DRAFT

MANUKA NATURAL AREA RESERVE

MANAGEMENT PLAN

Natural Area Reserves System Program

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

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Manuka Natural Area Reserve
Management Plan

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EXECUTIVE SUMMARY

This plan describes the management program at the Manuka Natural Area Reserve which was established on the island of Hawaii in 1983 by Executive Order 3164. The reserve occupies 25,550 acres on the southwest slope of Mauna Loa on the island of Hawaii. Elevations range from near sea level to 5,524 feet near Puu Ohohia at the reserve's apex. The reserve protects 18 different natural communities including dry and mesic forests, subalpine shrublands and forests, lowland and coastal shrublands and grasslands, anchialine pools, pioneer vegetation on lava flows, and lava tubes.

Management efforts will focus on reducing feral pig and goat damage and controlling invasive nonnative plant infestations. Fencing is proposed along the northwestern boundary and around the Kipuka management unit which contains a rare Koa/'Ohi'a Montane Mesic Forest community. Both public and staff hunting are proposed to remove ungulates. Access improvement is proposed in the Ohia management unit to facilitate ungulate control activities. Nonnative plant control will focus on removing invasive plant infestations in the most intact portions of the reserve.

Other management programs include: 1) other nonnative species control to reduce the impact of mosquitoes, ants, yellow jackets, and fish which could threaten the integrity of the native ecosystems in the reserve, 2) monitoring and research to determine the condition of the biological, cultural, and physical resources of the reserve and gauge the effectiveness of management projects, 3) fire control to prevent all wildfires in the reserve, and 4) education and volunteer support to build public understanding and support for the reserve and the Natural Area Reserves System.

Residential and agricultural lands border the reserve. Opportunities for cooperative ungulate control should be pursued with adjacent Mac Farms of Hawaii. To foster community support, nearby landowners and managers should be kept informed of reserve management activities.

The reserve's trails and jeep roads are well utilized by hunters, hikers and fishermen; camping is common along the beach below the lower reserve boundary. Marijuana cultivation and hardwood removal are the two most obvious illegal activities occurring in the reserve. The Division of Conservation and Resources Enforcement marijuana eradication project frequently targets Manuka. Encouraging nearby residents to watch for and report violations may help to prevent hardwood removal.

The management programs discussed form an integrated strategy to protect the natural area resources of the reserve. A six year implementation schedule is proposed. Average annual budget estimates are approximately 200,000 for the first two years, but should be reduced to approximately $50,000 beginning with year 3.

MANUKA NATURAL AREA RESERVE MANAGEMENT PLAN

I. INTRODUCTION

This plan describes the management program at the Manuka Natural Area Reserve which was established on the island of Hawaii in 1983 by Executive Order 3164. The reserve protects a diverse range of natural communities including dry and mesic forests, subalpine shrublands and forests, lowland and coastal shrublands and grasslands, anchialine pools, pioneer vegetation on lava flows, and lava tubes. These communities provide habitat to native plants and animals, several of which are considered rare such as the 'io (Hawaiian hawk) and the 'ope'ape'a (Hawaiian hoary bat).

Three major sources of information were used to prepare this plan. The first was a field inventory conducted in April 1989, specifically designed to collect data relevant to the management of the reserve's natural resources (See Manuka Natural Area Reserve Inventory Report, April 1989). The second was The Nature Conservancy's Hawaii Heritage database on rare species and unique natural communities. The third was a review of this plan by qualified managers, planners, and biologists familiar with the area and its problems.

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

II. RESOURCES SUMMARY

A. General Setting

Manuka Natural Area Reserve occupies 25,550 acres on the southwest slope of Mauna Loa on the island of Hawaii (Figure 1 and 2). Elevations range from near sea level to 5,524 feet near Puu Ohohia at the reserve's apex. Rainfall averages from 30 inches annually in the lower elevation to 40 inches at the reserve's apex. Precipitation is probably higher along a band in the mid-elevations (ca. 1,800 - 3,200 feet) where daily cloud cover results in fog drip. March is the wettest month, averaging 3 - 4 inches, and June the driest with only 1 - 4 inches (Giambelluca, Nullet, and Schroeder 1986).

Highway 11 runs through the center of the reserve at about 1,800 feet elevation. Along the highway in the center of the

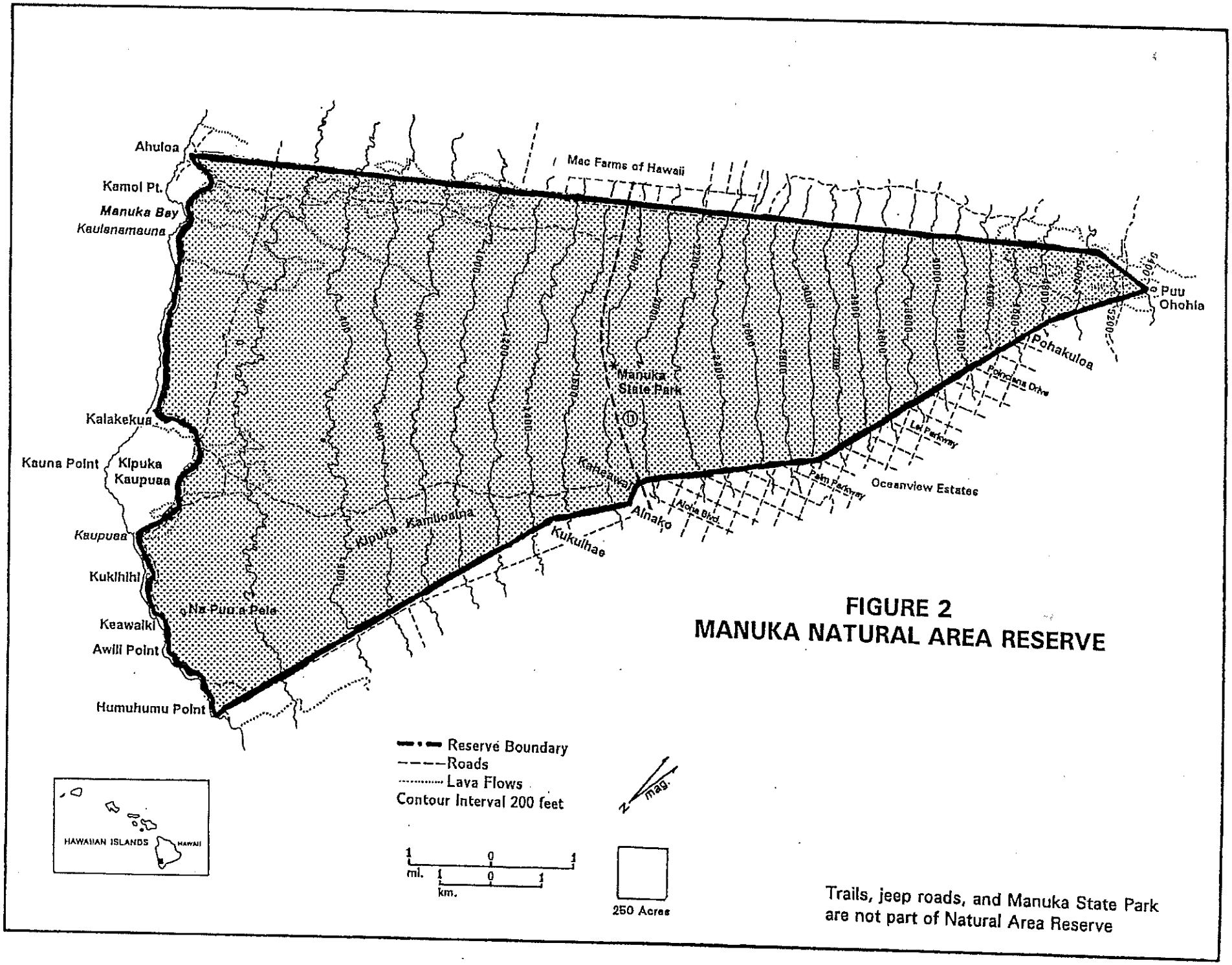


FIGURE 2
MANUKA NATURAL AREA RESERVE

Trails, jeep roads, and Manuka State Park are not part of Natural Area Reserve

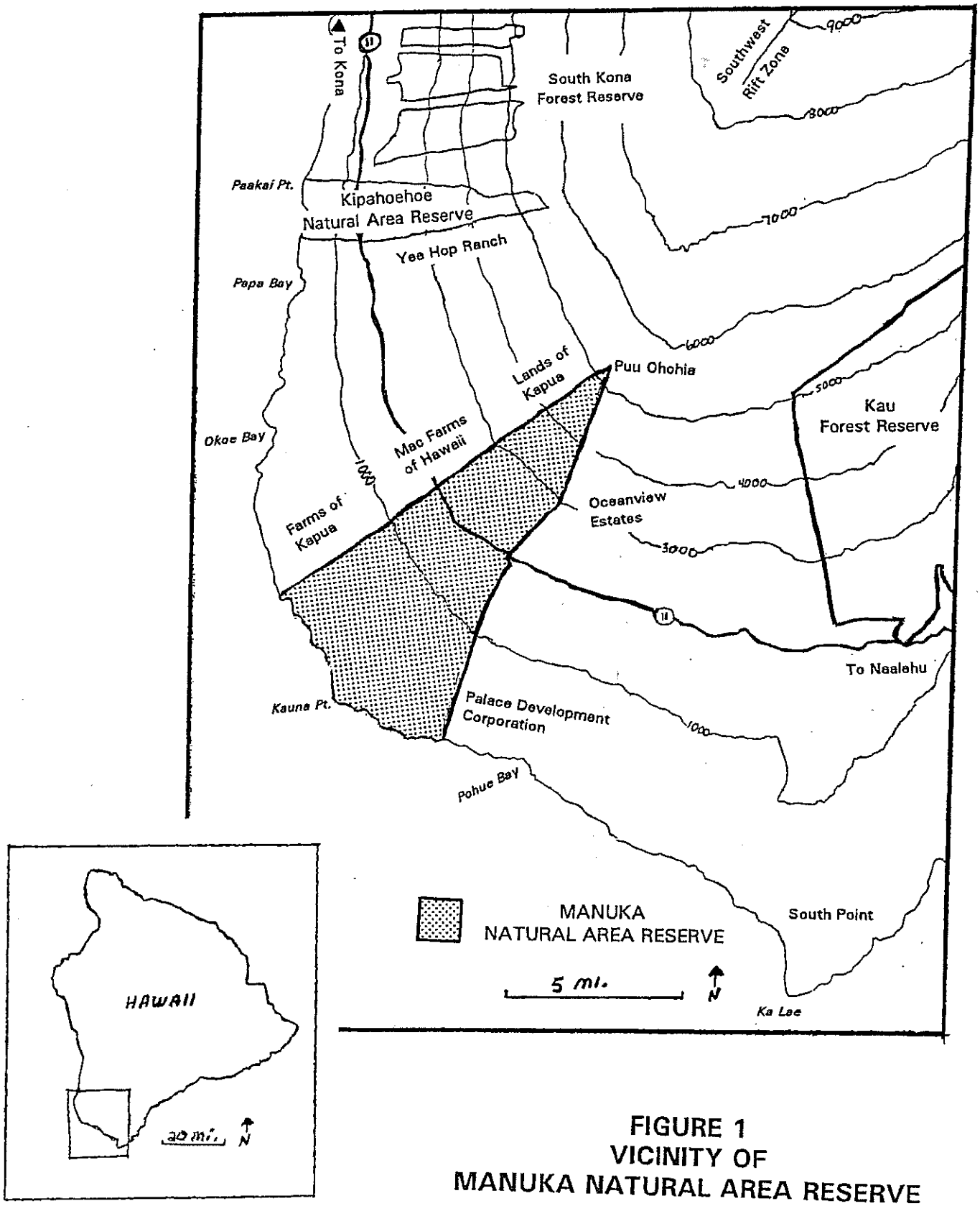


FIGURE 1
VICINITY OF
MANUKA NATURAL AREA RESERVE

reserve, Manuka State Park encloses 13 acres and provides visitor facilities including a restroom, arboretum, and camping area. Manuka State Park and two other parcels along Highway 11 are excluded from the reserve. One parcel of 5 acres is used as a highway maintenance base yard and the other (less than one acre) is privately owned. The coastal area, two kipuka (Kaulanamauna and Kaupuaa), the mauka-makai jeep roads, and Kaheawai Trail are not included in the Natural Area Reserve, but are state lands.

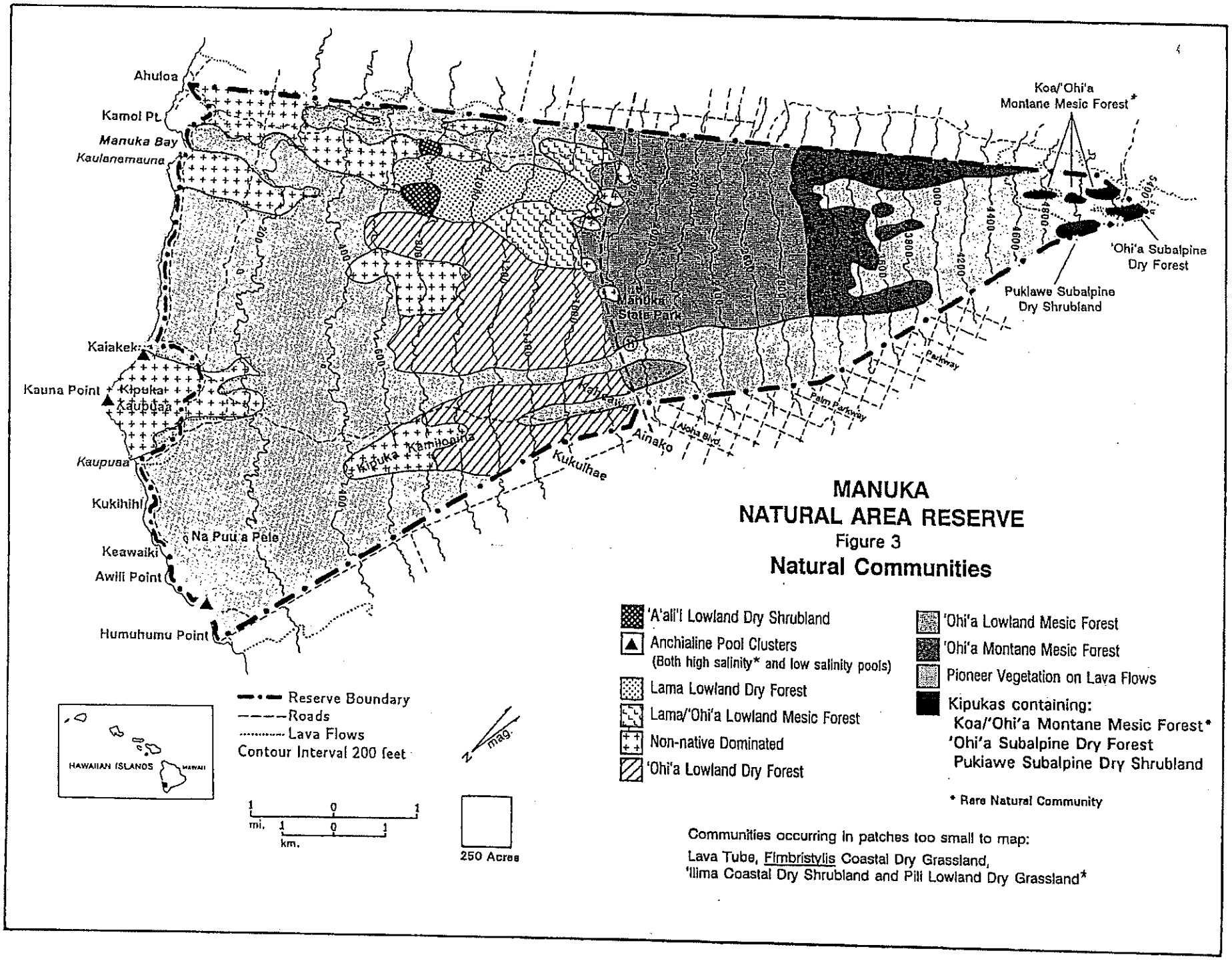
The reserve's eastern boundary borders developing residential subdivisions (Oceanview Estates). A resort development project is also planned for the makai lands along the eastern boundary (Palace Development Corporation). The western boundary borders agricultural lands, a large portion of which are macadamia nut orchards.

Above Highway 11, trails and roads provide access into the reserve from all sides. A loop trail from Manuka State Park extends up to 2200 feet in the central portion of the reserve. Trails from the Ocean View Estates subdivision lead into the reserve along the eastern boundary; a four-wheel drive road leads from the northern part of the subdivision onto Kahuku Ranch lands and across the reserve's apex. On the northwest boundary, Mac Farms of Hawaii has a road leading up from Highway 11. What appears to be an old, overgrown road and is now a foot trail, crosses into the center of the reserve along the 2,600 feet contour from Mac Farms road.

Two rough four-wheel drive roads lead from Highway 11 to the coast. One road, known as Manuka Bay Road, begins close to the northwestern boundary and leads down to Manuka Bay. The other road crosses private lands just east of the reserve, and becomes the reserve's eastern boundary from 700 feet elevation to Humuhumu Point. A coastal jeep road begins at Manuka Bay and extends just past Kipuka Kaupuaa. These roads are frequently used by fisherman and campers. Kaheawai Trail begins at Highway 11 near the eastern border and extends to the coast at Kipuka Kaupuaa. Though shown on maps as a four-wheel drive road, it is overgrown and only useable as a foot trail.

B. Flora and Fauna

Eighteen natural communities were observed in the reserve during the 1989 survey (Figure 3, Appendix 1) (See Manuka Inventory Report 1991). Of these, four non-vegetated aquatic and subterranean communities were seen: two kinds of anchialine pools (one rare) and two kinds of uncharacterized lava tubes. The fourteen vegetated communities ranged from coastal dry shrublands to subalpine forest including the rare Koa/'Ohi'a Montane Mesic Forest and Pili Lowland Dry Grassland communities.


Ahuloa
Kamoi Pt.
Manuka Bay
Kaulanamauna
Kaiakeki
Kauna Point
Kipuka Kaupuaa
Kaupuaa
Kukihihi
Na Puu a Pele
Keawaiki
Awili Point
Humuhumu Point
Manuka State Park
Kipuka Kamiloaina
Kukulhae
Ainako
Kahekili Hwy
Aloha Blvd
Palm Parkway
Koa/'Ohi'a Montane Mesic Forest*
'Ohi'a Subalpine Dry Forest
Puklawe Subalpine Dry Shrubland
MANUKA
NATURAL AREA RESERVE
Figure 3
Natural Communities
'A'ali'i Lowland Dry Shrubland
Anchialine Pool Clusters
(Both high salinity* and low salinity pools)
Lama Lowland Dry Forest
Lama/'Ohi'a Lowland Mesic Forest
Non-native Dominated
'Ohi'a Lowland Dry Forest
'Ohi'a Lowland Mesic Forest
'Ohi'a Montane Mesic Forest
Pioneer Vegetation on Lava Flows
Kipukas containing:
Koa/'Ohi'a Montane Mesic Forest*
'Ohi'a Subalpine Dry Forest
Pukiawe Subalpine Dry Shrubland
* Rare Natural Community
Reserve Boundary
Roads
Lava Flows
Contour Interval 200 feet
HAWAIIAN ISLANDS
HAWAII
mag.
mi.
km.
250 Acres
Communities occurring in patches too small to map:
Lava Tube, Fimbristylis Coastal Dry Grassland,
'Ilima Coastal Dry Shrubland and Pili Lowland Dry Grassland*

Of the seven rare plants confirmed within the reserve boundaries, 3 were observed during the 1989 field survey (Appendix 2 and 4).

Four common native birds were seen during the 1989 survey of Manuka reserve. 'Amakihi (*Hemignathus virens*), 'apapane (*Himatione sanguinea*), 'elepaio (*Chasiempis sandwichensis*), and 'i'iwi (*Vestiaria coccinea*). Two rare birds, the 'io, or Hawaiian hawk (*Buteo solitarius*), and the 'alala, or Hawaiian crow (*Corbus hawaiiensis*), and the rare 'ope'ape'a, or Hawaiian hoary bat(*Lasiurus cinereus semotus*) are known from the reserve (Appendix 3 and 4). Of these only the 'io was seen during the 1989 survey.

Non-native birds commonly seen in the reserve during the 1989 survey included Japanese white-eye (*Zosterops japonicus*), northern cardinal (*Cardinalis cardinalis*), zebra dove, (*Geopelia striata*), spotted dove (*Streptopelia chinensis*), Japanese bush-warbler(*Cettia diphone*), kalij pheasant (*Lophura leucomelana*) and common mynah (*Acridotheres tristis*).

A high diversity of native invertebrates including anchialine pool shrimp, crickets, spiders, flies, bees, wasps, planthoppers, and antlions (*Eidoleon wilsoni*) were seen during the 1989 survey. Non-native invertebrates present in the reserve included mosquitos, ants and yellow jackets (*Vespula* sp.), which are species of management concern because of their effects on native invertebrates.

II. MANAGEMENT

A. Key Management Considerations

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

1) Since the Manuka reserve is very large, intensive management of the entire reserve is not realistic at this time. Management priorities for specific areas are based on biological resources, the extent of current disturbances, the nature of biological threats within and near the area, and the feasibility of management.

2) Invasive nonnative plants and feral animals constitute a severe threat to the reserve's native vegetation. Invasive nonnative plants threaten the integrity of the reserve's natural communities by competing with native plants for space, light, and nutrients and facilitating the invasion of nonnative insects and birds.

Feral animals destroy native plants, distribute nonnative plant seeds, and create openings in the native ground cover. These openings contribute to soil erosion and facilitate the establishment of nonnative plants. Control of invasive weeds and feral animals will be necessary to preserve the integrity of the natural communities.

3) Marijuana cultivation in the reserve is a major problem. Clearings created by cultivators damage native plants and facilitate nonnative plant invasion. Cultivators protecting their plantings can jeopardize the safety of legitimate reserve users. Native hardwood removal is another problem in the reserve. The stump of a rare kauila (*Colubrina oppositifolia*) tree, one of less than fifty known in the reserve, was seen during the 1989 survey near Manuka Bay Road.

4) A number of archaeological sites are present in the reserve including burial caves and petroglyphs in the coastal area, and farming terraces in the forested area. The Kaheawai Trail below Highway 11 is an old Hawaiian foot trail which passes by rock carvings. These sites should be maintained and used as educational resources. Additional archaeological surveys and research are needed throughout the reserve. The Hawaii Island Burial Council should be consulted regarding the management of any burial caves in the reserve.

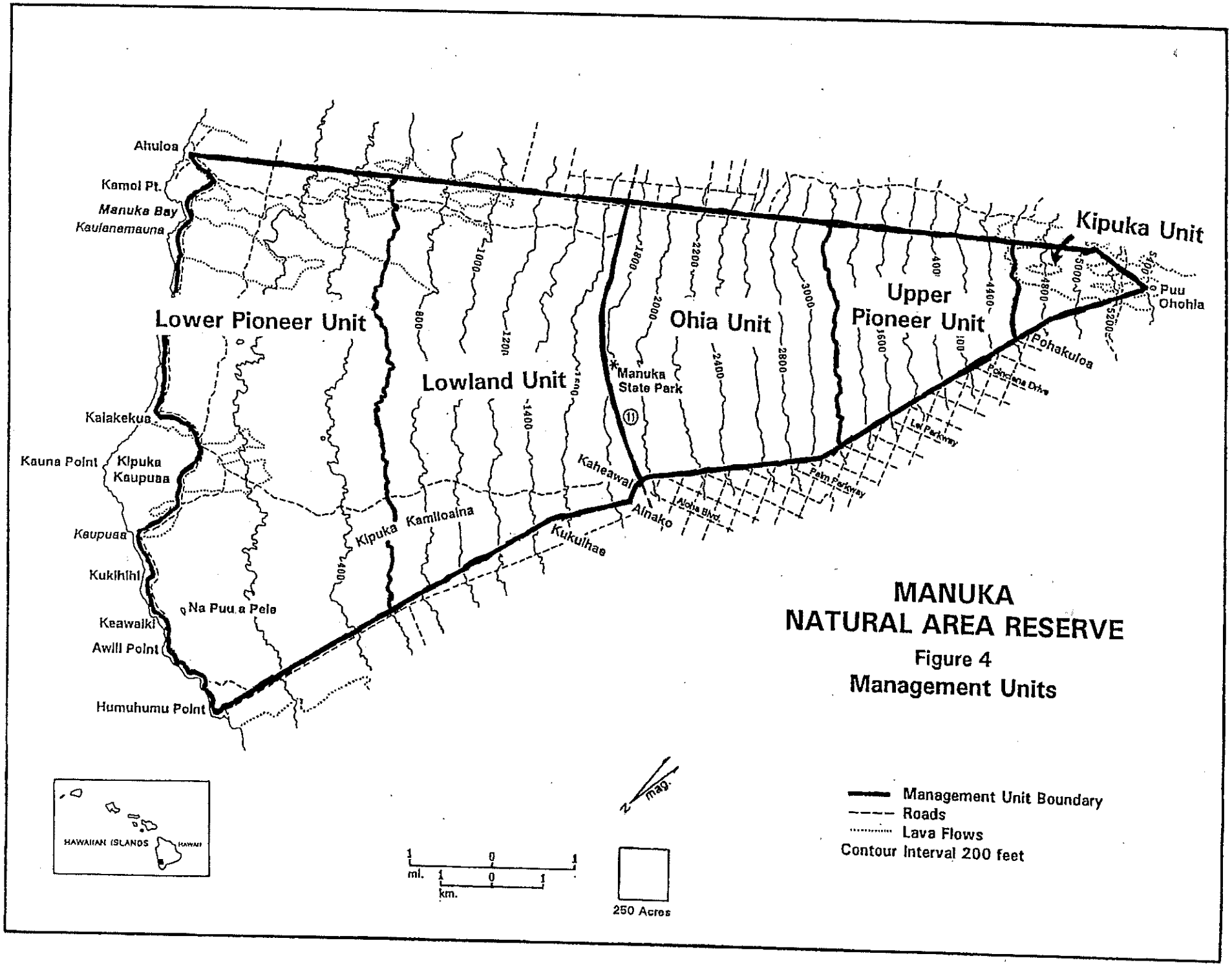
B. Management Units

The reserve has been divided into five management units (Figure 4). Resources and management problems identified during the 1989 survey are described for each unit.

1) Kipuka Unit - this 600-acre unit extends from the top of the reserve down to 4600 feet elevation. Pioneer vegetation on lava flows surrounds several kipukas which contain Koa/'Ohi'a Montane Mesic Forest, 'Ohi'a Subalpine Dry Forest, and Pukiawe Subalpine Dry Shrubland communities. Some old light pig and goat damage and only a few nonnative plants were present in the kipuka communities.

2) Upper Pioneer Unit - this 2300-acre unit extends from 4600 feet down to 3200 feet and contains primarily pioneer vegetation on lava flows, though portions of the 'Ohi'a Montane Mesic Forest community are also present along the lower and western boundaries. The communities in this unit were not surveyed for ungulate damage or weed infestation.

3) Ohia Unit - this 5100-acre unit extends from 3200 feet down to Highway 11. 'Ohi'a Lowland and Montane Mesic Forest, and



MANUKA NATURAL AREA RESERVE

Figure 4
Management Units

Pioneer Vegetation on Lava Flow communities are found in this unit. Several rare plants and animals including the 'alala have been reported in this unit. This unit contained widespread pig damage; several nonnative plants were present in the lower elevations which have a great potential for spreading.

4) Lowland Unit - this 7900-acre unit extends from Highway 11 down to the 600 foot contour interval. Mesic and Dry Lowland 'Ohi'a and Lama Forest communities, and patches of 'A'ali'i Lowland Dry Shrubland and Nonnative Dominated communities are present. In this unit, there was light pig damage in the upper forested regions; nonnative plant infestation was widespread.

5) Lower Pioneer Unit - this 9600-acre unit extends from 600 feet elevation down to the coastal boundary. Pioneer vegetation on lava flows dominates, while patches of Ilima Coastal Dry Shrubland, Pili Lowland Dry Grassland, Nonnative Dominated communities, and anchialine pools and lava tubes are also present. Light goat damage was found in the coastal regions.

C. Management Programs

The following four management programs outline the long-term goals for the reserve. A six-year implementation schedule is proposed. The four programs form an integrated management package.

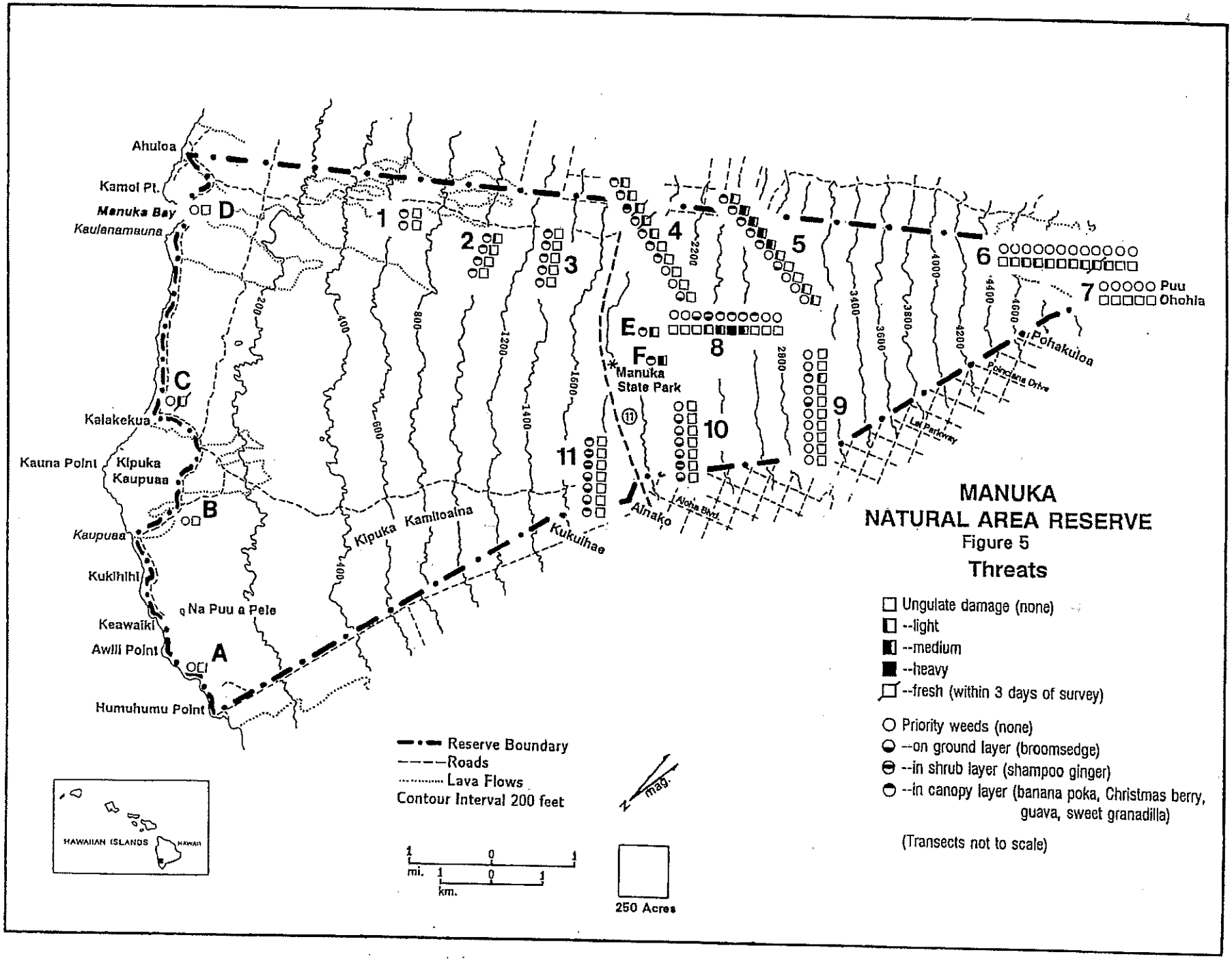
1. NONNATIVE SPECIES CONTROL

a. Feral Ungulate Control

GOAL: Reduce ungulate populations to the lowest possible level in areas of the reserve dominated by native species.

Statement of the Problem: Feral pigs and goats are a serious concern in the Manuka Natural Area Reserve. Figure 5 shows the degree of ungulate damage encountered along the transects in the 1989 survey. Pig damage was most abundant in the mesic 'ohi'a forests of the Ohia management unit, particularly near the northwestern boundary between the reserve and macadamia nut orchards. Goat sign was found in the uppermost and coastal regions of the reserve. Left unchecked, ungulate populations will continue to degrade the native ecosystems for which the reserve was established.

Public hunting is well established in the reserve. The Ohia, Upper Pioneer, and Kipuka management units are within Public Hunting Unit B which allows year round hunting with dogs.


MANUKA
NATURAL AREA RESERVE
Figure 5
Threats
Ungulate damage (none)
--light
--medium
--heavy
--fresh (within 3 days of survey)
Priority weeds (none)
--on ground layer (broomsedge)
--in shrub layer (shampoo ginger)
--in canopy layer (banana poka, Christmas berry, guava, sweet granadilla)
(Transects not to scale)
Reserve Boundary
Roads
Lava Flows
Contour Interval 200 feet
mag.
mi.
km.
250 Acres
HAWAIIAN ISLANDS
HAWAII
Ahuloa
Kamoi Pt.
Manuka Bay
Kaulanamauna
Kalakekua
Kauna Point
Kipuka Kaupuaa
Kaupuaa
Kukihihi
Keawaiki
Awili Point
Humuhumu Point
Na Puu a Pele
Kipuka Kamiloaina
Kukuihae
Ainako
Aloha Blvd.
Manuka State Park
Pohakuloa
Pendana Drive
Lai Parkway
Puu Ohohia
A
B
C
D
E
F
1
2
3
4
5
6
7
8
9
10
11
200
400
600
800
1200
1400
1600
2200
2800
3400
3600
3800
4000
4200
4400
4600

The Lowland and Lower Pioneer management units are within Public Hunting Unit C which allows hunting only from June to August without dogs.

The reserve is very large, but accessible along all of its boundaries. In the densely vegetated Ohia unit where pigs are widespread and existing trail access is limited, access improvement may help to direct and distribute hunting pressure.

Consideration of Alternative Actions:

1) Control ungulates using public hunting pressure. Though, public hunting can be a viable tool for ungulate control in the early stages of a removal program, public hunting alone is not effective in reducing ungulate populations to the levels necessary to prevent further degradation of the natural communities. Increased hunter presence in the reserve could provide additional corridors contributing to nonnative animal and plant invasion.

2) Control ungulates using trained staff hunters. Staff hunters may include volunteer or paid hunters appointed as agents of the state. Trained hunters using dogs in a systematic hunting program could lower ungulate populations to remnant levels. However, increased hunter presence in the reserve could provide additional corridors for nonnative animal and plant invasion.

3) Control ungulates with fencing. Fencing will prevent the movement of ungulates into certain areas and direct predictable ungulate movements within intensive control areas. However, fencing is expensive to build and maintain, and may not be necessary to adequately control ungulate damage in all areas of the reserve.

4) Control pigs using snares. Snaring is an effective control technique, especially in fenced areas which channel pig movements. However, snaring is not compatible with intensive public use or hunting with dogs.

Recommended Action: Initially alternatives 1, 2, and 3 are recommended. Fencing is recommended along the northwest boundary of the Lowland and Ohia management unit and will be considered around the upper Kipuka management unit. Ungulate removal will consist of public hunting supplemented by staff hunting with priority given to the Ohia, Lowland, and Kipuka management units. Access improvement is proposed in the Ohia management unit to facilitate ungulate control activities. Three projects, fence construction and maintenance, ungulate removal, and access improvement are described below.

Close monitoring will be essential to determine hunting effectiveness (See Monitoring program). Other alternatives such

as snaring in remote areas or areas closed to public hunting, and additional fencing may need to be reconsidered if monitoring indicates continued or increased ungulate damage.

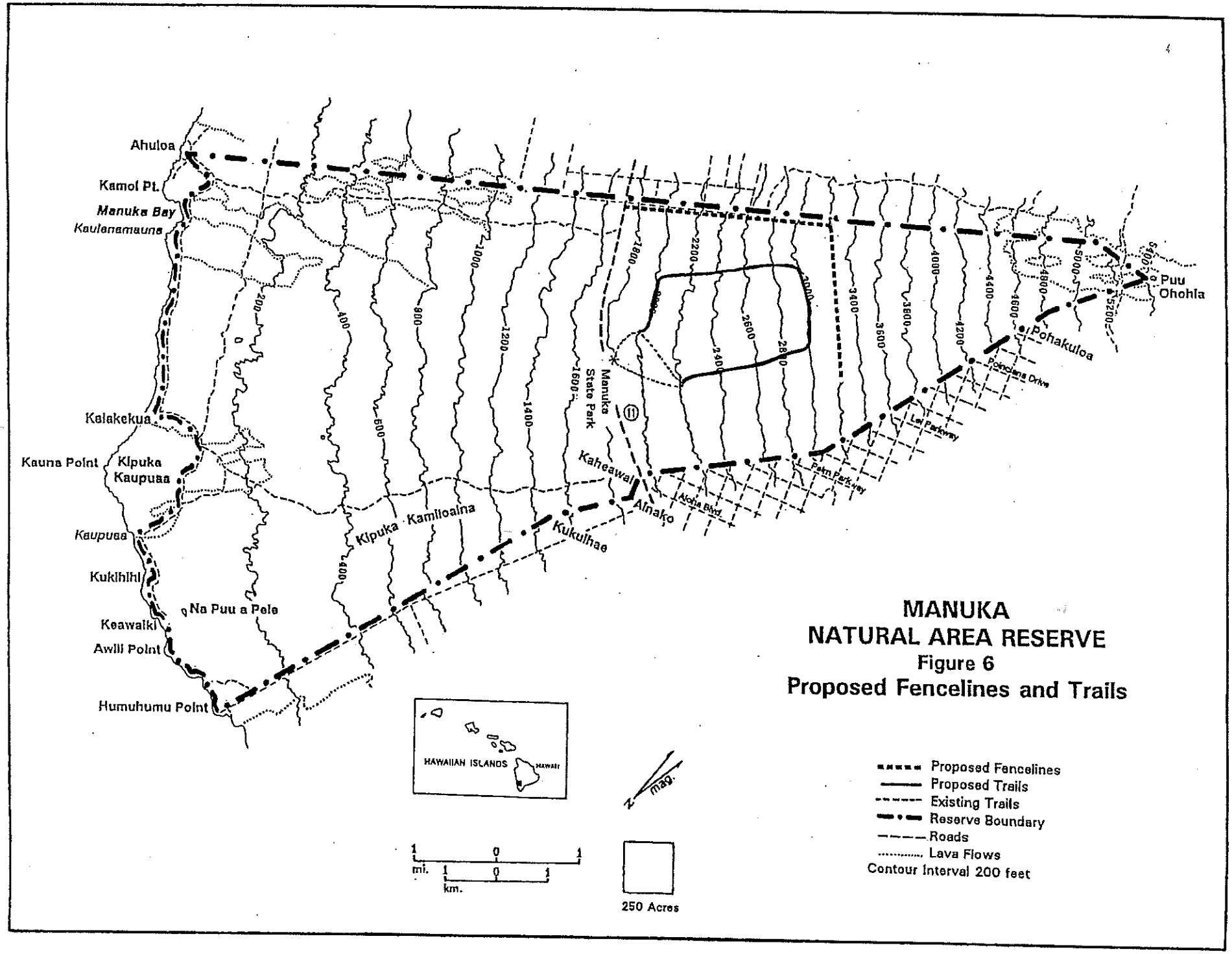
Project 1 - Fence construction and maintenance. Fencelines are planned along the northwestern boundary of the Lowland and Ohia management units to prevent pig migration between the reserve and the adjacent macadamia nut orchards (Figure 6). Fencing around the Kipuka management unit may also be necessary, as the rare Koa/'Ohi'a Montane Mesic Forest community is present in some of the kipukas.

The fences will consist of 47 inch high galvanized woven wire supplemented along the ground surface by one strand of barbed wire. Woven wire and barbed wire will be secured to steel posts placed no more than 10 feet apart. Concreted galvanized pipes will be used to secure the fenceline at certain corners.

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

Cost/Workload Estimate: Fence construction cost estimates are based at $40,000/mile by contract. Fencelines will be inspected 4 times a year and after major storms. 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. Personnel time listed is based on a four-person crew able to inspect and repair 3 miles of fence per day. Supplies for fence maintenance are estimated at $250/mile/year.

Year 1:	NW BOUNDARY FENCE CONSTRUCTION (4 mi.)	**TOTAL**	**$160,000**
Year 2:	KIPUKA UNIT FENCE CONSTRUCTION (4 mi.)	SUBTOTAL	$160,000
	FENCE MAINTENANCE (4 mi. - NW Boundary)		
	Personnel		
	Technicians/Laborers 32 PD		
	Subsistence allowance		$ 640
	Supplies and Support		$ 1,000
		SUBTOTAL	$ 1,640
		TOTAL	**$161,640**



MANUKA
NATURAL AREA RESERVE
Figure 6
Proposed Fencelines and Trails

Years 3-6: Fence Maintenance (8 mi. - NW Boundary and Kipuka)

Personnel		
Technicians/Laborers	64 PD	
Subsistence allowance		$ 1,280
Supplies and Support		$ 2,000
	TOTAL	**$ 3,280**

Project 2 - Ungulate removal. Both public and staff hunting are recommended to control pig and goat populations in the reserve.

In the Lower Pioneer and Lowland management units, public hunting restrictions currently in place should be relaxed to allow year round hunting with dogs and no bag limits. Special hunts could be used to increase public hunting pressure. All public hunters should be obligated to report data on health, sex, and age of ungulates captured to NARS staff. Data accumulated during control activities will be compiled and analyzed with other monitoring data to determine program effectiveness.

Staff hunting should focus initially on the more remote regions of the reserve where public hunters are less likely to visit, such as the upper kipukas. Aerial hunting may be necessary to control regional goat populations. The frequency of staff hunting expeditions should be adjusted according to hunting success and monitoring indicators. To the extent possible, ground staff hunting should be carried out by volunteer hunters who have their own hunting dogs. Volunteer hunters should receive training and logistical support to assist staff in intensive ungulate removal efforts.

Cost/Workload Estimate: Costs estimated below are based on quarterly hunts utilizing only volunteer staff hunters who have their own hunting dogs. Personnel time and supplies listed are based upon providing logistical support, supplies (ammunition and dog food), and training to volunteer staff hunters. Note that costs will be substantially higher if it is necessary to hire private hunters with dogs or purchase and maintain hunting dogs for staff use.

Year 1: VOLUNTEER STAFF HUNTING

Personnel		
Professional	24 PD	
Technicians/Laborers	32 PD	
Subsistence allowance		$ 1,120
Supplies and Support		
Arms		$ 5,000
Ammunition (4 cases at $200/ea)		$ 800
Dogfood		$ 500
Transportation		$ 500
Data recording paper		$ 500
Miscellaneous equipment and supplies		$ 1,000
	SUBTOTAL	$ 9,420

AERIAL HUNTING (biannual expeditions)		
Personnel		
Technicians 4 PD		
Supplies and Support		
Helicopter charter with IR spotting equipment (6 hours at $800/hour)		$ 4,800
Arms		$ 1,000
Ammunition (2 cases at $200/case)		$ 400
	SUBTOTAL	$ 6,200
	TOTAL	**$15,620**

Years 2-6: Same as year 1.

Project 3 - Access improvement. A 5.25 mile central loop trail branching off of the existing loop trail from Manuka State Park is planned for the Ohia management unit (Figure 5). This should help to direct and distribute hunting pressure in the central and upper portions of this unit. The proposed trail would be primarily used by hunters and management personnel, but could also be used by hikers. Prior to trail clearing an archaeological and a botanical survey should be carried out along the proposed route.

Both the Manuka Loop Trail and the Kaheawai Trail, as well as Manuka Bay Road will also be maintained. Strict sanitary procedures will be followed by management personnel to prevent introduction of weeds on their boots, clothing, and equipment.

Cost/Workload Estimate:

Year 1:	ESTABLISH CENTRAL LOOP TRAIL (5.25 mi.)		
	Personnel		
	Professional	7 PD	
	Technicians/Laborers	126 PD	
	Subsistence allowance		$ 2,660
	Supplies and Support		$ 2,000
		SUBTOTAL	$ 4,660
	MAINTAIN PARK LOOP TRAIL (2.25 mi.)		
	Personnel		
	Technicians/Laborers	20 PD	
	Subsistence allowance		$ 400
	Supplies and Support		$ 500
		SUBTOTAL	$ 900
	MAINTAIN KAHEAWAI TRAIL (6.0 mi.)		
	Personnel		
	Technicians/Laborers	10 PD	
	Subsistence allowance		$ 200
	Supplies and Support		$ 500
		SUBTOTAL	$ 700

	MAINTAIN MANUKA BAY ROAD		
	Personnel		
	Equipment operators 10 PD		
	Subsistence allowance		$ 200
	Supplies and Support		$ 2,000
		SUBTOTAL	$ 2,200
		TOTAL	**$ 8,460**
Years 2-6:	MAINTAIN TRAILS (13.5 mi)		
	Personnel		
	Technicians/Laborers 72 PD		
	Subsistence allowance		$ 1,440
	Supplies and Support		$ 2,000
		SUBTOTAL	$ 3,440
	MAINTAIN MANUKA BAY ROAD		
	Personnel		
	Equipment operators 10 PD		
	Subsistence allowance		$ 200
	Supplies and Support		$ 2,000
		SUBTOTAL	$ 2,200
		TOTAL	**$ 5,640**

b. Nonnative Plant Control

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

Statement of the Problem: There are many nonnative plants present throughout the reserve. Figure 5 shows the distribution of some of the priority weeds encountered along the transects sampled during the 1989 survey.

Nonnative plants were widespread in the Lowland and Lower Pioneer management units. Some areas were dominated by nonnative species such as kukui (*Aleurites moluccana*), Christmas berry (*Schinus terebinthifolius*), guava (*Psidium guajava*), *Lantana camara*, natal redtop (*Rhynchelytrum repens*), molasses grass (*Melinis minutiflora*), kiawe (*Prosopis pallida*), koa haole (*Leucaena leucocephala*), and fountain grass (*Pennisetum setaceum*) (Figure 3).

Grasses such as fountain grass and broomsedge are known to increase fuel loads and fire frequency. Fountain grass was only found in the coastal area. Broomsedge was found in the lowland ohia forest on the southern side of the reserve. Control of fountain grass and broomsedge especially in areas in close proximity to high quality native dominated communities will help

reduce the risk of fire damage or destruction (See Fire Control program).

Common weeds in the Lama and 'Ohi'a Lowland Dry Forests of the Lowland management unit included Christmas berry, honohono kukui (*Oplismenus hirtellus*), Jamaican verbain (*Stachytarpheta jamaicensis*), *Lantana camara*, laua'e (*Phymatosorus scolopendria*), and guava.

In the Ohia management unit, several weeds were common. Weed infestation was heaviest in the lower elevations. Some of the more prominent weeds in the 'Ohi'a Lowland Mesic Forest included pamakani, *Desmodium* sp., Hilo grass (*Paspalum conjugatum*), sweet granadilla (*Passiflora ligularis*), guava, and thimbleberry (*Rubus rosifolius*). A localized infestation of shampoo ginger (*Zingiber zerumbet*) was present. A few trees planted at the Manuka State Park arboretum appeared to be spreading into the reserve including trumpet tree (*Cecropia peltata*).

In the 'Ohi'a Montane Mesic Forest, weeds were not as common but include pamakani, dogtail (*Buddleia asiatica*), Hilo grass, sweet granadilla, *Phaius tankervilliae*, and *Youngia japonica*. A localized infestation of banana poka (*Passiflora mollissima*) was present.

The communities in the Upper Pioneer management unit were not surveyed for weed infestation.

In the Kipuka management unit, weeds were infrequent. The most prominent weed in the Koa/'Ohi'a Montane Mesic Forest and 'Ohi'a Subalpine Dry Forest kipuka communities was meadow ricegrass (*Ehrharta stipoides*). Weeds were generally sparse on the pioneer vegetation on lava flows communities throughout the reserve. However, some weeds such as broomsedge (*Andropogon virginicus*), *Pluchea symphytifolia*, and pamakani were present.

<u>Consideration of Alternative Actions</u>:

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 reserve. In the rest of the reserve, control priority weeds as necessary to prevent their expansion in the reserve.

<u>Recommended Action</u>: Alternative #2 is recommended. Nonnative plant removal will be undertaken regularly during monitoring surveys, and along fencelines, jeep roads, and trails. Localized populations of invasive weeds such as banana poka and shampoo

ginger will be located and removed immediately before they spread. Nonnative dominated areas and large infestations of weeds such as fountain grass and guava will be monitored and controlled to prevent their further spread.

Strict sanitary procedures will be followed to prevent introduction of weeds by management personnel on their boots, clothing, and equipment. 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 will continue to 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/Laborers 80 PD		
	Subsistence allowance		$ 1,600
	Supplies		$ 2,000
		TOTAL	**$ 3,600**

Years 2-6: Same as year 1.

c. Other Nonnative Species

GOAL: To reduce the impact of other types of nonnative species (including mosquitoes, ants, yellow jackets, and fish) which could threaten the integrity of the native ecosystems within the reserve.

Statement of the Problem: Several nonnative invertebrates (mosquitoes, ants, yellow jackets (*Vespula* sp.)) were encountered during the 1989 survey that are of management concern. Mosquitoes are known to carry avian malaria, which has contributed to the decline of native forest bird populations (Van Riper et al. 1982). Ants are known to prey upon endemic invertebrates including native pollinators (Reimer 1990). Yellow jackets are of similar concern as they prey upon endemic invertebrates, some of which may be native pollinators (Beardsley 1980).

Little information is available regarding the status of these problem invertebrates in the reserve. Dr. Neil Reimer has

received a research grant from the Natural Area Reserves System Program to conduct a baseline survey of the ant fauna of all of the Natural Area Reserves. However, additional research is needed in order to determine the magnitude of the threat posed by these species, and recommend strategies for their control. Van Riper (1982) recommended limiting mosquito breeding sites by controlling feral pigs, which create wallows which eventually fill with water and become mosquito breeding sites; as well as actively pursuing removal of other sources of stagnant water within the vicinity of the reserve.

Also, nonnative fish were observed in the anchialine pond communities during the 1989 survey. Both native and nonnative fish are of management concern due to their effects on native invertebrates. Maciolek and Brock (1974) associated both nonnative and native fish presence with diminished populations of the shrimp 'opae'ula (*Halocaridina rubra*). Additional surveys are needed to document the resources of the anchialine ponds and determine the threat posed by native and nonnative fish.

Recommended Action: Encourage and where possible provide financial support for research into the status of potentially problematic nonnative species, and actively pursue management recommendations resulting from this research. The feral ungulate control program discussed above should help to reduce the breeding sites for mosquitoes. Removal of other stagnant water sources within the area should also be actively sought. Any *Vespula* nests found during management activities should be removed.

Cost/Workload Estimate: Costs are covered with other management programs.

2. MONITORING AND RESEARCH

GOAL: To monitor the state of the biological, cultural, and physical resources of the reserve; gauge the effectiveness of management projects; and promote research to guide management programs.

Statement of the Problem: The management programs discussed above were developed using only limited information from preliminary surveys. Additional research and survey work are needed to identify resources within the reserve, i.e. for the anchialine pond and lava tube communities, and well as invertebrate fauna. Monitoring and research will be necessary to determine the effectiveness of the management programs and identify additional management needs. Systematic monitoring at specific locations 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 due to poor understanding of the area's biological needs.

Recommended Action: Establish a systematic monitoring program and increase monitoring intensity for select problems and areas as needed. Continue to encourage and foster management related research throughout the Natural Area Reserves System by providing logistical support and financial assistant in the form of annual research grants.

Monitoring activities 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. An annual reconnaissance overflight is also recommended. Immediate goals of the monitoring program are to determine: 1) the effectiveness of hunting 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	40 PD	
	Technicians/Laborers	80 PD	
	Subsistence allowance		$ 2,400
	Supplies and Support		
	Helicopter charter for reconnaissance (2 hours at $600/hour)		$ 1,200
	Supplies and equipment		$ 5,000
		TOTAL	**$ 8,600**

Years 2-6:	Personnel		
	Professional	20 PD	
	Technicians/Laborers	40 PD	
	Subsistence allowance		$ 1,200
	Supplies and Support		
	Helicopter charter for reconnaissance (2 hours at $600/hour)		$ 1,200
	Supplies and equipment		$ 2,000
		TOTAL	**$ 4,400**

3. FIRE CONTROL

Goal: Prevent all wildfires in the reserve.

Statement of the Problem: Fire is a potential problem in this reserve. Dry to mesic conditions prevail throughout the reserve. High risk areas for fire ignition are Highway 11, which bisects the middle of the reserve; Manuka State Park, which provides camping facilities; and the Lower Pioneer management unit which

contains fountain grass and below which campers often frequent the coastal areas. Fountain grass and broomsedge in the Lower Pioneer management unit are a problem as they provide easily combustible fuel and resprout and increase their domain after successive fires.

Recommended Action: Establish a fire management plan for the reserve which will include the mapping of priority areas. Ensure NARS personnel are adequately trained for fire control. Establish contacts with other fire fighting agencies who could provide manpower and equipment in the event of a fire in Manuka. Control and if possible eradicate fountain grass and broomsedge infestations especially in areas in close proximity to high quality native dominated communities. Post signs in Manuka State Park and in the frequently used camping areas along the coast to warn of high fire risk.

Minimum impact methods of suppression should be applied whenever such methods are sufficient. Bulldozers could be used along all existing roads; however, bulldozing and other extreme fire control measures would not be justified within the reserve unless a fire cannot be otherwise controlled and the bulldozing damage is outweighed by a probable greater loss of natural and archaeological resources (NARS 1990). A fire cache should be established near the reserve at Kiolakaa cabin.

Cost/Workload Estimate:

Year 1:	DEVELOP FIRE MANAGEMENT PLAN		
	Personnel		
	Professional 30 PD		
	Supplies and support		
	Aerial reconnaissance (2 hours at $600/hour)		$ 1,200
	Miscellaneous supplies		$ 500
		SUBTOTAL	$ 1,700
	ESTABLISH FIRE CACHE		
	Personnel		
	Carpenter 5 PD		
	Laborers/Technicians 20 PD		
	Subsistence allowance		$ 500
	Supplies and Equipment		$ 3,000
	Maintain Kiolakaa Cabin		$ 800
		SUBTOTAL	$ 4,300
		TOTAL	**$ 6,000**
Years 2-6:	MAINTAIN FIRE CACHE/KIOLAKAA CABIN		
	Personnel		
	Laborers/Technicians 20 PD		
	Subsistence allowance		$ 400
	Supplies and Equipment		$ 1,500
		TOTAL	**$ 1,900**

4. PUBLIC EDUCATION AND VOLUNTEER SUPPORT

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

Statement of the Problem: Most residents and visitors in Hawaii are unaware of the Manuka Natural Area 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: Maintain a community outreach program to give public presentations, provide informational material, and coordinate volunteer projects.

Inform the general public, especially local residents, about resources within the reserve and current management activities through presentations, media outlets, guided hikes, and brochures/guides. Place informational signs along roadsides and in Manuka State Park.

Volunteer reserve managers with varying levels of involvement could play a substantial role in maintaining trail systems, assisting in plant and animal control work, informing and educating the community, and reporting illegal uses.

Volunteer groups have already participated in the establishment and maintenance of a loop trail which begins and ends at Manuka State Park. A nature trail guide is being completed to accompany the trail which will be posted with marker signs to identify plants or archaeological sites of interest.

Cost/Workload Estimate:

Year 1:	Personnel		
	Professional 15 PD		
	Educational materials		
	Nature Trail Guide		$ 2,000
	Informational Signs		$ 2,000
	Supplies		$ 1,000
		TOTAL	**$ 5,000**

Year 2:	Personnel		
	Professional 10 PD		
	Supplies		$ 1,000
		TOTAL	$ 1,000
Year 3:	Personnel		
	Professional 20 PD		
	Educational materials		
	Brochure		$ 6,000
	Nature Trail Guide replacements		$ 2,000
	Informational Signs replacements		$ 2,000
	Supplies		$ 1,000
		TOTAL	$11,000
Years 4-6:	Personnel		
	Professional 10 PD		
	Supplies		$ 1,000
		TOTAL	$ 1,000

D. Boundary Administration

Participation and cooperation among adjacent landowners is an important factor for effective management of the Manuka reserve. The reserve is isolated between developing residential lands and agricultural lands. Mac Farms along the western boundary may be interested in pursuing cooperative ungulate control. Adjacent landowners and nearby residential community associations should be kept informed of ongoing management activities in the reserve. Roads through Ocean View Estates Subdivision are privately owned and maintained and permission should be sought for their use to access the eastern side of the reserve.

E. Permitted Uses and Enforcement

The reserve's trails and jeep roads are well utilized by hunters, hikers and fishermen; camping is common along the beach below the lower reserve boundary.

Marijuana cultivation and hardwood removal are the two most obvious illegal activities occurring in the reserve. The Division of Conservation and Resources Enforcement marijuana eradication project frequently targets Manuka. Encouraging nearby residents to watch for and report violations may help to prevent hardwood removal.

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.

The budget summary below does not include the administrative, clerical, computer and other expenses that are part of the overall budget costs for a state-wide NARS program. Required personnel time is tallied; 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. Starting with year 2, a 10% inflation increase is incorporated into every annual total.

MANUKA BUDGET SUMMARY

MANAGEMENT PROGRAM	* YR 1	* YR 2	* YR 3	* YR 4	* YR 5	* YR 6*
Ungulate Control Fence Construction & Maintenance	160,000	161,640	3,280	3,280	3,280	3,280
Ungulate Removal	15,620	15,620	15,620	15,620	15,620	15,620
Access Improvement	8,460	5,640	5,640	5,640	5,640	5,640
Nonnative Plant Control	3,600	3,600	3,600	3,600	3,600	3,600
Monitoring	8,600	4,400	4,400	4,400	4,400	4,400
Fire Control	6,000	1,900	1,900	1,900	1,900	1,900
Public Education	5,000	1,000	11,000	1,000	1,000	1,000
TOTAL	207,280	213,180	54,528	46,072	49,616	53,160

PERSONNEL (PD = person days)

Year 1

Professional	116 PD
Technician/Laborer	372 PD
Equipment Operator	10 PD
Carpenter	5 PD

Year 2

Professional	54 PD
Technician/Laborer	280 PD
Equipment Operator	10 PD

Year 3

Professional	64 PD
Technician/Laborer	312 PD
Equipment Operator	10 PD

Years 4-6

Professional	54 PD
Technician/Laborer	312 PD
Equipment Operator	10 PD

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APPENDIX 1
NATURAL COMMUNITIES OF MANUKA NATURAL AREA RESERVE

Natural Community	HHP Rank[1]	Acreage[2]
Vegetated Communities:		
'A'ali'i Lowland Dry Shrubland	3	120
Fimbristylis Coastal Dry Grassland	3	+
'Ilima Coastal Dry Shrubland	3	+
*Koa/'Ohi'a Montane Mesic Forest	1	+
Lama Lowland Dry Forest	3	820
Lama/'Ohi'a Lowland Mesic Forest	3	680
Nonnative Dominated	N	2,840
'Ohi'a Lowland Dry Forest	3	3,510
'Ohi'a Lowland Mesic Forest	3	3,530
'Ohi'a Montane Mesic Forest	3	1,350
'Ohi'a Subalpine Dry Forest	3	+
*Pili Lowland Dry Grassland	2	+
Pioneer Vegetation on Lava	3	12,700
Pukiawe Subalpine Dry Shrubland	3	+
Non-vegetated Communities:		
*High Salinity Anchialine Pool	2	+
Low Salinity Anchialine Pool	3	+
Uncharacterized Lowland Lava Tube	U	+
Uncharacterized Montane Lava Tube	U	+

*Rare Natural Community

[1] Key to Hawaii Heritage Program Ranks:
1 = Critically imperilled globally (typically 1-5 occurrences)
2 = Imperilled globally (typically 6-20 occurrences)
3 = Restricted range (typically more than 20 occurrences)
U = Uncertain, insufficient information for ranking
N = Nonnative community, no ranking

[2] Acreages are based on vegetation types mapped in Figure 2. Due to mapping and surveying constraints, complex transitions between communities, or small patches of communities within others, are not accounted for.

+ community occurs in patches too small to measure accurately

APPENDIX 2
RARE PLANTS OF MANUKA NATURAL AREA RESERVE

Scientific Name[1] Former Name[2] (Common Name)	Current (Historic) Occurrences[3]	Federal Status[4]	HHP Rank[5]
**Bobea timonioides* ('ahakea)	1(0)	C1	2
**Colubrina oppositifolia* (kauila, kauwila, o'u)	1(0)	C1	1
Diellia erecta (-)	0(1)	C1	2
**Flueggea neowawraea* *Neowawraea phyllanthoides* (mehamehame)	2(0)	- C1	1
Neraudia ovata (-)	0(1)	C1	1-2
Pelea hawaiensis (alani)	1(0)	C1	2
Tetramolopium consanguineum ssp. *leptophyllum* var. *kauense* (-)	1(0)	-	1

* Observed during 1989 survey.

[1] Pteridophytes from Wagner and Wagner Jr. (1987)
Flowering Plants from Wagner et al. (1990)

[2] Following taxonomy used in 1985 Federal Register

[3] Current occurrences reported since 1973

[4] Key to Federal Status (USFWS 1985):
C1 Candidate for endangered or threatened status
- No federal status. Recommended 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)

APPENDIX 3
RARE VERTEBRATES OF MANUKA NATURAL AREA RESERVE

Scientific Name (Common Name)	Population Estimate Big Island[1]	Federal Status[2]	HHP Rank[3]
Corvus hawaiiensis ('alala, Hawaiian crow)	<6	LE	1
**Lasiurus cinereus semotus* ('ope'ape'a, Hawaiian hoary bat)	NA	LE	2-3?
**Buteo solitarius* ('io, Hawaiian hawk)	1400-2500	LE	2

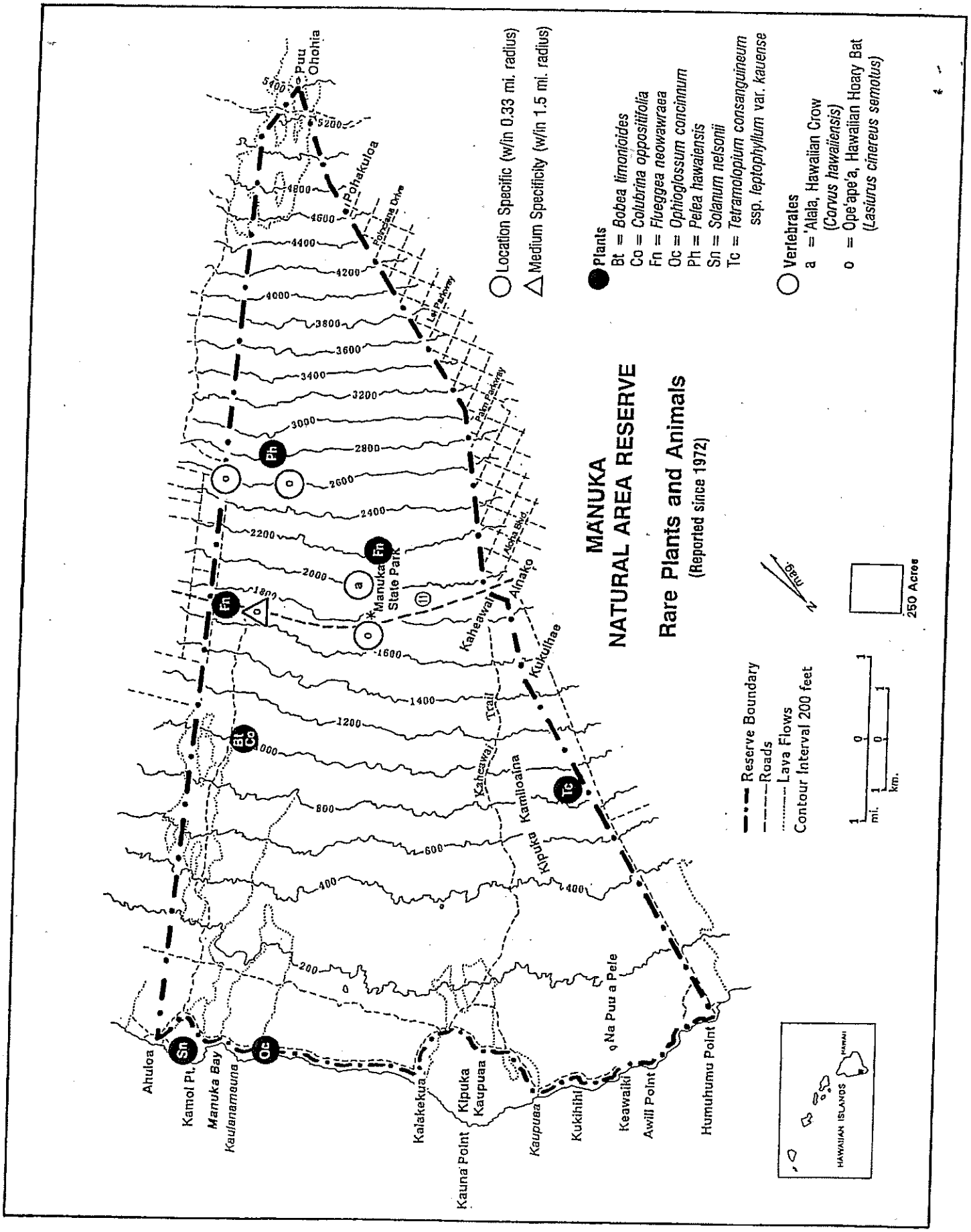
* Observed during 1989 survey

[1] Estimates for *Corvus* from DOFAW 1988; *Lasiurus* not available; *Buteo* from Griffin 1984.

[2] Key to Federal Status (USFWS 1989):
LE Endangered

[3] Key to Hawaii Heritage Program Ranks:
1 Critically imperilled globally (fewer than 1,000 individuals)
2 Imperilled globally (typically 1,000 - 3,000 individuals)
3 Restricted range (typically 3,000-10,000 individuals)
? Not enough information available to determine

Appendix 4


MANUKA
NATURAL AREA RESERVE
Rare Plants and Animals
(Reported since 1972)
Location Specific (w/in 0.33 mi. radius)
Medium Specificity (w/in 1.5 mi. radius)
Plants
Bt = Bobea timonioides
Co = Colubrina oppositifolia
Fn = Flueggea neowawraea
Oc = Ophioglossum concinnum
Ph = Pelea hawaiensis
Sn = Solanum nelsonii
Tc = Tetramolopium consanguineum ssp. leptophyllum var. kauense
Vertebrates
a = 'Alala, Hawaiian Crow (Corvus hawaiiensis)
o = Ope'ape'a, Hawaiian Hoary Bat (Lasiurus cinereus semotus)
Reserve Boundary
Roads
Lava Flows
Contour Interval 200 feet
250 Acres
mag.
N
Puu Ohohia
Pohakuloa
Poinciana Drive
Lei Parkway
Palm Parkway
Aloha Blvd.
Manuka State Park
Kaheawai
Alnako
Kukuihae
Trail
Kaheawai
Kamiloaina
Kipuka
Na Puu a Pele
Ahuloa
Kamoi Pt.
Manuka Bay
Kaulanamauna
Kalakekua
Kipuka Kaupuaa
Kauna Point
Kaupuaa
Kukihihi
Keawaiki
Awili Point
Humuhumu Point
HAWAIIAN ISLANDS
HAWAII