also abundant.

In the reserve's more dissected portion below 3,500 feet elevation, within the 'Ohi'a/'Olapa Montane Wet Forest, are patches of a relatively simple wet forest dominated by 'ohi'a and the mat fern uluhe (Dicranopteris linearis, Sticherus owhyensis) or uluhe lau nui (Diplopterygium pinnatum). This community was not sampled during the 1989 survey. 'Ohi'a/Uluhe Montane Wet Forests are widespread on steep windward slopes of Kauai, Oahu, Molokai, Maui and Hawaii. This community typically forms a dense ground cover 1 - 10 feet deep. Native trees and shrubs occur scattered throughout the mat fern layer. 'Ohi'a trees are the most abundant, but other shrubs and ferns from adjacent communities may be present. The community is not considered rare.

The 'Ohi'a/Mixed Shrub Montane Wet Forest is on the flat, relatively undissected portions above 3,800 feet elevation in the southeast corner near Puu Alii. This forest type is typically found above 3,000 feet elevation on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii. Dominated by 'ohi'a without any other canopy codominants, this forest has a diverse understory of native shrubs and ferns. It provides habitat for rare forest birds, land snails, and rare plants.

Under the dense 'ohi'a canopy of the 'Ohi'a/Mixed Shrub Montane Wet Forest is a secondary layer of native trees including 'olapa, kawa'u, kolea and pilo. Just below the secondary layer is a discontinuous layer of hapu'u. The native shrub layer includes 'ohelo kau la'au, pu'ahanui, manono, alani (Pelea clusiifolia), na'ena'e (Dubautia laxa), kopiko (Psychotria mauiensis), and ha'iwale (Cyrtandra procera). The diversity of native ferns is very high, including wahine noho mauna, Elaphoglossum spp., Asplenium spp., 'ae, ho'i'o, akolea, 'ama'u (Sadleria pallida), and kupukupu (Nephrolepis cordifolia). Where pig damage is light, native herbs such as

pa'iniu, 'ala'alawainui, makole (Nertera granadensis), pamakani (Viola chamissoniana ssp. robusta) and orchids (Liparis hawaiensis and Anoectochilus sandvicensis) are plentiful.

Two wet shrub communities extend into the reserve from the steep slopes and cliff faces of the adjacent valleys. Because of their location, they were not sampled during the 1989 survey. The 'Ohi'a Montane Wet Shrubland is typically found on the steep windward ridges and summit crests of Kauai, Oahu, Molokai, Maui and Hawaii. It provides habitat for a variety of rare plants and animals, including birds and snails.

Occupying the steepest wind-swept cliffs of Puu Alii reserve, 'Ohi'a Montane Wet Shrubland forms a mosaic with a Mixed Fern/Mixed Shrub Montane Wet Cliff community (description follows). It is a dense, wind-swept, low-statured shrubland with common associates including naenae, stunted 'olapa, 'ama'u, pilo, pukiawe, and 'uki (Machaerina angustifolia). Koli'i (Trematolobelia macrostachys) is frequently observed in this shrubland.

Mixed Fern/Mixed Shrub Montane Wet Cliffs are typically found on steep valley walls and cliff faces of Kauai, Oahu, Molokai, Maui and the Kohala Mountains of Hawaii. It was not sampled during the 1989 survey, but this community is known to be dominated by a variable association of native ferns and shrubs, and forms a mosaic with 'ohi'a shrublands on steeper cliff faces in the reserve. 'Ama'u ferns (Sadleria spp.) are often major constituents in this community, as are the native mat-forming ferns, uluhe and uluhe lau nui. 'Ape'ape (Gunnera petaloidea), conspicuous because of its enormous round leaves, is occassionally codominant.

A total of 34 rare plant taxa have been reported from the Puu Alii reserve and surrounding area (Appendix 3). For the purposes of this plan, a species is considered rare and imperilled if it is known from 20 or fewer locations worldwide, or fewer than 3,000 individuals. As a result of changes in plant taxonomy, some taxa currently listed by the U.S. Fish and Wildlife Service as candidate species in the 1985 Federal Register may no longer be considered rare by the Hawaii Heritage Program, and their federal status is being reevaluated (Herbst pers. com.). Because many native plants lack unique Hawaiian or common names, scientific names are used throughout this section. Hawaiian names, where available, are provided in Table 2.

Of the 34 rare taxa known from the reserve and surrounding area, 10 have been confirmed within the reserve boundaries, 3 of which were observed during the field survey (Table 2, Figure 3). The 24 taxa known from adjacent areas may be found within the reserve in future surveys. Of the adjacent taxa, seven have been reported recently (since 1972): Adenophorus periens,

TABLE 2
RARE PLANTS OF PUU ALII NATURAL AREA RESERVE

Scientific Name[1] Former Name[2] (Common Name)	Current (Historic) Occurrences[3]	Federal Status[4]	HHP Rank[5]
Cyanea profuga (`oha, haha, `ohawai)	0(1)	-	H
*Cyanea solenocalyx (`oha, haha, `ohawai)	3(0)	C1	?
*Cyrtandra biserrata (ha`iwale, kanawao ke`oke`o)	1(0)	C2	2
Eurya sandwicensis Eurya sandwicensis var. grandifolia (alani)	0(1)	- C1	2
Hesperomannia arborescens (-)	0(1)	C1	1
*Lobelia hypoleuca L. hypoleuca var. rockii (`oha, haha, `ohawai)	2(0)	- C2	1
Lysimachia maxima (-)	0(1)	-	1
Phyllostegia mannii (-)	0(1)	-	1
Schiedea pubescens var. pubescens (-)	0(1)	C2	2
Stenogyne bifida (-)	0(1)	-	1

* Observed during 1988 survey.

[1] Wagner et al. (in press), except Lysimachia ternifolia, described by St. John (1987).

[2] Following taxonomy used in 1985 Federal Register

[3] Current occurrences reported since 1972

[4] Key to Federal Status (USFWS 1985):
C1 Candidate for endangered or threatened status
C2 Candidate for endangered or threatened status, information lacking
- No federal status. Described as rare by Hawaiian botanists and confirmed by Heritage data

[5] Key to Hawaii Heritage Program Ranks:
1 Critically imperilled globally (typically 1-5 occurrences)
2 Imperilled globally (typically 6-20 occurrences)
H Historically known; no observations since 1972 throughout its range
? No more than 100 occurrences globally; rank not yet determined by HHP

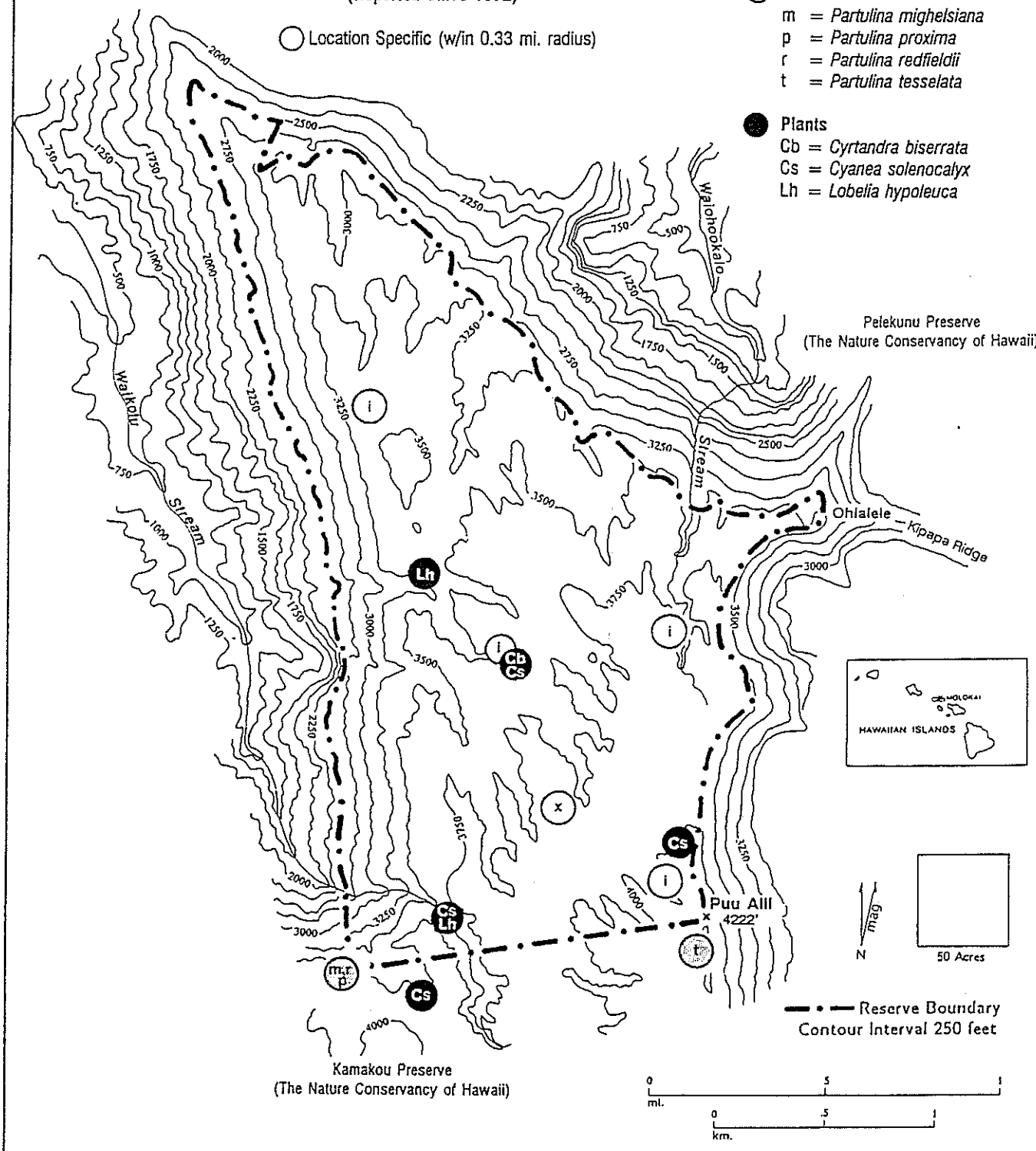
PUU ALII
NATURAL AREA RESERVE
Figure 3
Rare Plants and Animals
(Reported Since 1972)

◯ Location Specific (w/in 0.33 mi. radius)

◯ **Birds**
- i = 'I'iwi (*Vestiaria coccinea*)
- x = Molokai thrush (*Myadestes lanaiensis rutha*)

Snails
- m = *Partulina mighelsiana*
- p = *Partulina proxima*
- r = *Partulina redfieldii*
- t = *Partulina tesselata*

Plants
- Cb = *Cyrtandra biserrata*
- Cs = *Cyanea solenocalyx*
- Lh = *Lobelia hypoleuca*



Cyrtandra halawensis, C. macrocalyx, Joinvillea ascendens ssp. ascendens, Platanthera holochila, Schiedea diffusa and Zanthoxylum hawaiiense. The 17 remaining taxa known from the adjacent area were, for the most part, reported prior to the 1920s, but may be found in further surveys. Six other taxa, Gardenia remyi, Hedyotis mannii, Hibiscus kokio ssp. kokio, Huperzia sulcinervia, Lagenifera maviensis, and Lobelia dunbarii ssp. dunbarii have been reported for the general area, but not enough information is available to confidently depict them as in or adjacent to the reserve.

Three of the ten rare plant taxa reported within the reserve were observed during the survey. All populations of these three taxa were observed in 'Ohi'a/'Olapa Montane Wet Forest. Several fruiting plants of Lobelia hypoleuca were seen in the westcentral part of the reserve along a side branch of Waikolu Stream, above a large waterfall. Lobelia is a shrubby plant with blue flowers, and is found in mesic and wet forests throughout the main islands.

Cyrtandra biserrata and Cyanea solenocalyx were observed along another side branch of Waikolu Stream southeast of the Lobelia at a higher elevation, near a small waterfall. The one sterile shrub seen here is the only reported occurrence of Cyrtandra biserrata in the reserve and surrounding area. This species of Cyrtandra is known only from the wet forests of eastern Molokai (Wagner et al. 1990) The six Cyanea plants seen had large purple and white flowers. Cyanea solenocalyx is known only from the wet forests of eastern Molokai (Wagner et al. 1990).

South of the Cyrtandra and Cyanea, several more Lobelia hypoleuca were observed during the survey along a stream bank at the head of Waikolu Valley. These Lobelia were flowering. A sterile Cyanea solenocalyx was seen at the same site.

Cyanea solenocalyx was also observed on the rim of Pelekunu Valley north of Puu Alii along the reserve's eastern boundary. A scattered population of approximately eight plants was seen, some of which were flowering and fruiting.

C. Fauna

Birds make up the native terrestrial vertebrate fauna on Molokai. Of the seven endemic birds known from Puu Alii reserve, two are listed endangered by the U.S. Fish and Wildlife Service and one is considered endangered by the State of Hawaii. Two rare seabirds have been reported from the area, though the reserve's importance to these birds is unknown. In addition to the endemic birds reported from the reserve, one rare migrant raptor and ten nonnative birds have been reported (Appendix 4). Nonnative animals include pigs, goats, birds, and a few

invertebrates. Native invertebrate fauna in the reserve is very diverse, and includes beautiful land snails.

Of the six native forest and upland bird species known from the Puu Alii area, Molokai creeper, or kakawahie (Paroreomyza flammea), Molokai thrush or oloma'o (Myadestes lanaiensis rutha), and 'i'iwi (Vestiaria coccinea) are considered endangered (Figure 3, Table 3).

TABLE 3
RARE BIRDS OF PUU ALII NATURAL AREA RESERVE

Scientific Name (Common Name)	Population Estimate (Molokai)[1]	Federal/State Status[2]	HHP Rank[3]
Myadestes lanaiensis rutha (Molokai thrush or oloma'o)	19 ± 38	LE	1
Paroreomyza flammea (kakawahie, Molokai creeper)	(poss extinct)	LE	H
Vestiaria coccinea ('i'iwi)	80 ± 65	E	1

[1] Birds/km^2 with a 95% confidence interval (Scott et al. 1986)

[2] Key to Federal/State Status:
LE Endangered (USFWS 1989)
E Molokai population considered endangered by the State of Hawaii only (DLNR 1986)

[3] Key to Hawaii Heritage Program Ranks:
1 Critically imperilled globally (typically 1-5 occurrences)
H Historically known; no observations since 1972 throughout its range

Kakawahie is federally listed endangered (USFWS 1989), and was last recorded near Ohialele on the reserve's eastern boundary in 1963. Kakawahie was also seen at two other locations in the vicinity of Puu Alii and Kamakou Preserve in 1961 and 1962. It is possible that kakawahie is now extinct (Scott et al. 1986).

The oloma'o is also federally listed endangered (USFWS 1989). The small remnant population appears to have a low probability of long-term survival (Scott et al. 1986). It has been reported only along the Pelekunu Valley rim from Ohialele south and beyond Puu Alii, and the Olokui Natural Area Reserve east of Puu Alii reserve. It was last reported from the reserve

in 1979 during the U.S. Fish and Wildlife Forest Bird Survey in the south-central part of the reserve. Previous to this sighting, oloma'o was recorded in 1907 just south of Puu Alii and in Pelekunu.

'I'iwi is considered endangered by the State of Hawaii for Molokai, Oahu, and Lanai, but is a common species on Maui, Kauai, and Hawaii (DOFAW n.d.). The U.S. Fish and Wildlife Service 1979-80 Forest Bird Survey of Molokai found a relict distribution in the Olokui Natural Area Reserve and the Kamakou Preserve. 'I'iwi was last reported in the reserve near the southeast corner in May 1988 during the Molokai Forest Bird Survey (DOFAW 1988). It was also observed during the 1979 U.S. Fish and Wildlife Forest Bird Survey in the central and north-central part of the reserve.

Three more common, endemic bird species known from the reserve include the Hawaiian owl or pueo (Asio flammeus sandwichensis), 'apapane (Himatione sanguinea sanguinea) and 'amakihi (Hemignathus virens wilsoni). The pueo is common on Molokai and has been observed in adjacent Kamakou Preserve, but was not seen on the survey. 'Apapane was commonly heard and 'amakihi was heard less frequently during the January 1989 survey.

Three other rare birds have been reported from the reserve area, but the importance of Puu Alii's habitats to these birds is not known. In recent years two endemic seabirds, the threatened 'A'o or Newell shearwater (Puffinus newelli) and the endangered 'ua'u or Hawaiian dark-rumped petrel (Pterodroma phaeopygia sandwichensis) have been heard calling on east Molokai (USFWS n.d.). Historically they have been found on cliffs in Molokai valleys (Banko 1980a, 1980b). It is not known whether nesting occurs or if significant habitat exists in Puu Alii reserve for either species. Burrows are usually found in rugged terrain in forested areas and are very difficult to locate.

The third rare bird, which is listed as endangered by the U.S. Fish and Wildlife Service (1989), is an occasional to frequent migrant to Hawaii. During the survey, a single peregrine falcon (Falco peregrinus) was seen from the edge of Pelekunu Valley in pursuit of an 'amakihi.

Nonnative forest birds commonly heard during the January 1989 survey include Japanese white-eye (Zosterops japonicus), red-billed leiothrix (Leiothrix lutea) and Japanese bush-warbler (Cettia diphone).

Nonnative mammals in the reserve include feral pigs (Sus scrofa) and goats (Capra hircus). There are areas where little or no evidence of pig damage was seen during the survey. In

general, the effect of pigs increases at lower elevations, with moderate to heavy damage below 3,500 feet. Goats are present adjacent to the reserve in both Pelekunu and Waikolu valleys. Goat dropping and plants damaged by goats were seen during the survey on ridges leading to the edges of these valleys. Although goats have not yet extended far into the plateau portion of the reserve, they may slowly degrade the forests from the seaward portions upward if left unchecked. Management of these ungulates is discussed in the Ungulate Control section of this plan.

It is likely that rats (Rattus spp.) and mongooses (Herpestes auropunctatus) are present in the forest portion of the reserve, though no evidence of these introduced mammals was seen during the survey.

Native invertebrates incidentally sighted during the survey included crickets, drosophilid flies, Hawaiian happyface spiders, tornatellinid snails, and succinid snails. Since the native forests and shrublands are relatively intact, it is probable that additional invertebrate taxa will be discovered with more extensive survey work.

Four species of achatinellid land snails have been reported from the Puu Alii reserve area in recent years (Table 4). Partulina tessellata, P. redfieldii, P. proxima, and P. mighelsiana were found on or near the southern boundary of the reserve in adjacent Kamakou Preserve in 1988 (Figure 3). Because habitats of Kamakou Preserve and Puu Alii reserve are similar, it is highly probable that all four species occur in the reserve. Malacologists believe virtually all Hawaiian land snails are rare and in danger of extinction.

Nonnative invertebrates are more noticeable in the lowest elevations, where there are enough pigs and goats to support the nonnative flies often associated with feral animals. During the 1989 survey of the reserve, none of the problem species such as ants, yellowjackets (Vespula), or cannibal snails (Euglandina rosea) were noted in the forested areas, though unidentified slugs were seen.

TABLE 4
RARE SNAILS OF PUU ALII NATURAL AREA RESERVE

Scientific Name	Current Occurrences in Reserve[1]	HHP Rank[2]
Partulina mighelsiana	2	1
Partulina proxima	1	1
Partulina redfieldii	2	1
Partulina tessellata	2	1

[1] Current occurrences reported since 1972

[2] Key to Hawaii Heritage Program Ranks:
1 Critically imperilled globally (typically 1-5 occurrences)

III. MANAGEMENT

A. Key Management Considerations

The overall management goal is to protect and maintain the reserve's native ecosystems. The following key points were considered in the development of management programs to achieve this goal:

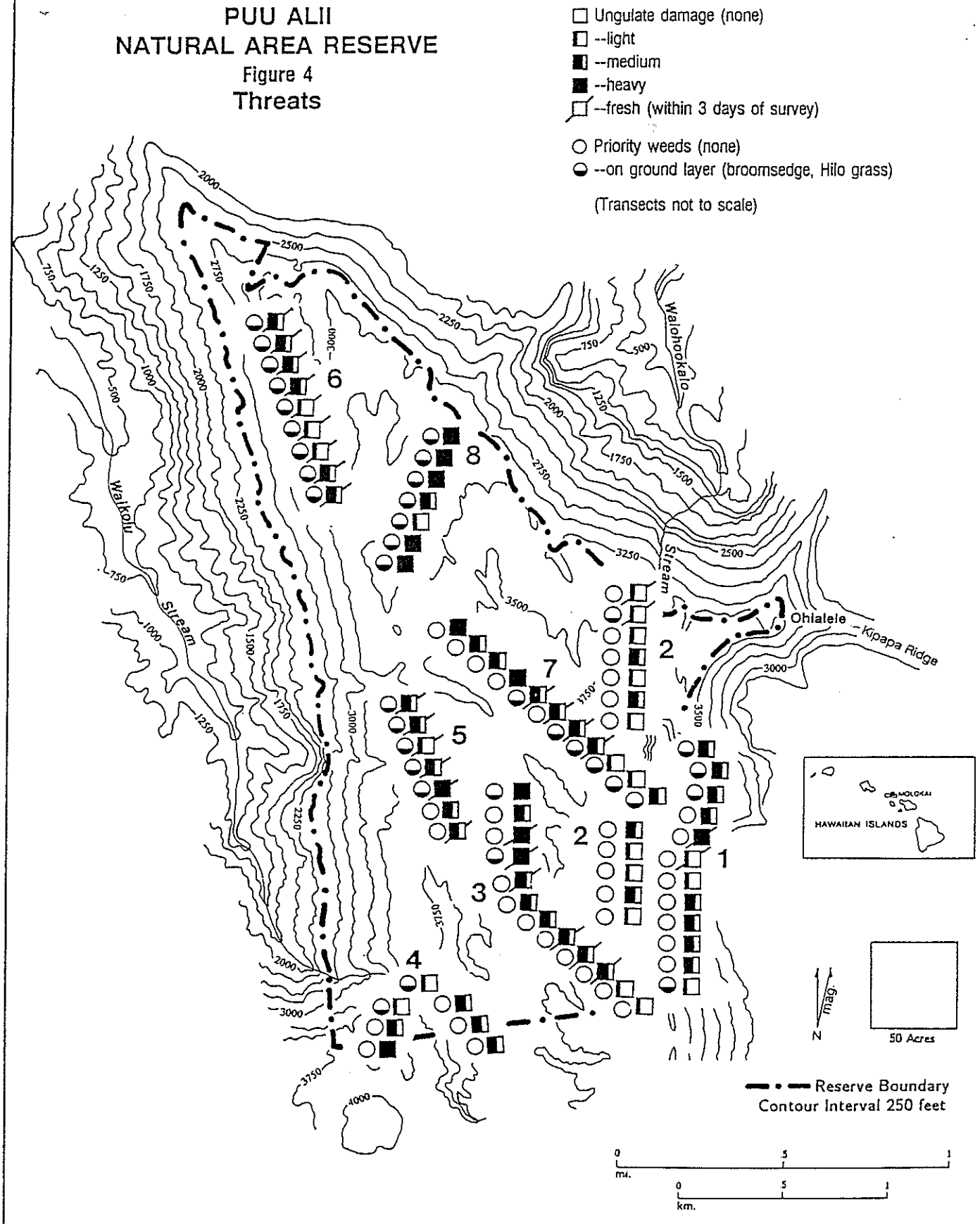
1) Feral pigs and goats constitute a severe threat to the reserve's native vegetation (Figure 4). The foraging activities of feral animals destroy native plants, disperse nonnative plant seeds, and create openings in the native ground cover. These openings allow soil erosion and facilitate the establishment of nonnative plants. Ungulate control is critical to the preservation of native ecosystems. It is the top management priority for the reserve.

2) Nonnative plants threaten the integrity of the reserve's natural communities by competing with native plants for space, light, and nutrients. They also facilitate the invasion of nonnative insects and birds. Control of invasive weed species will be necessary to preserve the integrity of the natural communities.

PUU ALII
NATURAL AREA RESERVE

Figure 4

Threats



B. Management Unit Descriptions

The reserve has been divided into two management units (Figure 5). Each unit is described with management priorities and key management programs.

1) Puu Alii Unit - This 640-acre unit encloses the higher elevation portion of the reserve. It includes the most intact and diverse forests in the reserve. Rare plants are present and there are reports of rare birds and invertebrates being in this area. Feral pig evidence is widespread; nonnative plant infestations are infrequent. Pig control is the top management priority for this unit. Fencing, snaring and aerial hunting are proposed control techniques.

2) Ohialele Unit - This 690-acre unit encloses the remaining lower portion of the reserve. It contains some relatively undisturbed portions of montane ʻohiʻa forest. The forest communities are much less diverse and considerably more disturbed than those in the Puu Alii unit. Weeds are becoming established in openings created by feral pigs. Goats are also present on the surrounding slopes and ridges and there was some evidence of their presence in the lower elevations of this unit. Ungulate control is also the top management priority for this unit. Snaring and aerial hunting are proposed control techniques.

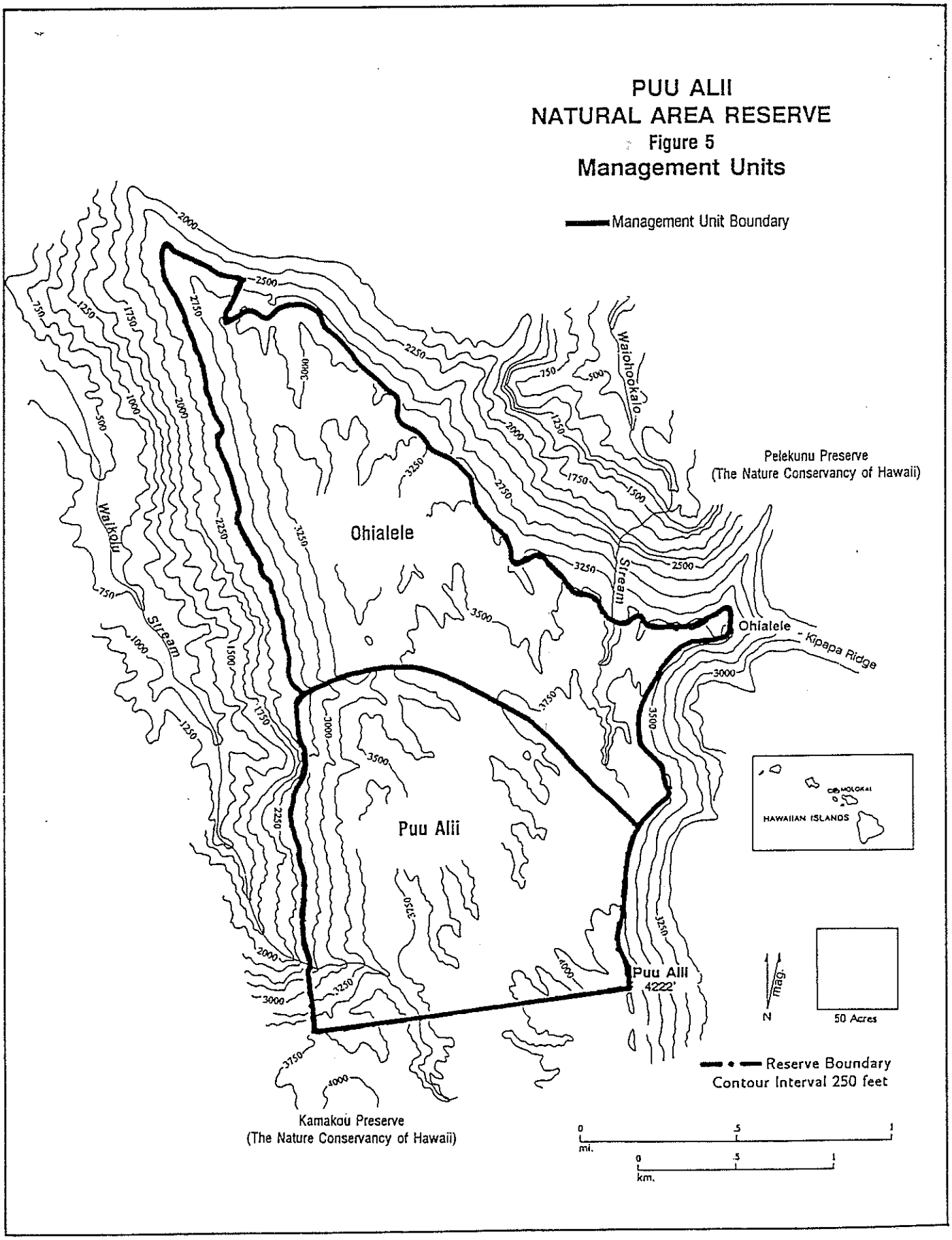
C. Management Programs

Five management programs are discussed below. Goals, problems, alternative and recommended actions, and cost estimates are discussed for each. A six-year implementation schedule is proposed.

UNGULATE CONTROL

GOAL: Eliminate ungulates in the upper Puu Alii management unit. In the Ohialele management unit, reduce the impact of ungulates to a level that prevents further degradation of the native ecosystems and allows the greatest possible recovery of the native species.

Statement of the Problem: Feral pigs and goats are the most serious concern in the Puu Alii Natural Area Reserve. Pigs are abundant in the lower Ohialele unit and goats are coming up from the coastal ridges and Waikolu Valley. Deer may soon be an additional problem as they are present in Waikolu and Pelekunu Valleys. The communities in the Puu Alii unit are still mostly intact, but there is widespread evidence of feral pig presence.


PUU ALII
NATURAL AREA RESERVE
Figure 5
Management Units
Management Unit Boundary
Pelekunu Preserve
(The Nature Conservancy of Hawaii)
Ohialele
Puu Alii
Puu Alii
4222'
Ohialele - Kipapa Ridge
Waiohookalo Stream
Waikolu Stream
Kamakou Preserve
(The Nature Conservancy of Hawaii)
MOLOKAI
HAWAIIAN ISLANDS
mag.
N
50 Acres
Reserve Boundary
Contour Interval 250 feet
mi.
km.

Alternative Actions and Probable Impacts:

1) Attempt to control ungulates using public hunting pressure. Implementation of this alternative is not recommended for the following reasons:

a) The area is extremely remote and hunters do not frequent the area in substantial numbers.

b) Ungulates inhabit and probably move into the reserve via the sheer sea cliffs and steep upper slopes surrounding the reserve where access is limited and hunting success is likely to be marginal.

c) The primary access into Puu Alii is through portions of The Nature Conservancy of Hawaii's (TNCH) Kamakou preserve which have been closed to public hunting due to low hunter visitation; snaring and other ungulate control methods are now being undertaken. Allowing hunter passage through these areas would present safety and enforcement problems.

2) Conduct an ungulate removal program using snaring in the accessible portions of the reserve and aerial hunting along the steep slopes and ridges. These actions should substantially reduce ungulate populations in the reserve.

3) Control ungulates with the aid of fences. Fencing will prevent the movement of ungulates into certain areas and direct predictable pig movements within intensive control areas.

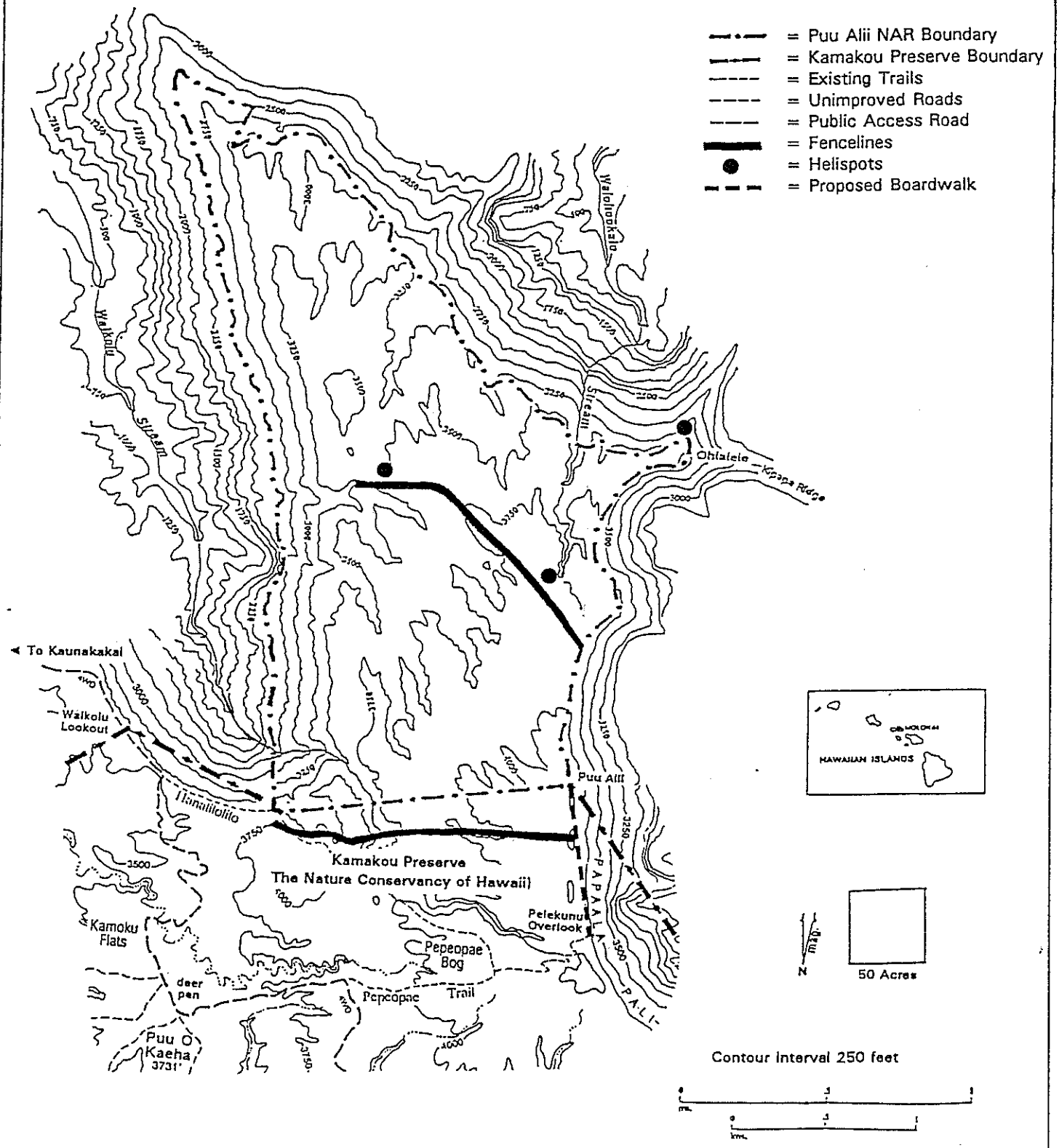
Recommended Action: Alternatives no. 2 and 3 are recommended. A combination of fencing, snaring and aerial hunting are proposed to control ungulate populations in the reserve. Three projects: fence construction, fence inspection and maintenance, and ungulate removal are described below.

Project 1 - Fence construction. Fence construction has already been completed. Two fencelines and the natural topographic barriers along the eastern and western boundaries enclose the Puu Alii management unit. One fenceline bisects the reserve separating the two management units and the other is situated just outside of the mauka boundary of the reserve within The Nature Conservancy's Kamakou Preserve (Figure 6).

Fencing to enclose the Ohialele management unit is not recommended at this time due to the extreme topography and numerous stream crossings.

The fences consist of 47 inch high galvanized woven-wire supplemented along the ground surface by one strand of barbwire stretched tightly across the ground. Wovenwire and barbwire are

PUU ALII
NATURAL AREA RESERVE
Figure 6
Fences, Trails, Helispots



secured to steel posts placed no more than 10 feet apart. Concreted galvanized pipes secure the fenceline at certain corners.

Fenceline locations were carefully cleared to minimize disturbance to existing vegetation. A botanist walked the flagged fence route to search for rare plants to be avoided during the clearing of the fenceline. Strict sanitary procedures were followed to prevent introduction of weeds by field personnel on their boots, clothing, and equipment.

Cost/Workload Estimate: Actual fence construction expenditures are outlined below. Required personnel time is listed; however, budget figures are not given as personnel costs are separately budgeted as part of an overall infrastructure cost necessary to run a statewide NARS program.

Year 1: Construction of the mauka fenceline within the Kamakou Preserve of The Nature Conservancy of Hawaii (TNCH) (1 mi.)

Contract with TNCH	**TOTAL**	**$ 34,560**

Year 2: Construction of the midsection fenceline (1 mi.)

Personnel		
Professional 5 PD		
Technicians 110 PD		
Supplies and Support		
Helicopter charter for crew and equipment transport (6 hours at $600/hour)		$ 3,600
Fencing materials and equipment		$10,000
	TOTAL	**$13,600**

Project 2 - Fence inspection and maintenance.

Cost/Workload Estimate: The following annual workload is projected for fence inspection 6 times a year. Costs are based on a three-person crew able to inspect both fencelines in one day. Supplies for fence maintenance are estimated at $250/mile/year.

Year 2:

Personnel		
Technicians 9 PD		
Supplies and Support		
Helicopter charter for crew transport (4 hours at $600/hour)		$ 2,400
Supplies		$ 250
	TOTAL	**$ 2,650**

Years 3-6: Personnel

Technicians 18 PD	
Supplies and Support	
Helicopter charter for crew transport (4 hours at $600/hour)	$ 2,400
Supplies	$ 500
TOTAL	**$ 2,900**

Project 3 - Ungulate removal. The fencing project will be followed by aggressive snaring to take advantage of induced pig movements and to avoid pig concentration in any one area. Snaring will be conducted in the Puu Alii and Ohialele management units of the reserve; aerial hunting will be undertaken along the inaccessible slopes and ridges surrounding the reserve.

Snares will be set along well-utilized pig trails, and topographic features and fencelines that channel pig movements. Areas where snares are set will be posted to restrict public access. If pigs are found alive in the snares, they will be disposed of as humanely as possible. Snare numbers will be increased over time to continue to catch pigs as their populations are reduced.

Areas that will be hunted from aircraft have low-stature vegetation which allow good visibility and use of infrared technology. The infrared spotter is heat sensitive and is used in the early morning when the landscape is still cool. The warmth of the ungulate's body shows up on the infrared screen and the aircraft can move directly to its location and make visual contact. As ungulate populations are diminished, helicopter hunting will be reduced in frequency.

Data on health, sex and age of ungulates captured during control activities will be compiled. Monitoring for signs of ungulate damage will be an integral part of the ungulate control program (see Monitoring Program). If monitoring reveals continued or increased ungulate presence in the reserve, other ungulate control techniques such as staff ground hunting may need to be utilized.

Cost/Workload Estimate: Snaring costs are based on a three-person crew able to establish 50 snares per day or check 250 snares per day. Snares will be replaced annually and inspected five times a year. Snare densities will be approximately 100 snares for every 250 acres.

Two technicians will be needed on each aerial hunting expedition, one for spotting and one for shooting. Aerial hunting personnel is currently contracted out at a cost of $200 per trip.

Year 1:	SNARING		
	Personnel		
	Technicians 66 PD		
	Supplies and Support		
	Helicopter charter for crew transport (4 hours at $600/hour)		$ 2,400
	Snares (550 at $6/each)		$ 3,330
	Supplies (flagging, tools)		$ 500
		SUBTOTAL	$ 6,200
	AERIAL HUNTING (monthly expeditions)		
	Personnel		
	Technicians 12 PD		
	Supplies and Support		
	Helicopter charter with IR spotting equipment (24 hours at $800/hour)		$19,200
	Arms		$ 1,000
	Ammunition (3 cases at $180/case)		$ 540
		SUBTOTAL	$20,740
		TOTAL	**$26,940**
Year 2:	SNARING		
	Same as year 1	SUBTOTAL	$ 6,200
	AERIAL HUNTING (monthly expeditions)		
	Personnel		
	Technicians 12 PD		
	Supplies and Support		
	Helicopter charter with IR spotting equipment (24 hours at $800/hour)		$19,200
	Ammunition (3 cases)		$ 540
		SUBTOTAL	$19,740
		TOTAL	**$25,940**
Year 3:	SNARING		
	Same as year 1	SUBTOTAL	$ 6,200
	AERIAL HUNTING (bi-monthly expeditions)		
	Personnel		
	Technicians 6 PD		
	Supplies and Support		
	Helicopter charter with IR spotting equipment (12 hours at $800/hour)		$ 9,600
	Ammunition (2 cases)		$ 360
		SUBTOTAL	$ 9,960
		TOTAL	**$16,160**

Years 4-6:	SNARING		
	Same as year 1	SUBTOTAL	$ 6,200
	AERIAL HUNTING (quarterly expeditions)		
	Personnel		
	Technicians 4 PD		
	Supplies and Support		
	Helicopter charter with IR spotting equipment (8 hours at $800/hour)		$ 6,400
	Ammunition (1 case)		$ 180
		SUBTOTAL	$ 6,580
		TOTAL	**$12,780**

NONNATIVE PLANT CONTROL

GOAL: To limit the spread and, where possible, eradicate invasive nonnative plant infestations.

Statement of the Problem: Generally, the communities in the Ohialele management unit have a greater degree of nonnative plant infestation (Figures 2 and 4).

The 'Ohi'a/Mixed Shrub Montane Wet Forest community, which is mostly in the Puu Alii management unit, has very little nonnative plant infestation. Infrequent weeds present are broomsedge (Andropogon virginicus), bog rush (Juncus effusus), Centella asiatica, carpetgrass (Axonopus fissifolius), fireweed (Erechtites valerianifolia), hairy cat's ear (Hypochoeris radicata), Hilo grass (Paspalum conjugatum) and thimbleberry (Rubus rosifolius).

The above mentioned weeds are much more frequent in the 'Ohi'a/'Olapa Montane Wet Forest community, which extends throughout both management units. Other weeds present here include Hamakua pamakani (Ageratina adenophora), maile honohono (Ageratum conyzoides), Athyrium japonicum, horseweed (Conyza canadensis var. pusilla), tarweed (Cuphea carthagenensis), pipili (Drymaria cordata var. pacifica), white ginger (Hedychium coronarium), Hydrocotyle verticillata, Kyllinga brevifolia, Oxalix corniculata, glenwood grass (Sacciolepis indica), Thelypteris parasitica, and oriental hawksbeard (Youngia japonica).

The 'Ohi'a/Uluhe Montane Wet Forest communities have relatively few nonnative plants. The 'Ohi'a Montane Wet Shrubland and the Mixed Fern/Mixed Shrub Montane Wet Cliff communities have not been sampled for weed content.

Hilo grass and broomsedge are apparent priority weeds for management throughout the reserve (Figure 4). Others, may also

be considered to be problem weeds as monitoring provides more information on their level and rate of infestation.

Alternative Actions and Probable Impacts:

1) Attempt to control all nonnative plant species in the reserve. This alternative would require substantial resources and is not practical.

2) Control and eradicate priority weeds in the intact communities of the Puu Alii management unit before they become widely established. In the Ohialele management unit, control priority weeds as necessary to prevent their expansion in the reserve.

Recommended Action: Alternative #2 is recommended. Nonnative plant removal will be undertaken regularly during monitoring surveys, and along fencelines and trails.

The use of manual and chemical weed control methods will be determined by the type of weed, the value and accessibility of the area it is invading, and the effectiveness of the control measure. Biocontrol is an important potential tool in the management of widespread nonnative plant infestations. The Natural Area Reserves System program should support interagency biocontrol projects.

Detailed records of the effectiveness of control measures used in the reserve will be kept. Communication with the National Park Service and other agencies involved in plant control work will ensure that the best available control techniques are utilized.

Cost/Workload Estimate:

Year 1:	Personnel		
	Technicians 9 PD		
	Supplies and Support		
	Helicopter charter for crew transport (4 hours at $600/hour)		$ 2,400
	Equipment, tools and herbicide		$ 1,000
		TOTAL	**$ 3,400**

Years 2-6: Same as year 1

MONITORING

GOAL: Monitor the effectiveness of management projects and track significant ecological changes through long-term scientific monitoring.

Statement of the Problem: Management activities may not always achieve desirable results and management efficiency needs to be evaluated. Systematic scientific monitoring is necessary to accurately assess changes in the abundance and distribution of native and nonnative plants and animals. Lack of a monitoring program could result in inefficient management.

Alternative Actions and Probable Impacts:

1) Conduct ad hoc monitoring whenever possible. This is likely to be considerably less effective in the long run than a systematic approach.

2) Establish a systematic scientific monitoring program. Increase monitoring intensity for select problems and areas as needed. This alternative would provide information needed to evaluate the effects of management activities and identify future management needs.

Recommended Action: Alternative #2 is recommended. Scientific monitoring will entail recording specific data at permanent points and transects in the reserve. A minimum crew of two people will be necessary for transect surveys.

Specific goals of the program are to determine: 1) the effectiveness of hunting and snaring activities in reducing ungulate damage, 2) the success of weed control activities, 3) the presence of new nonnative plant infestations, and 4) the status of native vegetation.

Cost/Workload Estimate: Costs are based on a three person crew conducting monitoring expeditions twice a year.

Year 1:	Personnel		
	Professional	20 PD	
	Technicians	40 PD	
	Supplies and Support		
	Helicopter charter for crew transport (4 hours at $600/hour)		$ 2,400
	Supplies		$ 500
		TOTAL	**$ 2,900**

Years 2-6: Same as year 1

PUBLIC EDUCATION AND VOLUNTEER SUPPORT

GOAL: To build public understanding and support for the Puu Alii reserve and the Natural Area Reserves System program in the local community by providing educational opportunities and coordinating volunteers to assist in reserve management.

Statement of the Problem: Most residents and visitors on Molokai are unaware of the Puu Alii reserve and the unique resources it contains. The public needs to understand the existing threats and rationale behind management actions being carried out to preserve this area. Management of this reserve will be a long term effort and public support is essential.

Volunteers opportunities can be educational and provide a valuable labor source for reserve management projects. In other reserves, volunteers with different levels of interest and experience have assisted in various projects such as trail establishment and maintenance, and nonnative animal and plant control.

Recommended Action and Probable Impact: Maintain a community outreach program to give public presentations and provide informational material. A reserve brochure should be created and distributed to inform the general public about resources within the reserve and current management activities. Information could also be presented through slide shows and talks to community groups, television, newspaper, and other local media outlets. An informational sign could be posted at nearby Waikolu lookout describing the reserve, its resources and accessibility.

Volunteers should be utilized in reserve management whenever possible. Trail improvement is proposed to facilitate public and volunteer access to the southeastern corner of the reserve (See Access Improvement). Since access to Puu Alii reserve is along trails passing through The Nature Conservancy's Kamakou Preserve, educational and volunteer projects should be coordinated with TNCH.

Cost/Workload Estimate:

Years 1-2:	Personnel		
	Professional 5 PD		
	Supplies and educational materials		$ 500
		TOTAL	**$ 500**

Year 3:	Personnel		
	Professional 10 PD		
	Technician 10 PD		
	Supplies and educational materials		$ 1,000
	Brochure		$ 8,000
		TOTAL	**$ 9,000**

Years 4-6: Personnel

Professional	10 PD	
Technician	10 PD	
Supplies and educational materials		$ 1000
	TOTAL	**$ 1000**

ACCESS IMPROVEMENT

GOAL: To facilitate reserve management and educational and volunteer opportunites by improving access.

Statement of the Problem: The reserve is located in an extremely remote area. Overland access is through TNCH's Kamakou Preserve along jeep and foot trails. The Pepeopae boardwalk trail leads from one jeep trail to a ridge overlooking Pelekunu Valley. From there, an unimproved trail leads up the ridgeline to Puu Alii at the southeastern corner of the reserve. Another rugged trail extends past Puu Alii along the reserve's southeastern boundary up to Ohialele. TNCH has established one helispot near Ohialele.

Trail improvement, and strategically located helispots are needed to provide access to managers. Trail improvement to the the reserve is also needed to provide limited access to the public and volunteers for educational purposes.

Recommended Action and Probable Impact: Coordinate with TNCH to extend their Pepeopae boardwalk trail through Kamakou Preserve to Puu Alii at the southeastern corner of the reserve (Figure 6). This will allow easy overland access to the reserve for managers, volunteers, and hikers. Public access into the reserve beyond the boardwalk should not be encouraged, and the trail from Puu Alii to Ohialele should be maintained only for management purposes. Two helispots have already been established during the fence construction project.

Cost/Workload Estimate: Supplies and support cost estimates include materials, equipment, and transportation costs.

Year 2: Helispot establishment (2)

Personnel		
Technicians	6 PD	
Supplies and Support		$ 500
	TOTAL	**$ 500**

Year 3: Boardwalk trail to Puu Alii

Personnel		
Professional	9 PD	
Technicians	45 PD	
Supplies and Support		$15,000
	TOTAL	**$15,000**

Years 4-6: Boardwalk maintenance

Personnel		
Technicians 3 PD		
Supplies and Support		$ 500
	TOTAL	**$ 500**

D. Boundary Administration

Participation and cooperation among adjacent landowners is an important factor for effective management of the Puu Alii reserve. The state owns lands along the western boundary of the reserve which are designated as Forest Reserve. With the exception of two small private parcels, the remaining lands around the reserve's boundaries are part of The Nature Conservancy's Pelekunu and Kamakou preserves (Figure 1).

The Kalaupapa National Historical Park, having an interest in preserving the natural and cultural resources of the Kalaupapa area, has entered into an agreement with the state for cooperative management of the lands within the Puu Alii reserve and the adjacent Forest Reserve.

Control of feral animals and nonnative plants in these surrounding areas will help slow their influx into the Puu Alii reserve. Efforts should be made to coordinate compatible management projects with The Nature Conservancy and Kalaupapa National Historical Park.

E. Permitted Uses and Enforcement Needs

The reserve is located in an extremely remote location. Public access is limited to trails extending through TNCH's Kamakou Preserve, which itself is only accessible by jeep roads.

For reasons discussed in the Ungulate Control program, public hunting should not be allowed in the reserve. The planned boardwalk trail will facilitate public access through TNCH's Kamakou Preserve up to the edge of Puu Alii reserve. Public access into Puu Alii reserve beyond the boardwalk should not be encouraged due to the rugged terrain and potential adverse impacts of increased human presence, such as nonnative plant introduction. Enforcement needs in this remote reserve are likely to be minimal.

IV. BUDGET SUMMARY

A six year implementation schedule is presented to accomplish management goals as efficiently as possible. The management programs outlined in this plan form an integrated strategy for managing the natural area resources of the reserve. Expensive projects such as fence and boardwalk construction during the first three years account for the high average yearly

budget. Beginning in year 5, the average yearly budget should be reduced to approximately $27,000.

The budget summary below does not include the personnel, administrative, clerical, computer and other expenses that are part of the overall budget costs for a state-wide NARS program. Starting with year 3, a 5% inflation increase is incorporated into every annual total.

PUU ALII BUDGET SUMMARY

MANAGEMENT PROGRAM	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6
Ungulate Control Fencing	34,560	13,600	-	-	-	-
Fence Maintenance	-	2,650	2,900	2,900	2,900	2,900
Ungulate Removal	26,940	25,940	16,160	12,780	12,780	12,780
Nonnative Plant Control	3,400	3,400	3,400	3,400	3,400	3,400
Monitoring	2,900	2,900	2,900	2,900	2,900	2,900
Public Education	500	500	9,000	1,000	1,000	1,000
Access Improvement	-	500	15,000	500	500	500
TOTAL	68,300	49,490	51,828	25,828	27,002	28,176

PERSONNEL (PD = person days)

Year 1	
Professional	25 PD
Technician	127 PD

Year 2	
Professional	30 PD
Technician	252 PD

Year 3	
Professional	39 PD
Technician	194 PD

Year 4	
Professional	30 PD
Technician	150 PD

Year 5	
Professional	30 PD
Technician	150 PD

Year 6	
Professional	30 PD
Technician	150 PD

V. BIBLIOGRAPHY

Banko, W. E. 1980a. History of Endemic Hawaiian Birds, Part I. Population Histories-Species Accounts, Sea Birds: Hawaiian Dark-rumped Petrel (ʻUaʻu). Cooperative National Park Resources Studies Unit. University of Hawaii. Avian History Report 5B.

Banko, W. E. 1980b. History of Endemic Hawaiian Birds, Part I. Population Histories-Species Accounts, Sea Birds: Newell Shearwater (ʻAʻo). Cooperative National Park Resources Studies Unit. University of Hawaii. Avian History Report 5A.

Division of Forestry and Wildlife. No Date. Endangered and Threatened Animals and Plants of Hawaii. Department of Land and Natural Resources, State of Hawaii.

Division of Forestry and Wildlife. 1988. Preliminary Report of the Molokai Forest Bird Survey. Department of Land and Natural Resources, State of Hawaii.

Giambelluca, T. W., M. A. Nullet, and T. A. Schroeder. 1986. Rainfall Atlas of Hawaii. Water Resources Research Center/Department of Meteorology, University of Hawaii at Manoa. State of Hawaii, DLNR, Division of Water and Land Development, Report R76. Honolulu, Hawaii.

Herbst, D. V. Personal Communications, June 1988. Endangered Species Botanist, Office of Environmental Services, U.S. Fish and Wildlife Service, 300 Ala Moana Blvd., #6307, Honolulu, Hawaii 96850.

Jacobi, J. D. 1985. Vegetation Maps of the Upland Plant Communities on the Islands of Hawaii, Maui, Molokai, and Lanai. U.S. Fish and Wildlife Service. Mauna Loa Field Station, Volcano, Hawaii.

Natural Area Reserves System. 1988. Natural Area Reserves System Inventory Field Manual. Division of Forestry and Wildlife, Department of Land and Natural Resources, State of Hawaii. Honolulu, Hawaii.

Pyle, R. L. 1988. Checklist of the Birds of Hawaii--1988, in: ʻElepaio 48 (11): 95-106.

Scott, M. J., S. Mountainspring, F. L. Ramsey, and C. B. Kepler. 1986. Forest Bird Communities of the Hawaiian Islands: Their Dynamics, Ecology, and Conservation. Studies in Avian Biology No. 9, Cooper Ornithological Society. Allen Press, Lawrence, Kansas.

St. John, H. 1987. Diagnoses of Lysimachia species (Primulaceae). Hawaiian Plant Studies 159. Phytologia 64(10): 43-50.

State of Hawaii. Hawaii Revised Statutes, Chapter 195-1.

U.S. Fish and Wildlife Service. 1989. Endangered and Threatened Wildlife and Plants; Animal Notice of Review. 50 CFR Part 17, Vol. 54, No. 4. Department of the Interior. U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. 1985. Endangered and Threatened Wildlife and Plants; Review of Plant Taxa for Listing as Endangered or Threatened Species; Notice of Review. Federal Register, 50 CFR Part 17. Vol. 50, No. 188. Department of the Interior. U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. No date. U.S. Fish and Wildlife Service Incidental Sightings 1979, Miscellaneous Hawaii and Molokai.

Wagner, W. L., D. R. Herbst and S. H. Sohmer. 1990. Manual of the Flowering Plants of Hawaii. Bishop Museum Press, Honolulu, Hawaii.

APPENDIX 1
Puu Alii Natural Area Reserve
Transect Specifications

Transect number	Transect length (ft)	No. of substations	Natural communities surveyed
1	5,412	34	'Ohi'a/'Olapa Montane Wet Forest
2	5,412	34	'Ohi'a/Mixed Shrub Montane Wet Forest 'Ohi'a/'Olapa Montane Wet Forest
3	5,412	34	'Ohi'a/Mixed Shrub Montane Wet Forest 'Ohi'a/'Olapa Montane Wet Forest
4	2,952	19	'Ohi'a/'Olapa Montane Wet Forest
5	2,952	19	'Ohi'a/'Olapa Montane Wet Forest
6	4,100	26	'Ohi'a/'Olapa Montane Wet Forest
7	5,084	32	'Ohi'a/'Olapa Montane Wet Forest
8	2,952	19	'Ohi'a/Mixed Shrub Montane Wet Forest 'Ohia/'Olapa Montane Wet Forest

Survey Participants

<u>Division of Forestry & Wildlife</u>
Michael Buck, NARS Coordinator
Thane Pratt, Ornithologist
Robert Hobdy, Maui Deputy Forester

<u>The Nature Conservancy of Hawaii</u>
Lyman Abbott, Ecological Asst.
Samuel Gon III, Ecologist
Steve Perlman, Botanist/Field Coordinator

APPENDIX 2
Puu Alii Natural Area Reserve
Sample Field Forms

NATURAL COMMUNITY FIELD OBSERVATION FORM TIME START: _____ END: _____
DATE: _____ TRANSECT#: _____ STATION#: _____ ELEVATION: _____
OBSERVER(S): _____
NC NAME: _____
NAR NAME: _____ EOCODE: _____
SUBSTRATE: _____ QUAD NAME: _____
ADJ NCS: _____

DESCRIPTION LINE: _____

ASPECT	SLOPE	CANOPY CLOSURE	TOPOGRAPHIC POSITION	CANOPY STATURE	MOISTURE	NC AREA
___N	__FLAT	__DENSE	__CREST	__<1M	__INUNDATED	__<1 AC
___E	__GENTLE	__CLOSED	__UPPER SLP	__1-2.5M	__SATURATED	__1-5 AC
___S	__MOD	__OPEN	__MID SLP	__2.5-5M	__MOIST	__6-10 AC
___W	__STEEP	__SCATTER	__LOW SLP	__5-10M	__MOIST-DRY	__>10 AC
__( )	__VERT	__VERY SC	__BOTTOM	__>10M	__DRY	__( )

*COVER CLASS CODES: 1 = <1% 2 = 1-5% 3 = 5-25%
(FOR USE BELOW) . 4 = 25-50% 5 = 50-75% 6 = 75-90% 7 = >90%

A. CANOPY DOMINANTS:

SPECIES	T	S	H	*COVER	AVE DIA	REMARKS

B. SUBCANOPY DOMINANTS:

SPECIES	T	S	H	*COVER	REMARKS

% LITTER: _____ % BARE GROUND: _____ SPECIES LIST ATTACHED: Y N
THREATS: _____

PROTECTION/MANAGEMENT RECOMMENDATIONS: _____

EORANK: _____ A = EXCELLENT B = FAIR-GOOD C = POOR D = DEGRADED
EO BOUNDARIES MAPPED: Y N MAP ATTACHED: Y N PHOTO ##: _____

PLANT FIELD OBSERVATION FORM

NAR NAME: _____ QUAD NAME: _____
DATE: _____ ISLAND: _____ SITE NAME: _____
SPECIES NAME: _____
OBSERVER(S): _____
PHOTO TAKEN: ____ Y ____ N
SPECIMEN #,COLLECTOR,REPOSITORY: _____
DIRECTIONS: _____

ELEVATION: _____
GENERAL DESCRIPTION OF AREA: _____

EODATA: _____

NATURAL COMMUNITY: _____
ASSOCIATED NATIVE SPECIES: _____

ASSOCIATED WEED SPECIES: _____

THREATS: _____

PROTECTION/MANAGEMENT RECOMMENDATIONS: _____

COMMENTS: _____

ASPECT	SLOPE	LIGHT	TOPOGRAPHIC POSITION	MOISTURE	DOMINANT SPECIES	%COVE
___N	__FLAT	__DENSE	__CREST	__INUNDATED		
___E	__GENTLE	__CLOSED	__UPPER SLP	__SATURATED		
___S	__MOD	__OPEN	__MID SLP	__MOIST		
___W	__STEEP	__SCATTER	__LOW SLP	__DRY-MESIC		
__( )	__VERT	__VERY SC	__BOTTOM	__DRY		

HABIT	PHENOLOGY	AGE STRUCTURE	VIGOR	FREQUENCY	POPULATION SIZE	POPULATIO AREA (M²
__TREE	__IN LEAF	__%SDLGS	__DYING	__COMMON	__ACTUAL	__1
__SHRUB	__IN BUD	__%IMM	__FEEBLE	__OCCAS	__1-10	__1-5
__HERB	__IN FLOWER	__%MAT	__NORMAL	__RARE	__10-50	__5-10
__VINE	__IMM FRUIT	__%SENESC	__VIGOROUS	__SOL	__50-100	__10-100
__PROST	__MAT FRUIT				__100-1000	__100+
	__DORMANT				__1000+	

TRANSECT STATION FIELD FORM Time Start: _____ End: _____ Date: _____
NC Name: _____ NAR Name: _____
Observer(s): _____
Transect#: _____ Station#: _____ Elevation: _____ Bearing: _____
Description Line: _____ Photo ##: _____
INCIDENTAL OBSERVATIONS:
CHK ITEM: REMARKS:

	Birds	
	Native Inverts	
	Small Mammals	
	Non-native Inverts	
	Fire	
	Erosion	
	Human Influence	
	Add'l Survey Needs	

ASPECT	SLOPE	CANOPY CLOSURE	TOPOGRAPHIC POSITION	CANOPY STATURE	SOIL MOISTURE
__ NORTH	__ FLAT	__ DENSE	__ CREST	__ <1 M	__ INUNDATED
__ EAST	__ GENTLE	__ CLOSED	__ UPPER SLP	__ 1-2.5 M	__ SATURATED
__ SOUTH	__ MOD	__ OPEN	__ MID SLP	__ 2.5-5 M	__ MOIST
__ WEST	__ STEEP	__ SCATTER	__ LOW SLP	__ 5-10 M	__ MOIST-DRY
__( )	__ VERT	__ VERYSC	__ BOTTOM	__ >10 M	__ DRY
__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG

Additional notes:

TRANSECT STATION FIELD FORM Time Start: _____ End: _____ Date: _____
NC Name: _____ NAR Name: _____
Observer(s): _____
Transect#: _____ Station#: _____ Elevation: _____ Bearing: _____
Description Line: _____ Photo ##: _____
INCIDENTAL OBSERVATIONS:
CHK ITEM: REMARKS:

	Birds	
	Native Inverts	
	Small Mammals	
	Non-native Inverts	
	Fire	
	Erosion	
	Human Influence	
	Add'l Survey Needs	

ASPECT	SLOPE	CANOPY CLOSURE	TOPOGRAPHIC POSITION	CANOPY STATURE	SOIL MOISTURE
__ NORTH	__ FLAT	__ DENSE	__ CREST	__ <1 M	__ INUNDATED
__ EAST	__ GENTLE	__ CLOSED	__ UPPER SLP	__ 1-2.5 M	__ SATURATED
__ SOUTH	__ MOD	__ OPEN	__ MID SLP	__ 2.5-5 M	__ MOIST
__ WEST	__ STEEP	__ SCATTER	__ LOW SLP	__ 5-10 M	__ MOIST-DRY
__( )	__ VERT	__ VERYSC	__ BOTTOM	__ >10 M	__ DRY
__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG	__ NO CHG

Additional notes:

TRANSECT SUBSTATION FIELD FORM Time Start: _____ End: _____ Date: _____
NC Name: _____
NAR Name: _____ Transect#: _____
Observer(s): _____
*COVER CLASS CODES: 1 = <1% 2 = 1-5% 3 = 5-25%
(FOR USE BELOW) 4 = 25-50% 5 = 50-75% 6 = 75-90% 7 = >90
STATION NUMBER:

ITEM:																		
UNGULATES:																		
PIGS																		
GOATS																		
CATTLE																		
DEER																		
CANOPY CHANGES:																		
RARE PLANTS:																		
BEARING																		

APPENDIX 3
Puu Alii Area
Vascular Plant Species List

This species list was compiled from available literature sources, personal communication with botanists familiar with the area (backed by specimen verification for rare plants), and field identification during this NARS field survey. Rare plants (less than 3,000 individuals, or known from fewer than 20 locations worldwide) with specific location information are noted by '+' and are either in the Reserve or its adjacent area (see the rare plants table for those confirmed in the Reserve). Rare plants thought to occur in the Reserve but which lack specific location information are noted by '#' in the status column.

Due to subjective location information, some plant species included on this list may not actually be present in the Reserve. Plants and their associated vegetation types reported from literature for the area, but not confirmed during this survey, are noted with an 'x'. Plants reported for the area without an associated vegetation type are assingned to the natural community are assigned to the natural community they would most likely occur they would most likely occur in with a '?'.

Descriptions of natural communities are in the text. Taxonomy follows Wagner et al. (in press) and Wagner and Wagner (1987).

Status	Taxon	ʻOhiʻa/Mixed Shrub Montane Wet Forest	ʻOhiʻa Montane Wet Shrubland	ʻOhiʻa/ʻOlapa Montane Wet Forest	ʻOhiʻa/Uluhe Montane Wet Forest	Mixed Fern/Mixed Shrub Montane Wet Cliffs
E	Adenophorus hymenophylloides	*		*		
+ E	Adenophorus periens	?	?	?	?	?
E	Adenophorus pinnatifidus	*		*		
E	Adenophorus tamariscinus	*		*		
E	Adenophorus tripinnatifidus	*		*		
N	Ageratina adenophora			*		
N	Ageratum conyzoides			*		
E	Alyxia oliviformis			*		
N	Andropogon virginicus			*		
E	Anoectochilus sandvicensis	*		*		
N	Anthoxanthum odoratum			x		
E	Asplenium acuminatum			*		
E	Asplenium contiguum	*		*		
I	Asplenium lobulatum	*		*		
I	Asplenium unilaterale	*		*		
E	Astelia menziesiana	*		*		
N	Athyrium japonicum			*		
E	Athyrium microphyllum	*		*		
E	Athyrium sandwichianum	*		*		

+ = Rare N = Non-native I = Indigenous E = Endemic

* = Confirmed in NARS field study x = Cited in literature sources
? = Cited in literature sources; needs confirmation in natural community

Status	Taxon	ʻOhiʻa/Mixed Shrub Montane Wet Forest	ʻOhiʻa Montane Wet Shrubland	ʻOhiʻa/ʻOlapa Montane Wet Forest	ʻOhiʻa/Uluhe Montane Wet Forest	Mixed Fern/Mixed Shr Montane Wet Cliffs
N	Axonopus fissifolius	*		*		
+ E	Bidens wiebkei	?	?	?	?	?
N	Briza minor			X		
E	Broussaisia arguta	*		*		
N	Calamagrostis sp.	X				
E	Callistopteris baldwinii	*		*		
+ E	Canavalia molokaiensis	?	?	?	?	?
E	Carex alligata			*		
N	Centella asiatica			*		
N	Cerastium fontanum ssp. triviale	?	?	?	?	?
E	Cheirodendron trigynum	*		*		
E	Cibotium chamissoi	*		*		
E	Cibotium glaucum	*		*		
E	Clermontia arborescens			*		
+ E	Clermontia oblongifolia ssp. brevipes	?	?	?	?	?
E	Clermontia pallida			*		
N	Conyza bonariensis	X				
N	Conyza canadensis			*		
E	Coprosma ochracea	*		*		
E	Ctenitis rubiginosa	*		*		
N	Cuphea carthagenensis			*		
+ E	Cyanea procera	?	?	?	?	?
+ E	Cyanea profuga	?	?	?	?	?
+ E	Cyanea solanacea	?	?	?	?	?
+ E	Cyanea solenocalyx			*		
+ E	Cyrtandra biserrata	*		*		
E	Cyrtandra grayana			*		
+ E	Cyrtandra halawensis	?	?	?	?	?
+ E	Cyrtandra hematos	?	?	?	?	?
E	Cyrtandra lysiosepala	?	?	?	?	?
+ E	Cyrtandra macrocalyx	X		X	X	
E	Cyrtandra procera	*		*		
E	Deschampsia nubigena			X		
E	Dianella sandwicensis			*		
I	Dicranopteris linearis			*		
+ E	Diellia erecta	?	?	?	?	?
E	Diplopterygium pinnatum	*		*		
E	Dodonaea viscosa			*		
N	Drymaria cordata var. pacifica			*		
E	Dryopteris acutidens	*		*		
E	Dryopteris fusco-atra			*		
E	Dryopteris glabra	*		*		
E	Dryopteris wallichiana			*		
E	Dubautia laxa ssp. laxa	*		*		
E	Dubautia plantaginea ssp. plantaginea	?	?	?	?	?
N	Ehrharta stipoides	X				
E	Elaphoglossum alatum	*		*		

+ = Rare N = Non-native I = Indigenous E = Endemic

* = Confirmed in NARS field study x = Cited in literature sources
? = Cited in literature sources; needs confirmation in natural community

Status	Taxon	'Ohi'a/Mixed Shrub Montane Wet Forest	'Ohi'a Montane Wet Shrubland	'Ohi'a/'Olapa Montane Wet Forest	'Ohi'a/Uluhe Montane Wet Forest	Mixed Fern/Mixed Shr Montane Wet Cliffs
E	Elaphoglossum crassifolium	*		*		
E	Elaphoglossum hirtum var. micans	*		*		
E	Elaphoglossum pellucidum			X		
E	Elaphoglossum wawrae	*		*		
E	Embelia pacifica			*		
N	Eragrostis tenella			*		
N	Erechtites valerianifolia	*		*		
+ E	Eurya sandwicensis	X				
+ E	Exocarpos gaudichaudii	?	?	?	?	?
N	Fraxinus sp.	X				
I	Freycinetia arborea	*		*		
# E	Gardenia remyi	?	?	?	?	?
E	Grammitis hookeri	*		*		
E	Grammitis tenella	*		*		
E	Gunnera petaloidea			X		
+ E	Haplostachys linearifolia	?	?	?	?	?
N	Hedychium coronarium			*		
E	Hedyotis centranthoides			*		
E	Hedyotis hillebrandii	?	?	?	?	?
# E	Hedyotis mannii					
E	Hedyotis terminalis	*		*		
+ E	Hesperomannia arborescens	?	?	?	?	?
# E	Hibiscus kokio ssp. kokio				?	
N	Holcus lanatus			X		
E	Huperzia erosa	*				
I	Huperzia phyllanthum			*		
# E	Huperzia sulcinervia	?	?	?	?	?
N	Hydrocotyle verticillata			*		
N	Hypochoeris radicata			*		
N	Hypochoeris sp.			*		
E	Ilex anomala	*		*		
E	Isachne distichophylla	X		X		
+ E	Joinvillea ascendens ssp. ascendens	X				
N	Juncus effusus	*		*		
E	Korthalsella cylindrica	?	?	?	?	?
N	Kyllinga brevifolia			*		
E	Labordia cf. hirtella	*				
E	Labordia hedyosmifolia	*		*		
# E	Lagenifera maviensis	?				
E	Liparis hawaiensis	*		*		
# E	Lobelia dunbarii ssp. dunbarii	?	?	?	?	?
+ E	Lobelia dunbarii ssp. paniculata	?	?	?	?	?
+ E	Lobelia hypoleuca			*		
I	Lycopodium cernuum			*		
I	Lycopodium venustulum	*		*		
+ E	Lysimachia ternifolia			?	?	
N	Lythrum maritimum	X		X		
I	Machaerina angustifolia			*		

+ = Rare N = Non-native I = Indigenous E = Endemic

* = Confirmed in NARS field study x = Cited in literature sources
? = Cited in literature sources; needs confirmation in natural community

Status	Taxon	ʻOhiʻa/Mixed Shrub Montane Wet Forest	ʻOhiʻa Montane Wet Shrubland	ʻOhiʻa/ʻOlapa Montane Wet Forest	ʻOhiʻa/Uluhe Montane Wet Forest	Mixed Fern/Mixed Shr Montane Wet Cliffs
E	Marattia douglasii			*		
E	Mecodium recurvum			*		
N	Melaleuca quinquenervia	x				
E	Metrosideros polymorpha	*		*		
I	Microlepia strigosa			x		
E	Myrsine emarginata			x		
E	Myrsine lessertiana	*		*		
I	Nephrolepis cordifolia	*		*		
I	Nertera granadensis	*		*		
I	Odontosoria chinensis			*		
N	Oxalis corniculata			*		
N	Paspalum conjugatum			*		
N	Paspalum dilatatum	x		x		
E	Pelea clusiifolia	*		*		
E	Pelea parviflora			*		
+ E	Pelea reflexa	?	?	?	?	?
E	Pelea sp.			*		
E	Peperomia macraeana	*		*		
?	Peperomia sp.			*		
E	Peperomia tetraphylla			*		
+ E	Phyllostegia mannii	?	?	?	?	?
+ E	Phyllostegia mollis	?	?	?	?	?
+ E	Phyllostegia stachyoides	?	?	?	?	?
E	Phytolacca sandwicensis			*		
E	Pilea peploides	x				
E	Pipturus albidus	*				
E	Pittosporum glabrum			*		
N	Pityrogramma calomelanos			*		
+ E	Plantago princeps var. laxiflora	?	?	?	?	?
+ E	Platanthera holochila	?	?	?	?	?
I	Pleopeltis thunbergiana	*		*		
N	Poa pratensis	x				
E	Polypodium pellucidum	*		*		
E	Pouteria sp.	x				
E	Pritchardia lowreyana			*		
I	Psilotum complanatum			*		
E	Psychotria hawaiiensis			x		
E	Psychotria mariniana			*		
E	Psychotria mauiensis	*		*		
I	Pteris excelsa			*		
+ E	Ranunculus mauiensis	?	?	?	?	?
E	Rubus hawaiensis			*		
N	Rubus rosifolius	*		*		
E	Rumex giganteus	x				
N	Sacciolepis indica			*		
E	Sadleria cyatheoides			*		
E	Sadleria pallida	*		*		
E	Sadleria souleyetiana			*		
E	Sadleria squarrosa			*		

+ = Rare N = Non-native I = Indigenous E = Endemic

* = Confirmed in NARS field study x = Cited in literature sources
? = Cited in literature sources; needs confirmation in natural community

Status	Taxon	ʻOhiʻa/Mixed Shrub Montane Wet Forest	ʻOhiʻa Montane Wet Shrubland	ʻOhiʻa/ʻOlapa Montane Wet Forest	ʻOhiʻa/Uluhe Montane Wet Forest	Mixed Fern/Mixed Sh Montane Wet Cliffs
E	Santalum freycinetianum var. freycinetianum	x				
E	Scaevola chamissoniana			*		
+ E	Schiedea diffusa	?	?	?	?	?
+ E	Schiedea pubescens var. pubescens			?	?	
E	Schizaea robusta	x		x		
E	Selaginella arbuscula			x		
N	Setaria gracilis	x				
+ E	Sicyos cucumerinus	?	?	?	?	?
E	Smilax melastomifolia	*		*		
E	Sphaerocionium lanceolatum			*		
E	Sphaerocionium obtusum			*		
+ E	Stenogyne bifida	?	?	?	?	?
E	Stenogyne kamehamehae			*		
E	Sticherus owhyensis	*		*		
I	Styphelia tameiameiae	*		*		
E	Tetraplasandra oahuensis			*		
I	Thelypteris interupta	?	?	?	?	?
N	Thelypteris parasitica			*		
E	Thelypteris sandwicensis			*		
E	Touchardia latifolia	x		x		
E	Trematolobelia macrostachys			*		
E	Trematolobelia sp.			*		
E	Urera glabra			x		
E	Vaccinium calycinum	*		*		
E	Vandenboschia davallioides			*		
+ E	Vandenboschia draytoniana			x		
N	Verbena litoralis	x				
E	Viola chamissoniana ssp. robusta	*		*		
I	Vittaria elongata	x				
E	Wikstroemia sp.	*		*		
E	Xiphopteris saffordii			x		
N	Youngia japonica			*		
+ E	Zanthoxylum hawaiiense			x		
N	Zingiber zerumbet	x				

+ = Rare N = Non-native I = Indigenous E = Endemic

* = Confirmed in NARS field study x = Cited in literature sources
? = Cited in literature sources; needs confirmation in natural community

APPENDIX 4
Puu Alii Area
Bird Species List

The birds listed have been reported from visual and audio indentification in or near the reserve. The list includes information on rare birds, compiled from the literature. Taxonomy follows the Checklist of the Birds of Hawaii by Pyle (1988).

Status	Species	Common name	Source
E	Asio flammeus sandwichensis	Pueo, Hawaiian Owl	?
N	Cardinalis cardinalis	Northern Cardinal	x
N	Carpodacus mexicanus	House Finch	x
N	Cettia diphone	Japanese Bush-Warbler	*
V	Falco peregrinus	Peregrine Falcon	*
N	Francolinus erckelii	Erckel Francolin	x
N	Francolinus francolinus	Black Francolin	x
N	Geopelia striata	Zebra Dove	x
E	Hemignathus virens wilsoni	ʻAmakihi	*
E	Himatione sanguinea sanguinea	ʻApapane	*
N	Leiothrix lutea	Red-billed Leiothrix	*
N	Lonchura punctulata	Nutmeg Mannikin	x
+E	Myadestes lanaiensis rutha	Oloma'o, Molokai Thrush	x
+E	Paroreomyza flammea	Kakawahie, Molokai Creeper	?
+E	Pterodroma phaeopygia sandwichensis	ʻUaʻu, Hawaiian Dark-rumped Petrel	?
+E	Puffinus newelli	Newell Shearwater, ʻAʻo	x
N	Streptopelia chinensis	Spotted Dove	x
+E	Vestiaria coccinea	ʻIʻiwi	x
N	Zosterops japonicus	Japanese White-eye	*

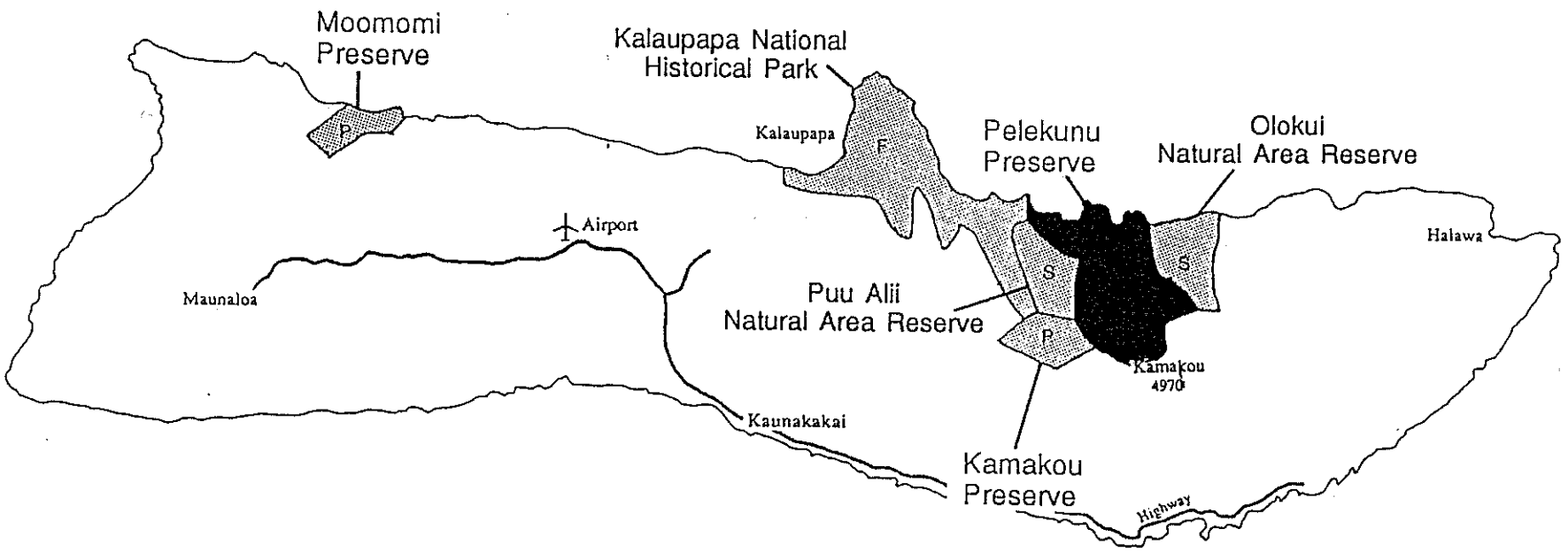
+ = Rare
E = Endemic
N = Non-native
I = Indigenous
V = Visitor

x = Cited in literature
* = Confirmed during NARS field study
? = Cited in literature; needs confirmation in Reserve

Figure 1

Pelekunu Preserve

Molokai



N

0 5 10 MI

0 5 10 15 KM

PARCEL INFORMATION:

S = State-owned
F = Federally-owned
P = Privately-owned
▨ = Already Protected

Map prepared: 90-12-05