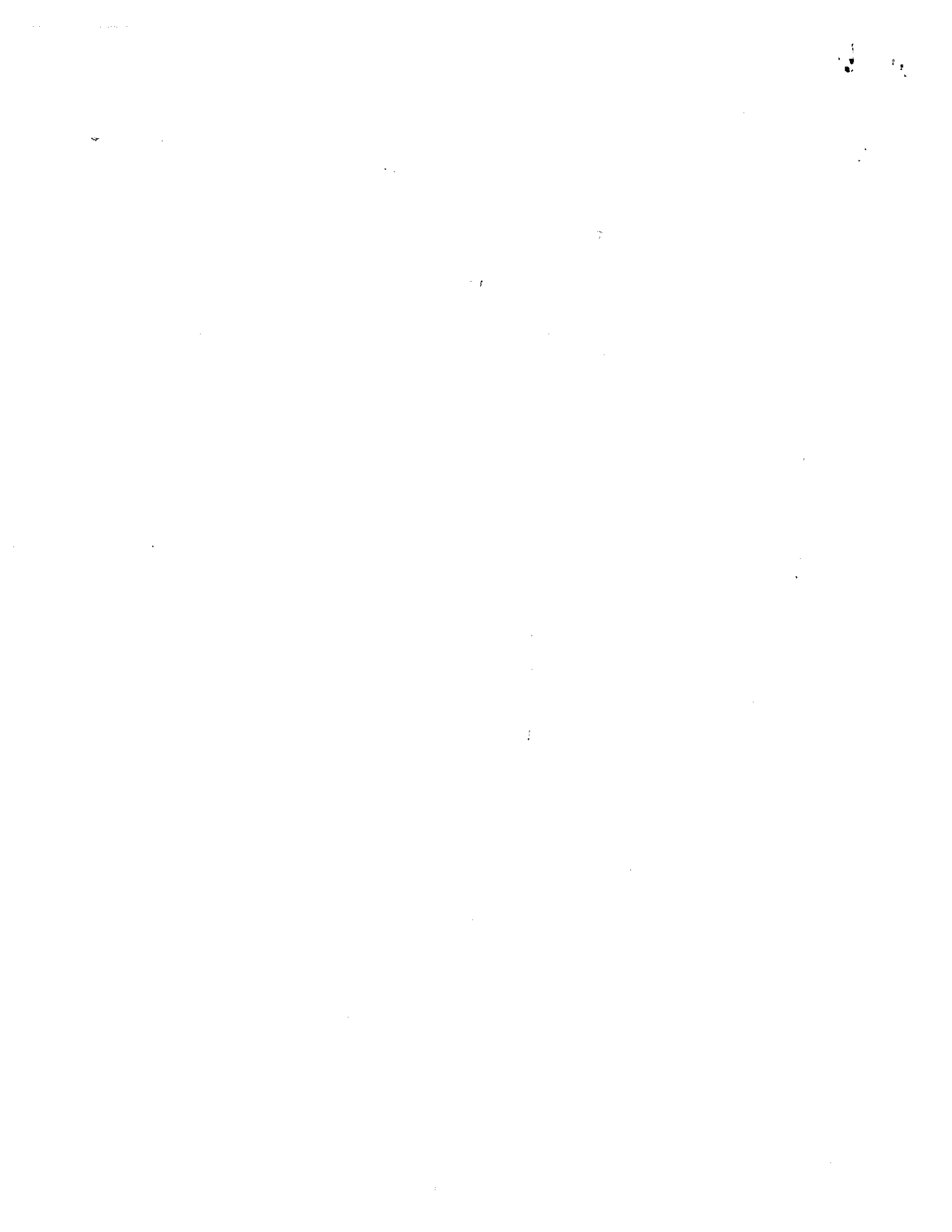


MOUNT KAALA
NATURAL AREA RESERVE
MANAGEMENT PLAN

Natural Area Reserves System Program

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

April 1990



EXECUTIVE SUMMARY

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). This plan describes the management program for the 1,100-acre Mount Kaala Natural Area Reserve, established in 1981 by Executive Order 3099. The reserve protects a diversity of native ecosystems, including native shrublands, forests, and a montane bog.

The reserve is located in the Waianae Mountains on the island of Oahu. It encompasses the island's highest point, Mount Kaala, at 4,020 feet elevation and descends to 1,200 feet elevation. Ten native communities and four non-native communities were observed in the Mount Kaala reserve during this August 1988 survey. The communities ranged from dry lowland shrublands to wet montane forests, and included two rare forests.

Because of the size of the reserve, priorities for intensive management of key areas are based on the biological resources and the threats to those resources. Important biological resources in the reserve include the montane bog community at the summit of Mount Kaala. Management activity over the next six years will focus on protecting the forests from feral pigs and removing priority weed species from intact portions of natural communities. The effectiveness of management projects will be determined through long-term scientific monitoring.

A six-year implementation schedule is proposed to accomplish management objectives. The annual budget averages \$47,000 over this time period. Once the pig threat is reduced, annual management costs should decrease.

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Mount Kaala Natural Area Reserve

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MOUNT KAALA 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 is legally mandated 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 195-1). To date, there are 18 reserves on 5 islands, occupying more than 108,000 acres of the state's most biologically diverse ecosystems.

This plan describes the management program at the 1,100 acre Mount Kaala Natural Area Reserve, established in 1981 by Executive Order #3099. The reserve was established to protect a pristine mountain bog, which is at the highest point on the island of Oahu, as well as other native forest and shrubland communities. The plan consists of five parts:

- o a brief Introduction to acquaint the reader with the project and how the plan was prepared;
- o a Resources Summary describing the natural resources within the reserve;
- o a Management plan describing programs recommended to maintain the reserve's resources with an analysis of alternative actions and impacts;
- o a Budget Summary listing the funds necessary to carry out the management plan; and
- o Appendices describing resource information in more detail.

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 field inventory conducted in August 1988, specifically designed to collect data relevant to management of the reserve's natural resources. The third was a review of this plan by qualified managers, planners, and biologists familiar with the area and its problems.

Survey crews spent four field days gathering data along five transects, ranging from 985-1,475 feet in length, and at one

supplemental station (Appendix 1 and Figure 1). Transects were intended to sample the range of natural vegetation types determined from aerial photos. Detailed field forms were completed at sampling stations every 165 feet, noting the presence of natural communities, rare plants, native birds, feral ungulates, and weeds (Appendix 2). Aerial reconnaissance was used to collect vegetation cover information in the steeper sections of the reserve's interior, where no transects were established.

This survey was designed to gather management-oriented resource information over a large area in a short time period, and was not intended to be a comprehensive biological inventory. Sampling of small mammals, birds, and insects was incidental rather than systematic. An in-depth search for land snails was conducted on four of the five transects by a trained malacologist. Detailed survey methods are available upon request. Plant species currently known from the reserve are listed in Appendix 3; a list of bird species is in Appendix 4.

This plan is intended to establish long-range goals and management priorities at Mount Kaala Natural Area Reserve, and to describe specific program and activities to be accomplished during the next six years. This plan will be updated biannually to incorporate new knowledge and refine management concepts.

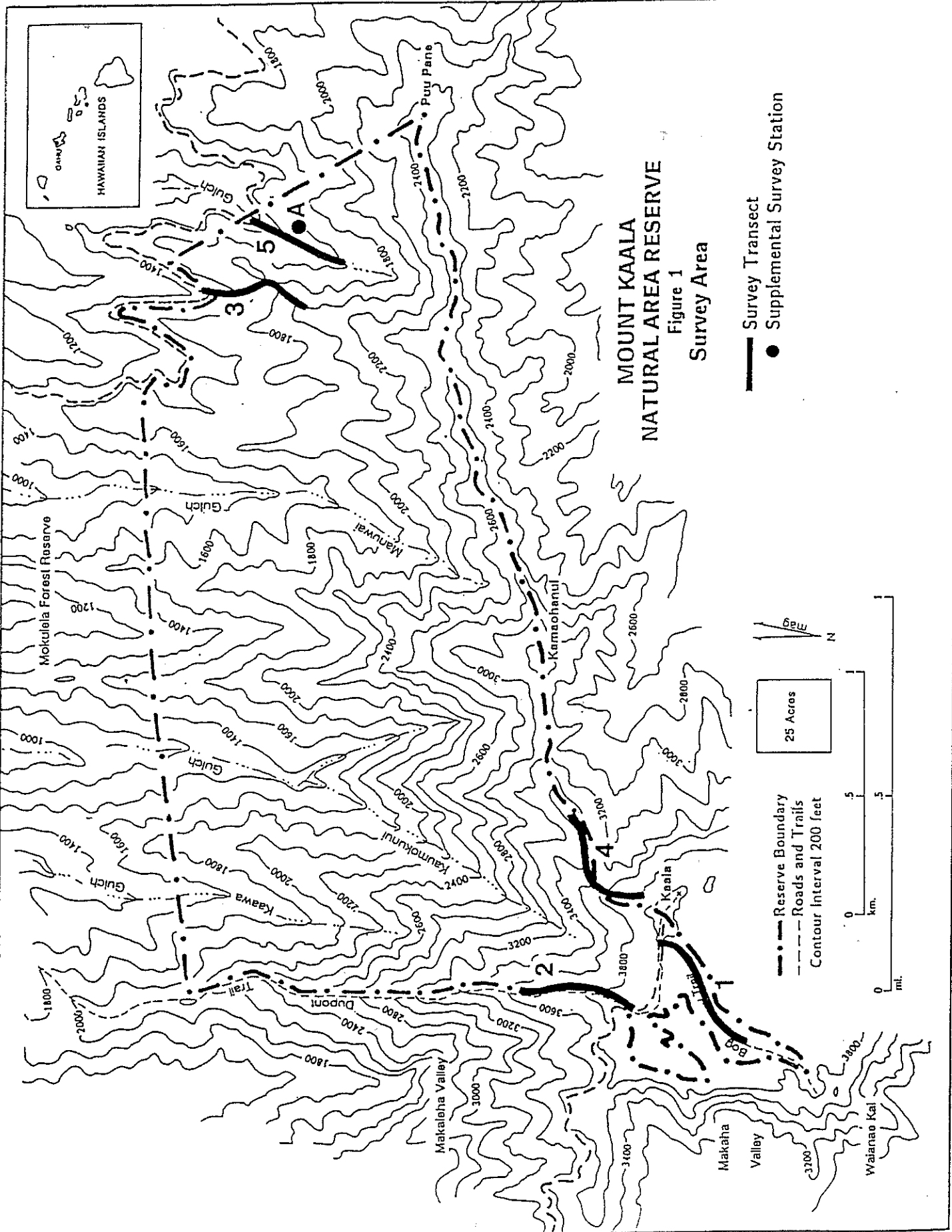
II. RESOURCES SUMMARY

A. General Setting



Mount Kaala Natural Area Reserve occupies 1,100 acres in the Waianae Mountains, stretching from 1,200 feet to the top of Mount Kaala, the highest point on Oahu at 4,020 feet elevation. Rainfall in the area averages 60-80 inches annually, with only 2-3 inches falling in the driest month and 8-12 inches falling in a wetter winter month (Giambelluca, Nullet, and Schroeder 1986). The reserve is adjacent to the Mokuleia and Waianae Kai Forest Reserves. The summit plateau was formed by hundreds of feet of dense a'a (Hawaiite) lava flows, and remains a very slightly eroded remnant of the original volcano which created the Waianae Mountains. Access is by a restricted paved road, the use of which is regulated by the FAA and Hawaii Air National Guard.



B. Flora


Fourteen vegetation types are known from the Mount Kaala Natural Area Reserve (Table 1). Of these, four are dominated by non-native plant communities. Two of the native-dominated communities, Lonomea (Sapindus oahuensis) Lowland Dry Forest and Oahu Diverse Mesic Forest, are considered rare and occupy only




**MOUNT KAALA
NATURAL AREA RESERVE**
Figure 1
Survey Area

-  Survey Transect
-  Supplemental Survey Station

 Reserve Boundary
 Roads and Trails
 Contour interval 200 feet

 N
 mag

 25 Acres

0 5 5
 0 km. 5
 0 1
 0 mi.

small areas of the reserve. For the purposes of this management plan, a species or natural community is considered rare if it is known from 20 or fewer locations worldwide, or less than 3,000 individuals. Due to changes in taxonomy, some taxa currently listed as candidate species in the most recent Federal Register may no longer be considered rare by the Hawaii Heritage Program, and their federal status is being reevaluated (Herbst pers. com.).

TABLE 1
NATURAL COMMUNITIES OF MOUNT KAALA NATURAL AREA RESERVE

| Natural Community | HHP Rank ¹ | Acreage ² |
|---|-----------------------|----------------------|
| 'A'ali'i Lowland Dry Shrubland | 3 | 44 |
| Christmas Berry Lowland Dry Shrubland | E | 341 |
| Koa/'Ohi'a Lowland Mesic Forest | 3 | + |
| Kukui Lowland Wet Forest | E | 198 |
| Lama Lowland Dry Forest | 3 | ++ |
| * Lonomea Lowland Dry Forest | 1 | x |
| Mixed Shrub/Fern Montane Wet Cliffs | 3 | 176 |
| Molasses Grass Lowland Dry Grassland | E | ++ |
| * Oahu Diverse Lowland Mesic Forest | 1 | x |
| 'Ohi'a Montane Wet Shrubland | 3 | 341 |
| 'Ohi'a/Uluhe Montane Wet Forest | 3 | ++++ |
| 'Ohi'a/'Olapa and Lapalapa Montane Wet Forest | 3 | +++++ |
| 'Ohi'a/Mixed Shrub Montane Wet Forest | 3 | +++++ |
| Toon Lowland Mesic Forest | E | +++ |

* Rare Natural Community

¹ Key to Hawaii Heritage Program Ranks:

- 1 Critically imperilled globally (typically 1-5 occurrences)
- 3 Restricted range (typically 21-100 occurrences globally)
- E Exotic; non-native community

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.

- x Acreage too small or scattered to accurately estimate
- + Acreage included in 'A'ali'i Lowland Dry Shrubland
- ++ Acreage included in Christmas Berry Lowland Dry Shrubland
- +++ Acreage included in Kukui Lowland Wet Forest
- ++++ Acreage included in Mixed Shrub/Fern Montane Wet Cliffs
- +++++ Acreage included in 'Ohi'a Montane Wet Shrubland

The reserve's natural communities show a distribution determined by altitude, moisture and topography (Figure 2). 'Ohi'a (Metrosideros polymorpha)-dominated forests occupy the flat-topped summit of Mount Kaala, and extend east, then north, on ridges leading from the summit. On exposed, narrow ridges near the summit, a dense shrubland dominated by 'ohi'a grades into a mixed fern/shrub community on the steepest ridge sides.

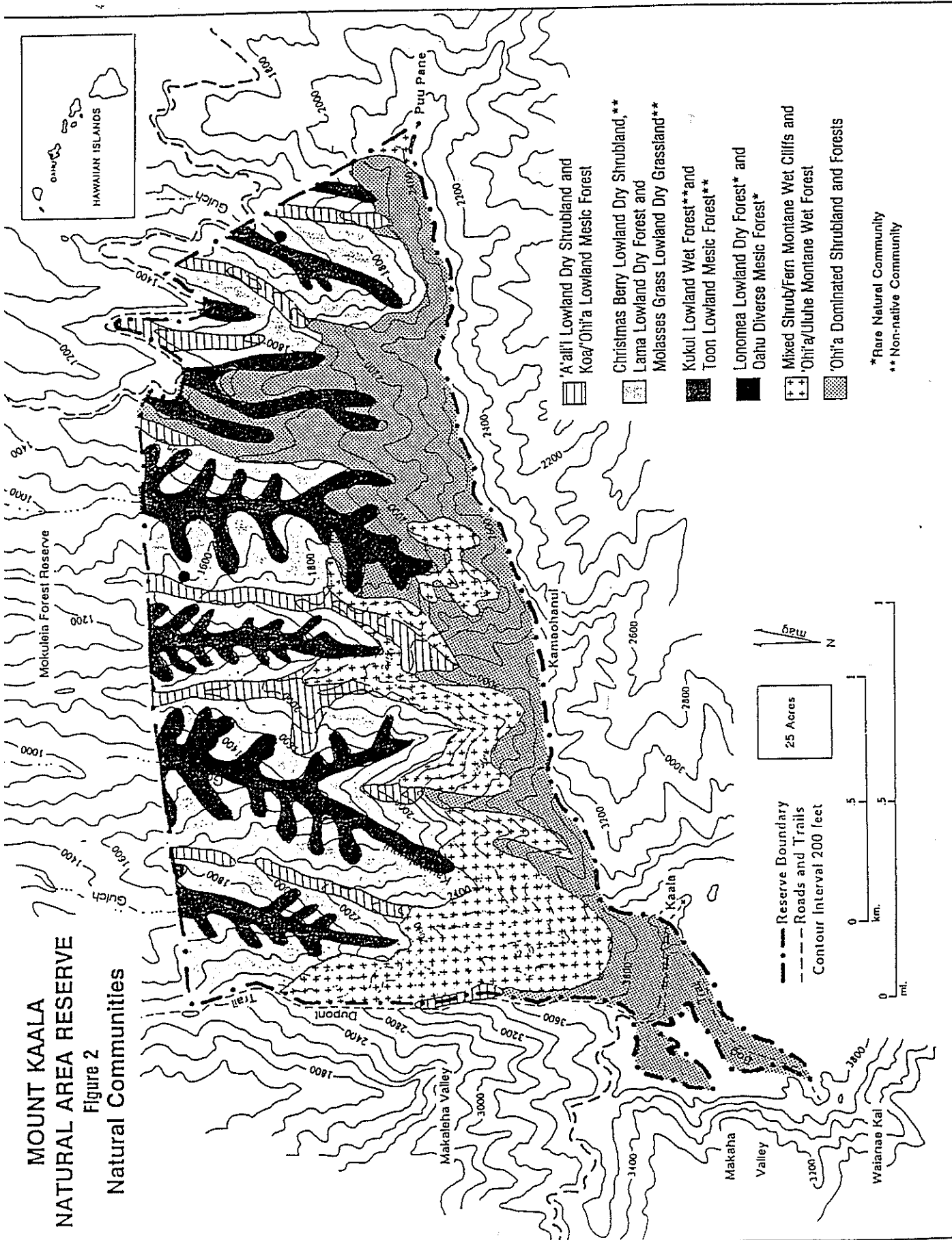
On steep to moderate slopes below about 3,000 feet elevation, 'ohi'a/uluhe (usually Dicranopteris linearis) forest and uluhe shrubland predominate, while on ridge tops, 'ohi'a forest grades into koa (Acacia koa)/'ohi'a forest and 'a'ali'i (Dodonaea viscosa) shrubland. Koa/'ohi'a forest and 'a'ali'i shrublands persist on the ridge tops to the reserve's lower elevations (north), but become degraded by non-native species.

On the slopes below about 2,000 feet, lama (Diospyros spp.) forest, and the rare Oahu diverse mesic and lonomea forests, grade into a variety of non-native vegetation. Christmas berry (Schinus terebinthifolius) shrublands and molasses grass (Melinis minutiflora) grasslands occupy drier slopes; kukui (Aleurites moluccana) forests and toon (Toona ciliata var. australis) forests occupy the wetter gulch bottoms. Other non-native vegetation that forms scattered stands in parts of the reserve includes silk oak (Grevillea robusta), Java plum (Syzygium cumini), and guava (Psidium spp.).

Wet forests above 3,000 feet elevation dominated by 'ohi'a (Metrosideros polymorpha and M. tremuloides) and 'olapa (Cheirodendron trigynum) and/or lapalapa (Cheirodendron platyphyllum) are known from all the major Hawaiian Islands. In the reserve, the 'ohi'a/'olapa or lapalapa montane wet forests observed were restricted to the summit plateau and highest ridges. Lapalapa was the prevalent Cheirodendron on the summit plateau, while a mix of lapalapa and 'olapa was seen on the ridges. The canopy reached 33 feet in height, but was usually less than 17 feet high. Large tree snags (8-16 inches in diameter), probably 'ohi'a, suggested past dieback; the low stature canopy may represent a regenerative phase. Associated canopy species included kawa'u (Ilex anomala), kolea (Myrsine sandwicensis and M. lessertiana), alani (Pelea clusiifolia and other species) and hapu'u (Cibotium glaucum and C. chamissoi). Shrub species noted during this field survey included alani, pukiaue (Styphelia tameiameia), 'ohelo kau la'au (Vaccinium calycinum), pu'ahanui (Broussaisia arguta), na'ena'e (Dubautia laxa ssp. hirsuta), and pilo (Coprosma ochracea). Native ferns included akolea (Athyrium microphyllum), Dryopteris glabra, Asplenium contiguum, 'ae (Polypodium pellucidum), and 'ama'u (Sadleria pallida). The ground cover was moss-dominated. On the summit plateau, an introduced Sphagnum sp. was sometimes abundant, especially in poorly drained, disturbed areas.

MOUNT KAALA NATURAL AREA RESERVE

Figure 2
Natural Communities



'Ohi'a Montane Wet Shrublands in the reserve were observed on the tops of very steep, cloud-shrouded slopes just below the summit plateau. The shrublands were wind-swept and low-statured. Sparse emergent trees of 'ohi'a, 'olapa, lapalapa, 'ohi'a ha (Syzygium sandwicensis) were observed, especially in the transition between the shrubland and adjacent forest vegetation. Other common associates of the 'ohi'a shrubland included pu'ahanui, pukiawe, alani, kolea, manono (Hedyotis terminalis), 'ohelo kau la'au, pilo, 'uki (Machaerina angustifolia), olomea (Perrottetia sandwicensis), and kawa'u. Native ferns such as 'ama'u, Dryopteris glabra, akolea, pala'a (Odontosoria chinensis), uluhe, uluhe lau nui (Diplopterygium pinnatum), hapu'u pulu (Cibotium glaucum), and wawae'iole (Lycopodium cernuum and L. venustum) were also well-represented. A variety of mosses, liverworts and smaller ferns may grow under the shrub canopy, and herbs such as 'ala'alawainui (Peperomia macraeana) were also present.

The 'Ohi'a/Mixed Shrub Montane Wet Forest observed during this survey formed a mosaic with 'ohi'a/'olapa or lapalapa forest and 'Ohi'a Montane Wet Shrubland on ridge tops. The 'ohi'a canopy of this forest usually exceeded 15 feet, but graded into the adjacent lower-stature shrublands. The canopy also included kawa'u, 'olapa, lapalapa, kolea, alani, and pilo. Under the tree layers, tree ferns (hapu'u) were occasionally present, but a well-developed native shrub layer was prominent. The shrub layer included species such as 'ohelo kau la'au, pu'ahanui, pukiawe, kamakahala (Labordia fagraeoides), manono, alani, kolea, koli'i (Trematolobelia macrostachys), pilo (Coprosma ochracea and C. longifolia), and saplings of 'ohi'a, lapalapa, and 'olapa.

Native fern development was also good, including ho'i'o (Athyrium sandwichianum), akolea, 'ae, wahine noho mauna (Adenophorus spp.), Asplenium contiguum, Dryopteris glabra, and pala'a. The herb layer contained mosses, liverworts, seedlings of a variety of plants and 'ala'alawainui. Native vines included hoi kuahiwi (Smilax melastomifolia) and 'ie'ie (Freycinetia arborea). Two native mints, Phyllostegia lantanoides and P. grandiflora, were also common, vining through the shrub layer. Epiphytes were well developed, including a variety of mosses, liverworts and ferns. In pig-disturbed areas, certain sensitive species such as pa'iniu (Astelia menziesiana) could only be found as epiphytes.

The Mixed Shrub/Fern Montane Wet Cliff community seen during the survey formed the vegetation on the steepest slopes above 3,000 feet elevation. Dominant species included 'ama'u, uluhe and uluhe lau nui, hapu'u and hapu'u pulu, ho'i'o and other ferns. These more dominant species formed a mosaic with common native shrubs such as 'ohi'a, pu'ahanui, and pilo. Occasionally, shrubs such as na'ena'e, 'ohelo kau la'au, kamakahala, koli'i, alani, mamaki (Pipturus albidus), manono, and 'ape'ape (Gunnera

petaloidea) were present. On the steepest wet slopes adjacent to waterfalls, 'uki was locally abundant. A variety of mosses, liverworts and smaller ferns may grow under the mixed fern and shrub canopy, and herbs such as 'ala'alawainui were also present. The steep slopes on which the mixed fern/shrub community grows are subject to erosion, and can be sites for non-native plant invasions.

Some of the steep slopes covered with uluhe or uluhe lau nui were under an open canopy of 'ohi'a. In this 'Ohi'a Montane Wet Forest, the fern mat reached a thickness in excess of 10 feet. Relatively few other native species can compete with the fast-growing mat ferns, however, scattered trees of 'olapa, lapalapa, and alani (Pelea penduncularis) were occasionally present, as well as a few hapu'u. Native shrubs and other low-growing plants were generally absent from this community because of the thick uluhe mat, however, native vines such as the native mint Phyllostegia spp., were sometimes present.

Lowland mesic forests dominated by koa and 'ohi'a are known from many sites on Kauai and Oahu. Although none of the survey transects passed through intact Koa/'Ohi'a Lowland Mesic Forest, patches of the community were observed through binoculars on some of the ridge tops leading from the summit to the northeast. The largest of these patches was in the vicinity of Puu Pane. A relatively simple understory of mixed shrubs, including 'a'ali'i, pukiaawe, and other mesic species are typically found in this natural community.

'A'ali'i Lowland Dry Shrublands seen during this survey extended from about 2,000 feet elevation to the lowest portions of the reserve on ridge tops. Though not particularly diverse, these shrublands included native shrubs such as pukiaawe, 'ohi'a, ferns such as pala'a, and lichens such as Cladonia. Dryland mosses were present in crevices of rocky sections of the ridge, under the shade of vegetation. The shrublands were bordered by koa/'ohi'a or 'ohi'a forests above, and by non-native dryland vegetation below. Adjacent native vegetation on the ridge sides below 'a'ali'i shrubland included lowland dry forests dominated by lama or lonomea. Outside of the reserve, small patches of wiliwili (Erythrina sandwicensis) forest on ridge slopes occurred adjacent to 'a'ali'i shrubland. Non-native vegetation encroaching on the 'a'ali'i shrubland included Christmas berry, molasses grass, guava (Psidium guajava), and Java plum (Syzygium cumini), as well as a variety of other grasses, shrubs and herbs at lower elevations.

Patches of Lama Lowland Dry Forest occupied nearly every gulch in the reserve's eastern portion, on steep talus slopes with variable soil development. However, the patches were usually surrounded by non-native vegetation dominated by kukui, toon, Christmas berry, or Java plum. The lama canopy was

usually closed and of medium stature (ca. 15 feet). Few other trees shared the canopy but olopua (Nestegis sandwicensis), mehame (Antidesma pulvinatum), lonomea, and alahe'e (Canthium odoratum) were present. The understory was sparse, and, as in many dry and mesic forests, included palapalai (Microlepia strigosa), and two native sedges often associated with mesic forest, Carex wahuensis and C. meyenii. Non-native understory elements included the ferns Blechnum occidentale and Thelypteris spp., and invading shrubs and trees included guava, Christmas berry, toon and Java plum.

Below 3,000 feet elevation, on the sides of low ridges of Oahu's Waianae Mountains, fewer than 10 examples of the rare Oahu Diverse Lowland Mesic Forest exist. In this rare mesic forest, the canopy contains a diverse blend of tree species, with no single species dominant; instead, five to eight different tree species may be co-dominant. Similar, but distinct diverse forests are known from Lanai and Kauai, and they are also considered rare.

Although no examples of Oahu Diverse Mesic Forest were encountered during the survey, patches of this rare diverse forest type are known within the reserve boundary. One such patch was last observed and described in 1986 above Manuwai Gulch (Perlman 1986). During the 1986 observations, the forest patch was on an east-facing slope, adjacent to lama forest and above kukui forest in the gulch bottom and contained lama, lonomea, mehame, ahakea (Bobea elatior and the rare B. sandwicensis), 'ohi'a, papala kepau (Pisonia sandwicensis), aulu (Pouteria sandwicensis), halapepe (Pleomele halapepe and the rare P. forbesii), Cyanea angustifolia, kalia (Elaeocarpus bifidus), kolea, olopua, kopiko (Psychotria mariniana), hao (Rauvolfia sandwicensis), 'ohe (Tetraplasandra oahuensis), mehamehame (Flueggea neowawraea, a rare tree), 'ie'ie, Hedyotis acuminata, and unspecified native ferns. Other scattered patches of this forest type probably exist on the steeper slopes in the reserve.

Examples of Lonomea Lowland Dry Forest were observed in the reserve on lower ridge slopes, near gulch bottoms on boulder substrate with variable soil development. The lonomea forest community was often heavily invaded by non-native trees and plants that displaced lonomea, such as kukui in gulch bottoms, and toon, guava, Java plum, and Christmas berry, which invaded ridge slopes. There was one patch of lonomea forest found exceeding 5 acres in size that maintained native-dominated (greater than 60 percent) cover. Lonomea-dominated patches in the reserve contained other native trees such as lama, olopua, mehame, alahe'e, and papala (Charpentiera obovata). A rare ahakea tree (Bobea sandwicensis) was observed in intact and kukui-degraded examples of lonomea forest in the north-east corner of the reserve, and in Palikea Gulch. The ground cover of lonomea forest in the reserve was not well developed, consisting

of seedlings and saplings of the most common native trees, and a few ferns such as the native palapalai and non-native Blechnum occidentale, Thelypteris dentata and T. parasitica.

Oahu is the second oldest of the seven major islands, and its highly dissected topography has resulted in very localized distributions of many species. Oahu has the largest percentage (27.3 percent) of candidate plant taxa in the state (Wagner et al. 1985). Of the 67 rare plant taxa reported from the Mount Kaala reserve area, 37 have been verified within the reserve boundary, 14 of which have been seen recently (since 1972) (Table 2). The other 30 taxa are known from adjacent areas. Five other rare taxa (Pelea sandwicensis, Plantago princeps var. longibracteata, Schiedea kaalae, Vandenboschia draytoniana, and Viola chamissoniana ssp. chamissoniana) are reported in literature for the reserve area, but location information is insufficient to list definitively as in the reserve or immediately adjacent (Appendix 3).

Due to changes in taxonomy, some taxa currently listed as candidate species in the most recent 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.

None of the 37 rare plant taxa reported to occur in the Mount Kaala reserve is officially listed as endangered by the U.S. Fish and Wildlife Service (1987). One of these taxa, uhiuhi (Caesalpinia kavaiensis), was proposed endangered under previous taxonomic treatment.

Three of the 37 rare plant taxa confirmed within the reserve were seen during the survey (Table 2 and Figure 3). Four vigorous plants of Abutilon sandwicense were observed west of Palikea Gulch, in degraded Lonomea Lowland Dry Forest. This taxon is a tall shrub with whitish hairs, and bright green pendant flowers. It is found only in the dry forests of the Waianae Mountains of Oahu (Wagner et al. 1990).

Two populations of Bobea sandwicensis were observed during the survey. One tree was observed where the Abutilon sandwicense was seen, and four other mature trees and one sapling were also observed in the Lonomea Lowland Dry Forest of Palikea Gulch. This taxon has small, inconspicuous flowers, which sometimes are functionally unisexual. It is found on Oahu, Molokai, Lanai, and Maui (Wagner et al. 1990). Two plants of Diellia falcata were seen in the Lonomea Lowland Dry Forest of Palikea Gulch, at the same location as Bobea sandwicensis. This fern is found only on Oahu (Wagner and Wagner 1987).

TABLE 2
RARE PLANTS OF MOUNT KAALA NATURAL AREA RESERVE

| scientific Name ¹ Former Name ² (Common Name) | Current (Historic) Occurrences ³ | Federal Status ⁴ | HHP Rank ⁵ |
|---|--|--------------------------------|--------------------------|
| <u>Abutilon sandwicense</u> (-) | 1(1) | C1 | 1 |
| <u>Alectryon macrococcus</u> var. <u>macrococcus</u> <u>A. macrococcum</u> (mahoe) | 0(2) | - C1 | 2 |
| <u>Alsinidendron trinerve</u> (-) | 0(1) | C1 | 1 |
| <u>Bobea sandwicensis</u> ('ahakea) | 3(0) | - | 2 |
| <u>Caesalpinia kawaiensis</u> <u>Mezoneuron kawaiense</u> (uhiuhi) | 1(0) | - PE | 1 |
| <u>Cenchrus agrimonioides</u> var. <u>agrimonioides</u> (kamanomano) | 0(1) | - | 1 |
| <u>Colubrina oppositifolia</u> (kauila) | 0(1) | C1 | 1 |
| <u>Stenitis squamigera</u> (-) | 0(1) | C1 | H |
| <u>Cyanea grimesiana</u> ssp. <u>grimesiana</u> ('oha, haha, 'ohawai) | 1(0) | - | ? |
| <u>Cyanea superba</u> ssp. <u>superba</u> <u>C. superba</u> ('oha, haha, 'ohawai) | 0(1) | - C1 | 1 |
| <u>Delissea subcordata</u> ('oha, haha, 'ohawai) | 0(1) | - | 1 |
| <u>Diellia falcata</u> (-) | 2(1) | C1 | 1 |
| <u>Dubautia sherffiana</u> (na'ena'e) | 3(1) | - | 1 |
| <u>Flueggea neowawraea</u> <u>Neowawraea phyllanthoides</u> (mehamehame) | 3(2) | - C1 | 1 |
| <u>Hedyotis degeneri</u> var. <u>coprosdifolia</u> <u>H. degeneri</u> (pilo) | 0(1) | - C1 | 1 |

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TABLE 2, continued
RARE PLANTS OF MOUNT KAALA NATURAL AREA RESERVE

| Scientific Name ¹ Former Name ² (Common Name) | Current (Historic) Occurrences ³ | Federal Status ⁴ | HHP Rank ⁵ |
|--|--|--------------------------------|--------------------------|
| <u>edyotis degeneri</u> var. <u>degeneri</u> <u>H. degeneri</u> (pilo) | 0(1) | - C1 | 1 |
| <u>esperomannia arbuscula</u> (-) | 0(1) | C1 | 1 |
| <u>hibiscus brackenridgei</u> ssp. <u>mokuleianus</u> <u>H. brackenridgei</u> (ma'o hau hele) | 0(2) | - C1 | H |
| <u>sodendron longifolium</u> (aupaka) | 1(0) | C1 | 2 |
| <u>pinvillea ascendens</u> ssp. <u>ascendens</u> ('ohe) | 1(0) | - | 1 |
| <u>ipochaeta lobata</u> var. <u>lobata</u> (nehe) | 0(1) | - | 2 |
| <u>ipochaeta remyi</u> (nehe) | 0(1) | - | 1 |
| <u>ipochaeta tenuifolia</u> (nehe) | 1(0) | C1 | 1 |
| <u>obelia niihauensis</u> (-) | 0(1) | C1 | 2 |
| <u>eraudia angulata</u> var. <u>angulata</u> <u>N. angulata</u> (ma'aloa, ma'oloa, 'oloa) | 0(2) | - C1 | 1 |
| <u>eraudia melastomifolia</u> (ma'aloa, ma'oloa, 'oloa) | 1(0) | C2 | 2 |
| <u>ptothoestrum latifolium</u> ('aiea) | 1(1) | C1 | 1 |
| <u>pototrichium humile</u> (kulu'i) | 0(2) | C1 | 2 |
| <u>pelea christophersenii</u> (alani) | 0(1) | C1 | 1 |
| <u>pelea cinerea</u> var. <u>cinerea</u> <u>P. cinerea</u> (alani) | 0(1) | - C1 | 1 |
| <u>pelea cinerops</u> (alani) | 0(1) | C1 | 1 |
| <u>pyllostegia hirsuta</u> (-) | 0(1) | C2 | ? |

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TABLE 2, continued
RARE PLANTS OF MOUNT KAALA NATURAL AREA RESERVE

| Scientific Name ¹ Former Name ² (Common Name) | Current (Historic) Occurrences ³ | Federal Status ⁴ | HHP Rank ⁵ |
|---|--|--------------------------------|--------------------------|
| <u>Phyllostegia mollis</u> | 0(1) | - | 1 |
| <u>P. mollis</u> var. <u>hochreutineri</u> | | C1 | |
| <u>P. mollis</u> var. <u>lydgatei</u> | | C1 | |
| <u>P. mollis</u> var. <u>micrantha</u> | | C1 | |
| (-) | | | |
| <u>Pleomele forbesii</u> | 1(1) | - | 1 |
| <u>Dracaena forbesii</u> | | C1 | |
| (halapepe) | | | |
| <u>Pritchardia kaalae</u> | 1(0) | - | 2 |
| (loulu) | | | |
| <u>Schiedea hookeri</u> | 0(1) | C2 | 1 |
| (ma'oli'oli) | | | |
| <u>Tetramolopium lepidotum</u> ssp. | 0(2) | - | 1 |
| <u>lepidotum</u> | | | |
| <u>T. lepidotum</u> | | C1 | |
| (-) | | | |

Observed during 1988 survey

Wagner et al. (1990)

Wagner and Wagner (1987)

Taxonomy used in 1985 Federal Register

Current occurrences reported since 1972

Key to Federal Status (USFWS 1985, 1987):

PE Proposed endangered

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

Key to Hawaii Heritage Program Ranks:

1 Critically imperilled globally (typically 1-5 occurrences)

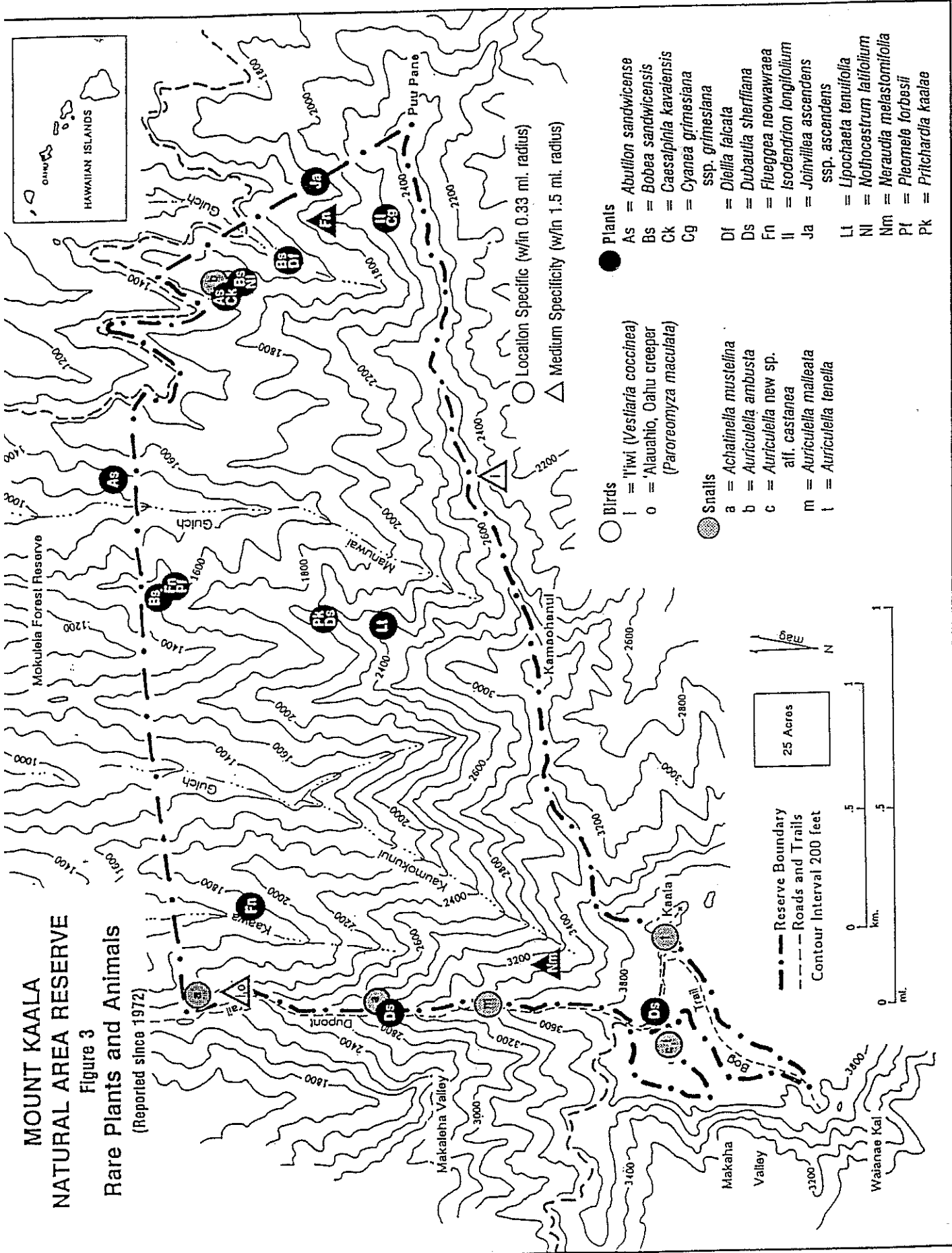
2 Imperilled globally (typically 6-20 occurrences)

? No more than 100 occurrences globally; rank not yet determined by HHP

H Historically known (no observations since 1972 throughout its range)

MOUNT KAALA NATURAL AREA RESERVE

Figure 3
Rare Plants and Animals
(Reported since 1972)



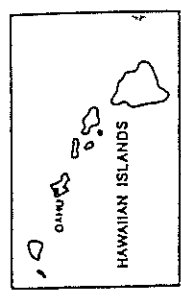
- Birds**
- l = 'I'iwi (*Vestiaria coccinea*)
 - o = 'Alauahio, Oahu creeper (*Paroreomyza maculata*)
- Snails**
- a = *Achatinella mustelina*
 - b = *Auriculella ambusta*
 - c = *Auriculella* new sp. aff. *castanea*
 - m = *Auriculella malleata*
 - t = *Auriculella tenella*
- Plants**
- As = *Abutilon sandwicense*
 - Bs = *Bobea sandwicensis*
 - Ck = *Caesalpinia kavaiensis*
 - Cg = *Cyanea grimesiana* ssp. *grimesiana*
 - Df = *Dilella falcata*
 - Ds = *Dubautia sterriflora*
 - Fn = *Flueggea neowawraea*
 - Il = *Isodendron longifolium*
 - Ja = *Joinvillea ascendens* ssp. *ascendens*
 - Lt = *Lipochaeta tenuifolia*
 - Ni = *Nothocostium laeifolium*
 - Nm = *Neraudia melastomifolia*
 - Pf = *Pleomele forbesii*
 - Pk = *Pritchardia kaalae*

○ Location Specific (w/in 0.33 mi. radius)
△ Medium Specificity (w/in 1.5 mi. radius)

25 Acres

--- Reserve Boundary
--- Roads and Trails
--- Contour Interval 200 feet

0 0.5 1
km.
0 0.5 1
mi.



Thirty additional taxa have been reported near, but not in, the reserve (Appendix 3). Of these, only 7 taxa have been seen recently. The area just southwest of the reserve is very diverse, and deserves special note for the large numbers of rare taxa reported from that area, but not from the Mount Kaala reserve. These taxa include Exocarpos gaudichaudii, Mariscus pennatiformis ssp. pennatiformis, Platydesma cornuta var. decurrens, Schiedea pubescens var. purpurascens, and Gouania meyenii. Additional surveys may uncover all of these taxa, as well as new taxa, within the reserve boundaries.

C. Fauna

Birds make up the native vertebrate fauna on Oahu. During this August 1988 survey, low numbers of the more common native forest bird species, 'apapane (Himatione sanguinea sanguinea) and 'amakihi (Hemignathus virens chloris), were observed above 3,000 feet elevation. In the lower gulches (below 3,000 feet), the only native bird observed was Oahu 'elepaio (Chasiempis sandwichensis gayi). The indigenous White-tailed Tropicbird, or koa'e kea (Phaethon lepturus dorotheae), was seen in flight over the heads of steep gulches in the vicinity of the Dupont trail. Two rare forest birds are known from the reserve, 'i'iwi (Vestiaria coccinea) and Oahu creeper (Paroreomyza maculata), but neither were seen during this survey.

'I'iwi and Oahu creeper were most recently seen during 1977 in two separate locations very near the reserve's south-central and western boundaries (Figure 3). 'I'iwi is listed by the State of Hawaii as "endangered" on the islands of Oahu, Lanai, and Molokai (DLNR 1986). Oahu creeper is listed as endangered by both federal and state agencies. Though Oahu 'elepaio is not listed as endangered, its population has declined steadily in recent years.

Non-native birds observed throughout the reserve during this survey included Japanese white-eye (Zosterops japonicus), white-rumped shama (Copsychus malabaricus), hwamei (melodious laughing-thrush, Garrulax canorus), and red-vented bulbul (Pycnonotus cafer). A complete list of birds known from the reserve is in Appendix 4.

The reserve contains a variety of native invertebrates including insects, spiders and land snails. The rich array of habitats, from montane wet to lowland dry, together with plant diversity, offers varied habitats for invertebrates. Native invertebrates persisted even at the lowest elevations in the reserve, although in the disturbed areas non-native invertebrates known to adversely affect native species were also seen.

Few collectors or land snail experts have visited the Mount Kaala area in the latter half of this century. It is known that

the distribution and abundance of native land snails have declined dramatically in recent years. Today, all species in the genus Achatinella are on the federal list of endangered species. Malacologists believe that virtually all the larger endemic land snails are rare and in danger of extinction.

Five species of rare land snails have been reported from the reserve (Table 3, Figure 3). Auriculella ambusta, Auriculella tenella, and Auriculella new sp. aff. castanea were seen during this August 1988 survey, while Achatinella mustelina and Auriculella malleata were last reported from the reserve in 1987. Though all five of these rare species reported from the Mount Kaala reserve are considered rare, only Achatinella mustelina is listed endangered by the Fish and Wildlife Service (1987).

TABLE 3
RARE SNAILS OF MOUNT KAALA NATURAL AREA RESERVE

| Scientific Name | Current (Historic) Occurrences in Reserve ¹ | Federal Status ² | HHP Rank ³ |
|--|---|--------------------------------|--------------------------|
| <u>Achatinella mustelina</u> | 2 (4) | LE | 1 |
| * <u>Auriculella ambusta</u> | 1 (2) | - | 1 |
| * <u>Auriculella</u> new sp. aff. <u>castanea</u> | 1 (1) | - | 1 |
| <u>Auriculella malleata</u> | 1 (1) | - | 1 |
| * <u>Auriculella tenella</u> | 2 (2) | - | 1 |

* Observed during 1988 survey

¹ Current occurrences reported since 1972

² Key to Federal Status (USFWS 1987):

LE Endangered

- No federal status. Recommended as rare by Hawaiian malacologists and confirmed by Heritage data

³ Key to Hawaii Heritage Program Rank:

1 Critically imperilled globally (typically 1-5 occurrences)

A large and colorful tree snail, Achatinella mustelina has been seen in the reserve's western section, where its populations appear to be shrinking steadily (Figure 3). Only two individuals were seen in 1987, though old collection records (from the first half of this century) indicate large populations occurred in the areas around Kamaohanui and Puu Pane. Achatinella mustelina may still exist in isolated pockets along the upper slopes between

Puu Pane and the Dupont trail. Auriculella malleata, which occurs above an elevation of 3,000 feet around Mount Kaala and nowhere else, was also seen in the western section of the reserve in 1987, but was not encountered during this survey.

During this survey, two live Auriculella ambusta were observed in the gulch west of Palikea Gulch, along with numerous empty shells of this species and Euglandina rosea, a predatory snail that feeds on other snails. Auriculella ambusta was also recorded from the summit area and in Haleauau Gulch in 1948. Auriculella tenella was observed during the survey at the summit with Auriculella new sp. aff. castanea and other more common succinid and tornatellinid species. In 1983, Auriculella tenella was observed at the summit and in 1948, south of the reserve. Over 30 Auriculella new sp. aff. castanea were found above 3,600 feet elevation on the summit during this survey. This species is very rare elsewhere. Other ground snail genera, Leptachatina and Amastra, were found only as faded, dead shells in Palikea Gulch by the survey crew.

Comprehensive snail surveys of this area have not been undertaken recently, and it is possible that species reported prior to 1945 may still exist, and that other rare snails reported from outside the reserve may be present in the reserve. Two other Achatinella species have been recorded from the Mount Kaala area, though not since 1945. Achatinella lehuiensis, historically found elsewhere in the Waianae Mountains, was last collected in 1936 from Haleauau Gulch; Achatinella thaanumi is known only from Haleauau Gulch (Christensen 1983). Pleuropoma sandwichiensis, another rare land snail, was reported in 1987 from north of the reserve, and could exist at lower elevations within the reserve.

Non-native species found in the reserve with potential adverse affects on native resources include pigs, cattle, mosquitoes, ants, and the predatory snail Euglandina rosea. Pigs and cattle are discussed in detail in the Ungulate Control Program. The problem posed by Euglandina rosea is extremely serious for rare native land snails. During the survey, subfossil shells of a variety of litter-dwelling native land snails were found in the lower gulches, rather than fresh or living specimens. In all cases, shells of Euglandina rosea were present, and it is likely that they have contributed to the local extinction of several species of native snails.

Other non-native invertebrates observed during this survey included flies associated with pigs and other large mammals, and mosquitoes in the gulches below 3,000 feet elevation. Mosquito-borne avian diseases probably have limited most forest birds to elevations above 3,000 feet in the reserve, but aside from removing man-made breeding sites for mosquitoes, particularly in the summit facilities, there is probably little to be done to

change the situation. The same is true for ants in the lower dry and mesic portions of the reserve, although in many of the lower gulches, very high densities of native crickets are maintaining themselves even where ants are present.

III. MANAGEMENT

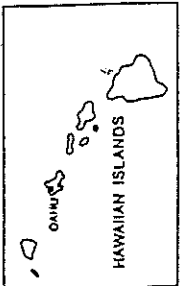
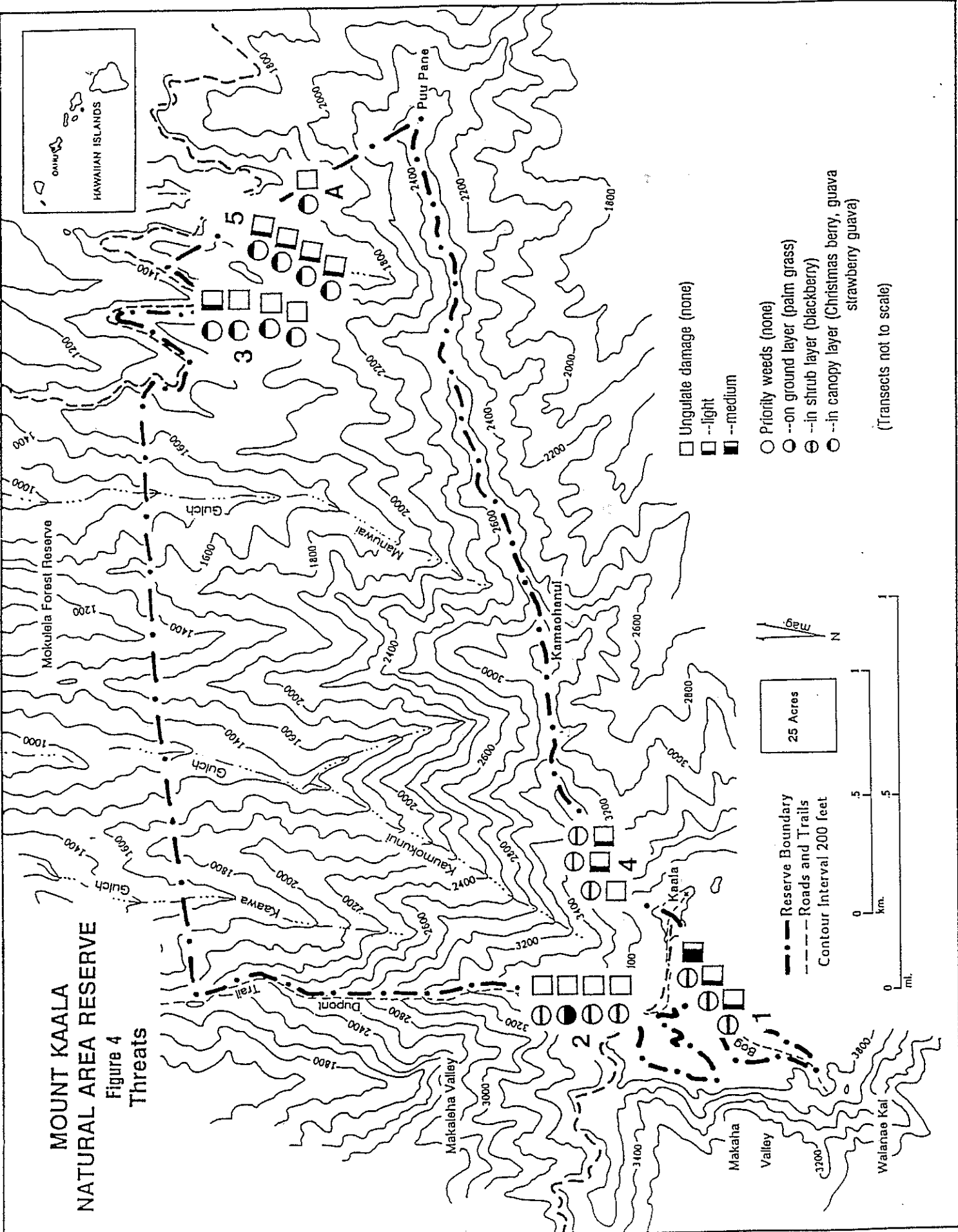
A. Key Management Considerations

The overall management goal is to protect and maintain the reserve's native ecosystems. The following key considerations were included in the management programs developed to achieve this goal:

- 1) At this time, it is not economically realistic to intensively manage the entire Mount Kaala reserve. Management of specific areas have been prioritized based on the biological resources they contain, the extent of current disturbances, the nature of other biological threats within and near the area, and the feasibility of management (e.g. topography and access). Management activities will focus on the summit bog and patches of intact lowland forests, protecting these ecosystems from feral ungulates and aggressive non-native weeds (See the Management Unit descriptions).
- 2) Pigs constitute the most severe threat currently affecting the reserve (Figure 4). Their rooting and wallowing destroy native plants and disturb ground cover on the forest floor. Such damage limits effective regeneration of native plants, and creates conditions favorable for certain non-native weeds throughout the reserve. This in turn degrades the quality and integrity of native plant communities and threatens the existence of species that rely on the forest for survival. Control of feral pigs is the essential first step in maintenance of the reserve's native ecosystems. Management to achieve this is outlined in detail in the Ungulate Control Program.
- 3) Many non-native plants observed in the reserve are shade intolerant and pose no major problem as long as the native canopy and ground cover remain intact. There are several weed species in the reserve, however, that have formed monotypic stands and displaced native vegetation over large areas. Large-scale removal of these infestations is not cost effective and control activities will focus on priority weeds within specific management areas, and on localized populations of priority weed species, which could spread if not controlled.

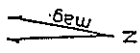
MOUNT KAALA NATURAL AREA RESERVE

Figure 4
Threats



- Ungulate damage (none)
- ◻ --light
- ◼ --medium
- Priority weeds (none)
- ◉ --on ground layer (palm grass)
- ⊖ --in shrub layer (blackberry)
- ⊙ --in canopy layer (Christmas berry, guava strawberry guava)

(Transects not to scale)



- Reserve Boundary
- - - Roads and Trails
- Contour Interval 200 feet

25 Acres

B. Management Unit Descriptions

The reserve has been divided into three management units (Figure 5). Descriptions of each unit follow, and spell out key features, problems, and priorities for management:

Kaala Bog Unit - This 60-acre unit, located at the summit of Mount Kaala, contains some of the least disturbed native 'ohi'a forest in the reserve. This is the reserve's most unique area and has the highest priority for feral pig and weed control. Fencing is recommended. Seedlings and saplings of strawberry guava (Psidium cattleianum) and Clidemia have been found, and monitoring and removal is necessary to ensure that these weeds do not gain a foothold in the bog. A recently built boardwalk has proven to be a valuable management tool and should be maintained and expanded.

Kaumokunui Cliffs Unit - This 690-acre unit of steep and mostly inaccessible cliffs, contains native forest and shrub communities. The unit's steep topography limits intensive management, but annual monitoring should be used to assess the condition of the native forest, feral ungulate disturbance, and priority weed species. The Dupont Trail is an important access route to this unit and should be maintained.

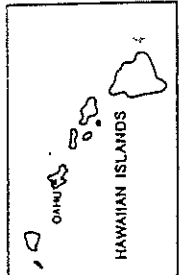
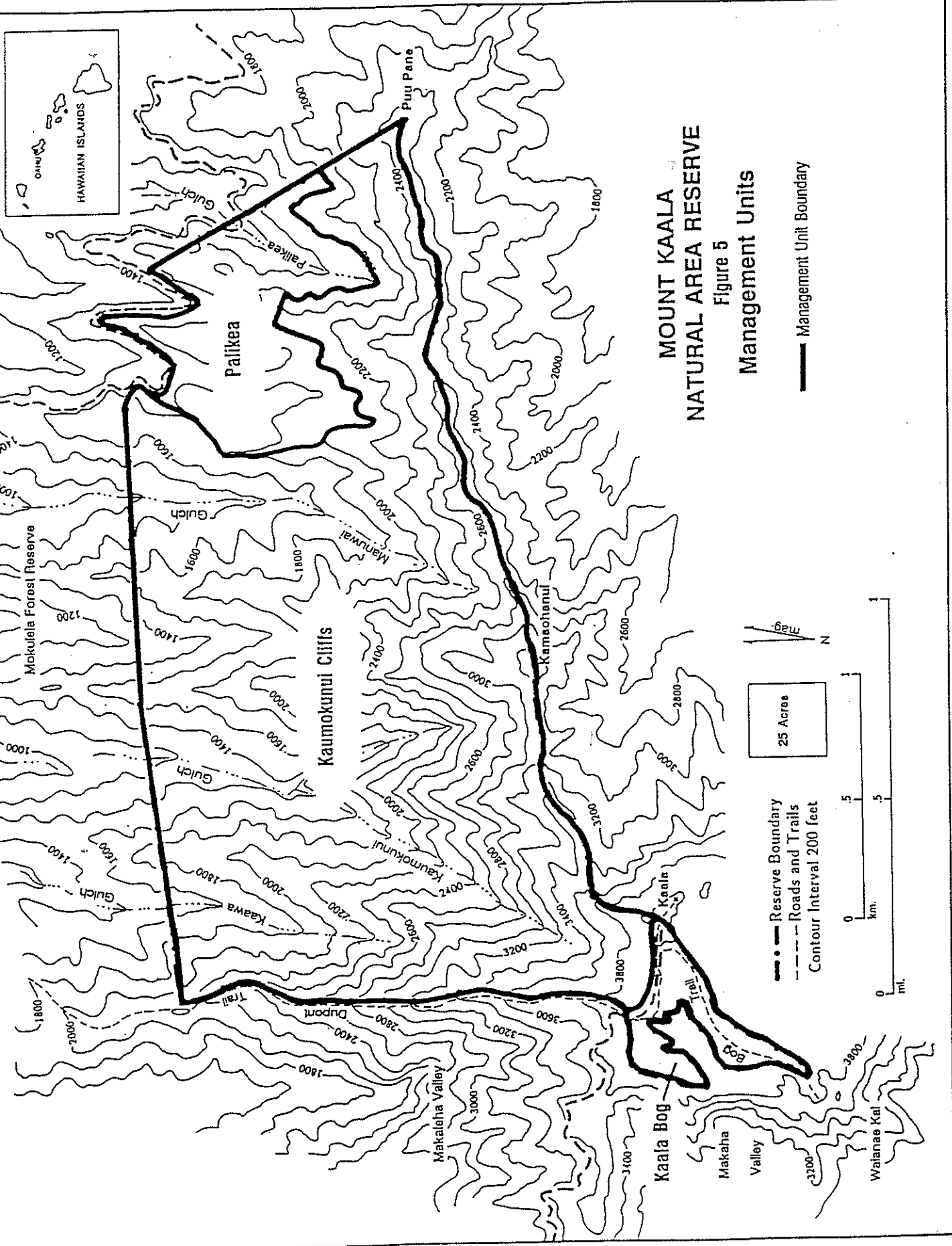
Palikea Unit - This 350-acre unit contains intact examples of native shrub and forest communities. Control is needed to arrest the encroachment of aggressive introduced plant species, especially Clidemia. Pig damage is light but hunting pressure needs to be increased. Cattle trespass is also a problem. Access is through private land, and a permanent access agreement with Castle and Cooke Land Company needs to be established. Additional survey work is needed to identify other intact native communities in the unit. A management trail system is proposed to improve access within the unit.

C. Management Programs

Four management programs outline the long-term goals for the reserve. A six-year implementation schedule is proposed. The programs are listed by priority, and fit together to form an integrated management package.

Priority #1 - Ungulate Control Program (KAA-RM-01)

GOAL: Eliminate ungulates in select areas of high biologic value. In the rest of the reserve, reduce the impact of ungulates to a level that prevents further degradation of the reserve's native ecosystems and allows the greatest possible recovery of the reserve's native species.



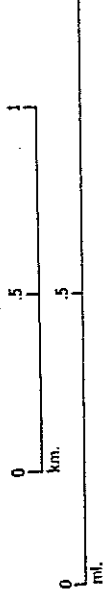
MOUNT KAALA NATURAL AREA RESERVE

Figure 5

Management Units

— Management Unit Boundary

••• Reserve Boundary
 - - - Roads and Trails
 Contour Interval 200 feet



Statement of the Problem: Feral ungulate control is critical to the survival of native ecosystems in the reserve. There are many techniques for feral ungulate control. The reserve manager will need the flexibility to use all the tools available, as the Mount Kaala reserve presents different access problems, resource protection priorities, and target species. These tools include public hunting, fencing, staff hunting, and snaring.

A component of the feral ungulate control program is systematic monitoring. Monitoring will evaluate changes in levels of ungulate damage, the effectiveness of the management program in reducing damage, and the recovery of native vegetation (See Priority #3 - Monitoring Program).

Pig browsing and damage to native plants is an ongoing problem in the Kaala Bog Unit. Pig trails are evident throughout the unit, with areas of heavy localized disturbance. Pigs have removed certain species from the forest floor in the 'ohi'a/'olapa communities, such as the Hawaiian orchid Liparis hawaiiensis, 'ohawai (Clermontia spp.) and pa'iniu (Astelia menziesiana), which were observed only as epiphytes.

Cattle and pig damage is evident in the Palikea Unit and is probably responsible for the removal of much of the native understory in the more accessible gulch bottoms and adjacent slopes. Light to moderate damage and trails were observed in gulch bottoms. Pig trails and bedding sites were observed in the Kaumokunui Cliffs Unit, although the steep topography has restricted damage to the more gently sloped areas.

The eastern boundary of the Mount Kaala reserve lies above the Waialua Ranch, where both cattle and goats are raised. While there was no evidence of goats above the forest reserve boundary, droppings, browsing and trails of cows were evident well into the forest reserve and along the reserve boundary, especially along the old roadcut leading from Puu Iki to the Schofield Military Reservation.

Alternative Actions and Probable Impacts:

- 1) No action. Accept the continuing deterioration of Mount Kaala's forest watershed and native resources. Without control, feral ungulates degrade native communities, lower biological diversity and increase non-native plant invasion.
- 2) Attempt control of feral ungulates using only public hunting. Do not attempt to use fences, staff hunting, or snaring within the reserve. Impacts of ungulates under this alternative will probably be roughly the same as alternative #1, except for portions of the reserve where increased hunting activity may keep

populations down and protect small areas of forest. Ungulate removal will be less effective without fences to keep new populations from moving into the reserve.

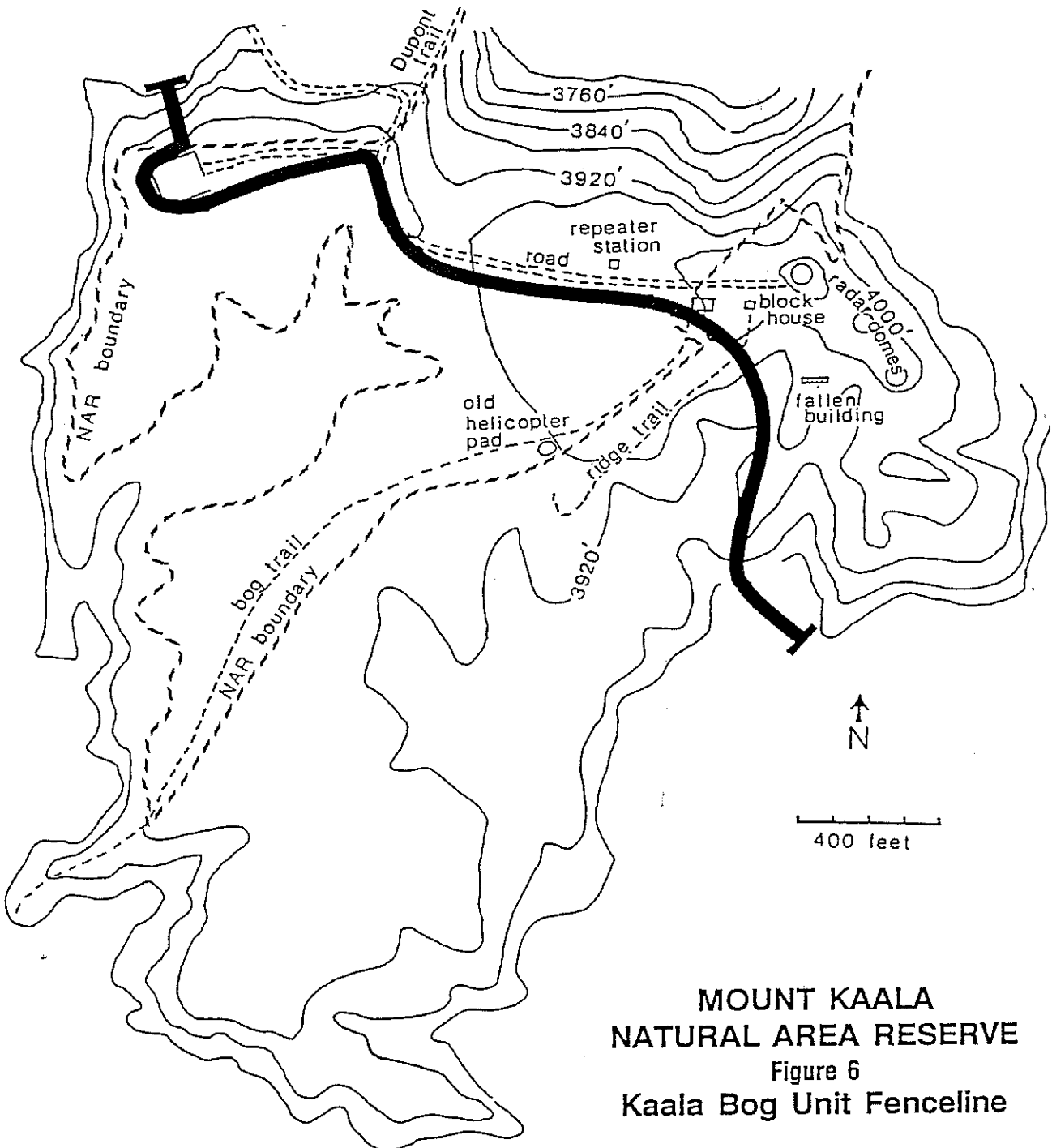
3) Control feral ungulates by staff hunting, fencing, and snaring, supplemented with a public hunting program. This method has proven successful and beneficial for the preservation of native ecosystems. Recovery of native vegetation has occurred in similar areas where management programs have been implemented. The advance of non-native weed species encouraged by ungulate disturbance can also be slowed. Native plant species surviving only as epiphytes because of ungulate disturbance can become re-established on the forest floor.

Recommended Action: Alternative #3 is recommended. NARS staff involvement will be required in all reserve ungulate control programs. Activities will range from organizing special public hunts to direct removal of animals.

Public hunting pressure will be increased in the Palikea Unit by establishing management access through Waialua Ranch. This access will be for official use only and special public hunts are recommended. The intensity of unsupervised public use of this access will be determined by the nature of the agreement reached with the private landowner. Special hunts concentrate hunters in specific portions of a reserve and allow NARS managers to monitor hunting success and collect biological data on harvested animals. Maintained hunting trails will help direct and distribute hunting pressure. Volunteer groups can play an important role in establishing and maintaining forest trails in the reserve (see Priority #4 - Volunteer Support Program).

Fencing strategies are dictated by the topographic nature of the reserve and the priority of resources threatened. Fence locations should not be restricted by reserve boundaries, but strategically placed to protect the largest parcels of intact forest and utilize the reserve's steep topography. Natural barriers should be used whenever possible. A one-mile fence is recommended for the Kaala Bog Unit which will prevent pigs from moving up from the lower forested areas (Figure 6). The fencing proposed will not only protect the Bog unit, but an additional 30 acres of intact native bog on lands controlled by the Army. Pig removal is essential in conjunction with the fencing project to take advantage of induced pig movements and to avoid restriction of pigs in one location causing heavy localized damage.

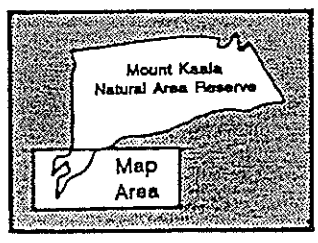
Careful clearing of fence lines is needed to minimize disturbance to existing vegetation. All clothing and equipment should be cleaned to avoid spreading or introducing non-native plants and invertebrates. A botanist should walk the flagged fence route to locate and flag rare plants to be avoided by the brushing crew. Ideally, fences should be inspected and at least



400 feet

**MOUNT KAALA
NATURAL AREA RESERVE**
Figure 6
Kaala Bog Unit Fenceline

█ Fenceline



six times a year or after major storms. Inspections should be done in conjunction with other resource management activities such as ungulate removal, monitoring, and non-native plant control. All priority weed species found along fence lines should be removed.

Snaring is an effective pig control tool in areas with a combination of well-utilized pig trails, trees to anchor the snares, and restricted public access. The Kaala Bog Unit is ideally suited for this control technique. The most effective approach is to set snares and leave the area unattended to minimize the effect of human presence, returning later to assess the success and condition of the snares. Snares in rain forests last six months to a year. Hunting may be alternated with snaring in intensive control units.

Public access will be restricted and signs posted in all areas where snares are set. Because of the proximity of the communications facility at the summit of Mount Kaala, the bog unit will be a hunter safety zone, where public hunting is not allowed. Snare locations will be mapped, adequately marked in the field, and set to avoid harm to non-target species. Snares should be checked as frequently as possible. If found alive, pigs caught in snares should be disposed off as humanely as possible. Data on health, sex, and age of captured pigs will be recorded to determine effectiveness of snaring program. Pig control activities in the reserve will be coordinated with the FAA and Hawaii Air National Guard. (See Boundary Administration and Special Uses.) Quarterly inspection of the Waialua Ranch's boundary fences will be done to ensure no future cattle trespass into the reserve. All cattle presently in the reserve should be immediately removed by Waialua Ranch or NARS staff.

Cost/Workload: The following resources will be needed to conduct the ungulate control project:

Ungulate removal activities in year 1 will consist of fence construction, access improvement, 10 days of staff hunting (2-person crew), 10 days of special hunts for the general public (1 person), and snaring 60 acres.

| | | |
|---------|--------------------------------|-----------------|
| Year 1: | <u>Personnel</u> | |
| | Technician 52 person days (PD) | \$ 3,640 |
| | Reserve Manager (70 PD) | 5,950 |
| | <u>Materials and supplies</u> | |
| | Access improvement | 7,000 |
| | Fence construction (1 mi.) | 12,000 |
| | Staff hunting | 1,200 |
| | Snares (50) | 300 |
| | Trail development | <u>2,500</u> |
| | Total | \$32,590 |

Ungulate removal activities in years 2-4 will consist of fence and access maintenance, 10 days of staff hunting (2-person crew), 20 days of special hunts for the general public (1 person), and snaring 60 acres.

| | |
|-------------------------------|-----------------|
| Year 2-6: <u>Personnel</u> | |
| Technician 32 PD | \$ 2,240 |
| Reserve Manager 20 PD | 1,700 |
| <u>Materials and supplies</u> | |
| Access maintenance | 2,500 |
| Staff hunting | 1,200 |
| Snares (50) | 300 |
| Fence and trail maintenance | <u>2,500</u> |
| Total | \$10,440 |

Costs are based on a 2-person crew able to establish 50 snares per day or check 100 snares per day. Snares (\$6 each) will be replaced every year and inspected five times a year. Snaring densities will be approximately 50 snares for 60 acres in the Kaala Bog Unit. Supplies and support for a 2-person crew for staff hunting (dogs, ammunition, etc.) are estimated at \$100 per day. Salaries are \$85 per day for a Reserve Manager and \$70 per day for technicians. Access improvement includes road grading and gate installation.

Fence costs are based on \$12,000 per mile. Costs include materials and supplies. Labor for fence construction will be supplied by the NARS Volunteer Program under the direction of the Reserve manager. Fence maintenance costs are based on a 2-person crew able to inspect and fix 1 mile of fence per day. Supplies for fence maintenance are estimated at \$500 per mile per year.

Priority #2 - Non-native Plant Control Program (KAA-RM-02)

GOAL: To limit the spread, and where possible, eradicate introduced plant species which are already or may become invasive weeds in the reserve.

Statement of the Problem: Many non-native plants have become established in Hawaii and their total removal from the reserve is not feasible. The best control strategy is maintenance of intact native forests through limiting disturbance. While feral ungulate control will help, it is not completely effective in limiting weed spread, as many weeds are spread by birds and people.

Control of priority weed species in key management units will be necessary. Priority weeds are non-native plant species that have the capability to invade native ecosystems and displace native vegetation over large areas. Manual and chemical weed

control is costly and use should be prioritized by the nature of the weed, the value of the area it is invading, and the effectiveness of the control measure. Biocontrol is potentially an important tool in the management of wide-spread priority weed species, and the NARS should support interagency biocontrol projects with appropriate lobbying, logistical support, and release sites for control agents.

The most threatening priority weed in the reserve is blackberry (Rubus argutus), which is widespread above 3,000 feet elevation. Blackberry has the capacity to spread into adjacent undisturbed areas, which is a major management concern. It is found in the 'ohi'a/'olapa, 'ohi'a shrubland, and 'ohi'a mixed forest communities.

Other non-native plants found in these communities include Juncus planifolius, Hilo grass (Paspalum conjugatum), fireweed (Erechtites valerianifolia), pamakani (Ageratina adenophora), thimbleberry (Rubus rosifolius), and grasses such as carpet grass (Axonopus fissifolius) and Glenwood grass (Sacciolepis indica).

Seedlings of two other priority weeds, Koster's curse (Clidemia hirta) and strawberry guava (Psidium cattleianum) have been found scattered along pig trails in the Kaala Bog Unit. A mature population of Koster's curse has also been found in the Palikea Unit, and efforts are ongoing to remove this weed from the reserve.

Four non-native plants are dominant in portions of the reserve, forming their own communities; Christmas berry, molasses grass, kukui, and toon. The Christmas berry formed closed to open shrublands on lower ridges and slopes. Toon forests lay immediately below the Christmas berry shrublands. Patches of molasses grass occurred on upper slopes and ridge tops in the Mount Kaala reserve, overlapping broadly with the upper edge of Christmas berry-dominated shrublands. Where the molasses grass was dominant, it was usually monospecific, forming a thick mat. Because of its high resin content and tendency to form thick, dry mats, molasses grass is a fire threat.

Nearly all of the gulch bottoms below 3,000 feet elevation in the reserve were dominated by a kukui forest overstory. However, seedlings and saplings of lonomea, lama, and papala kepau were abundant, and other native species such as mehame, olopuu, and alahe'e were present, but not abundant. Ground cover was sparse, but included an occasional palapalai and ho'i'o. Two rare trees, Abutilon sandwicense and Bobea sandwicensis, were noted in the kukui forest. The non-native elements of kukui forest in the reserve included trees such as toon, Christmas berry, and guava; shrubs such as ti (Cordyline fruticosa), thimbleberry and koa haole (Leucaena leucocephala); basket grass (Oplismenus hirtellus); and ferns such as Blechnum occidentale,

Thelypteris dentata, and T. parasitica. Many of the gulches in the reserve contained closed canopy Toon Lowland Mesic Forest immediately above kukui in the gulch bottoms.

The level of non-native plant establishment in these communities is beyond current control methods. However, where remnant native communities are still intact, and non-native plants are absent or present in low numbers, limited plant control measures are justified. Control of weeds in intact pockets of native vegetation, especially in the koa/'ohi'a, lonomea, lama, and Oahu mixed diverse forests would encourage regeneration of the native canopy trees and assure survival of these native communities.

Alternative Actions and Probable Impacts:

1) Control ungulates, but do not attempt to control any priority weeds. This will reduce the spread of many ungulate-dispersed weeds, but will allow continued advance of plants spread by birds and people. Decreased rooting and disturbance to the forest floor by feral pigs will slow down establishment of many non-native plants, but already established plants may continue to spread unchecked. A few especially aggressive weeds would overwhelm large areas.

2) Control priority non-native weed species in the key management areas before they become widely established. Set up monitoring transects to locate other populations of priority weed species. Management measures would include selective use of herbicide and manual removal with hand tools.

3) Control all non-native plant species in the reserve. This alternative would require substantial resources and is not practical.

Recommended Action: Alternative #2 is recommended. Remove blackberry from Kaala Bog Unit. Koster's curse should be removed where found. Non-native plant removal along trails and fences should occur as part of periodic maintenance. Establish monitoring transects for other priority weeds.

In relatively intact pockets of native vegetation, non-native tree species such as toon and Christmas berry will be girdled in small increments, so that a gradual dieback occurs over a period of about five years. During that time, the gaps that form in the canopy will be filled by both native and non-native species. Management teams can keep non-native regeneration in check, while allowing fast-growing native tree species such as papala kepau and lonomea to mature.

Detailed records of the effectiveness of control methods used in the reserve will be kept. Coordination between NARS and

other involved agencies in plant control work will reduce management costs. Strict precautions will be taken to ensure management personnel do not transport weed seeds into the reserve on their shoes or equipment (including helicopters). Hikers and hunters will be informed of this threat by posted signs along access trails into the reserve.

Cost/Workload:

| | | |
|-----------|-------------------------|------------------------|
| Year 1: | Reserve Manager (48 PD) | \$ 4,080 |
| | Technician (48 PD) | \$ 3,360 |
| | Supplies and support | \$ 4,000 |
| | | Total \$ 11,440 |
| Year 2-6: | same as year 1 | Total \$ 11,440 |

Salaries are \$85 per day for reserve manager and \$70 per day for technician. Supplies and support include tools, herbicide, logistical support for volunteer and staff work crews.

Priority #3 - Monitoring Program (KAA-RM-03)

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 predicted results and management efficiency needs to be judged. Monitoring changes in non-native and native plant distribution, and animal species abundance entails recording specific data at permanent points and transects in the reserve. Monitoring also documents progress and facilitates refinement of management techniques employed in the reserve.

Alternative Actions and Probable Impacts:

- 1) No monitoring program. This could lead to inefficient management as a result of poor understanding of the area's biological needs.
- 2) Conduct ad hoc monitoring whenever possible. This is likely to be considerably more expensive and less effective in the long run than a systematic approach.
- 3) Establish systematic monitoring programs for ungulate damage, non-native weed invasion, native vegetation recovery, and status of rare species. Increase monitoring intensity for select problems and areas as needed.

Recommended Action: Alternative #3 is recommended. Develop monitoring programs to evaluate effects of management activities and identify future management needs. Most transects will

require a two-person crew for safety. Two-person monitoring crews will hike in, take data at established monitoring points, and hike out. Specific goals of the program are to determine: 1) the effectiveness of staff and public hunting in reducing ungulate damage; 2) the success of priority weed species control; 3) the location of localized populations of other priority weeds; and 4) status of known rare species. Some monitoring activities will be done in conjunction with fence inspection.

Due to the steep topography and difficult access, much of the reserve remains unexplored. There may be additional examples of rare community types, especially Oahu Diverse Mesic Forest and Lonomea Lowland Dry Forest, both known only from a few other areas in the state. Additional rare plants and animals (such as land snails) may be discovered in those areas.

Cost/Workload: The following resources will be needed to conduct the monitoring project and future survey work:

| | | |
|-----------|-------------------------|-----------------------|
| Year 1: | Reserve Manager (15 PD) | \$ 1,275 |
| | Technician (20 PD) | 1,400 |
| | Supplies | <u>1,000</u> |
| | Total | \$ 3,675 |
| Year 2-6: | Same as year 1 | Total \$ 3,675 |

Salaries are \$85 per day for reserve manager and \$70 per day for a technician. Supplies are for office and computer supplies for data gathering and analysis.

Priority #4 - Public Education and Volunteer Program (KAA-RM-04)

GOAL: To build public understanding and support for the reserve and the NARS in the local community. Educational opportunities will be provided for interested groups. Volunteer labor to help staff in management activities will be procured.

Statement of the Problem: Most Oahu residents and visitors are unaware of Hawaii's natural heritage. Even fewer realize that native resources and the benefits they provide are being threatened. Management of this reserve will be a long-term effort, and public support is essential. There are popular hiking trails along the boundary of the reserve and through the bog, which offer excellent potential for public education. The general public can be kept informed of ongoing management activities through appropriate media outlets.

Volunteer groups have proven successful in past management activities in the reserve, especially in labor-intensive efforts such as fence construction, weed control, and trail maintenance.

They tend to be extremely motivated, representing a valuable resource for the reserve manager.

Alternative Actions and Probable Impacts:

1) Do not attempt to inform the general public about the resources protected in the reserve or explain reasons for specific management actions. Do not use volunteer groups in relevant reserve management activities. The results of this alternative could include less public and legislative support for the NARS, misunderstanding among certain groups resulting in vandalism of capital improvements, and increased costs for overall NARS management, especially in plant control work.

2) Maintain community outreach program to give public presentations, provide informational material, and utilize concerned volunteer groups. This could result in cooperation with the general public and result in less expensive yet more effective management results. It could also provide a local constituency that would support reserve management activities.

Recommended Action: Alternative #2 is recommended. Inform the general public about resources within the reserve and management activities through television, newspaper, and other local media outlets. Utilize volunteer groups for reserve management whenever feasible. Present slide shows and talks to community groups. Develop a brochure that describes the resources and ongoing management activities within the reserve.

Cost/Workload:

| | | |
|-----------|-------------------------|--------------|
| Year 1: | Reserve Manager (60 PD) | \$ 5,100 |
| | Technician (10 PD) | 700 |
| | Support and supplies | <u>4,000</u> |
| | Total | \$ 9,800 |
| Year 2: | Reserve Manager (50 PD) | \$ 4,250 |
| | Technician (20 PD) | 1,400 |
| | Support and supplies | <u>3,000</u> |
| | Total | \$ 8,650 |
| Year 3-6: | Reserve Manager (20 PD) | \$ 1,700 |
| | Technician (50 PD) | 3,500 |
| | Support and supplies | <u>3,000</u> |
| | Total | \$ 8,200 |

Salaries are \$85 per day for reserve manager and \$70 per day for a technician. Supplies and support include tools, gloves, refreshments, brochures, audio-visual aids, production of a volunteer program newsletter, and recognition materials such as plaques, t-shirts, and patches.

D. Boundary Administration and Special Uses

Cooperation among adjacent landowners is an important factor for effective management of the Mount Kaala reserve. The Federal Aviation Administration (FAA), Hawaii Air National Guard (HANG), U.S. Army, and Castle and Cooke Land Company all own property or hold leases on land bordering the reserve. Cooperative agreements will need to be established with the Army (fencing the bog) and Castle and Cooke Land Company (access to the lower reserve area). The FAA and HANG need to be kept informed of management activities at the summit bog. The FAA has concerns regarding the safety of volunteers as they are transported to and from the reserve on their road. The reserve manager should see to that all reasonable measures are taken to assure the safety of the volunteers.

IV. BUDGET SUMMARY

A six-year implementation schedule is presented to accomplish management goals as efficiently as possible. Four management programs are proposed to achieve this. Although listed by priority, they build upon each other to form an integrated strategy.

The budget summary does not include all the administrative, clerical, and facility support needed to run a state-wide NARS or to manage the other two natural area reserves on the island of Oahu. These infrastructure costs for the NARS will be identified and documented separately. Operations costs such as vehicles (one four-wheel drive truck with radio), two portable radios, and maintenance for vehicle/equipment are included in program KAA-OP-01. Starting with year 3, a 1 percent inflation increase is incorporated into every yearly total.

**MOUNT KAALA NATURAL AREA RESERVE
BUDGET SUMMARY**

| PROGRAM | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 |
|---|-------------------|---------------|---------------|---------------|-------------------|---------------|
| KAA-RM-01 | 32,600 | 10,500 | 10,500 | 10,500 | 10,500 | 10,500 |
| KAA-RM-02 | 11,400 | 11,400 | 11,400 | 11,400 | 11,400 | 11,400 |
| KAA-RM-03 | 3,700 | 3,700 | 3,700 | 3,700 | 3,700 | 3,700 |
| KAA-RM-04 | 9,800 | 8,700 | 8,200 | 8,200 | 8,200 | 8,200 |
| KAA-OP-01 | 25,000 | 2,500 | 6,250 | 6,250 | 6,250 | 6,250 |
| TOTAL (\$) | 82,500 | 36,800 | 40,500 | 40,900 | 41,300 | 41,700 |
| <u>MANAGEMENT PROGRAMS</u> | | | | | | |
| KAA-RM-01 - Ungulate Control (Priority 1) | | | | | | |
| KAA-RM-02 - Non-native Plant Control (Priority 2) | | | | | | |
| KAA-RM-03 - Monitoring (Priority 3) | | | | | | |
| KAA-RM-04 - Public Education/Volunteer Support (Priority 4) | | | | | | |
| KAA-OP-01 - Operating Expenses | | | | | | |
| <u>PERSONNEL</u> (PD = person days) | | | | | | |
| YR 1 - | R. Manager 193 PD | | | YR 4 - | R. Manager 103 PD | |
| | Technician 130 PD | | | | Technician 150 PD | |
| YR 2 - | R. Manager 133 PD | | | YR 5 - | R. Manager 103 PD | |
| | Technician 120 PD | | | | Technician 150 PD | |
| YR 3 - | R. Manager 103 PD | | | YR 6 - | R. Manager 103 PD | |
| | Technician 150 PD | | | | Technician 150 PD | |

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APPENDIX 1
 Mount Kaala Natural Area Reserve
 Transect Specifications

| Transect number | Transect length (ft) | No. of substations | Natural communities surveyed |
|-----------------|----------------------|--------------------|--|
| 1 | 984 | 7 | 'Ohi'a/Lapalapa Montane Wet Forest |
| 2 | 1,476 | 10 | 'Ohi'a/Uluhe Montane Wet Forest 'Ohi'a/Mixed Shrub Montane Wet Forest 'Ohi'a Montane Wet Shrubland |
| 3 | 1,476 | 10 | Kukui Lowland Wet Forest Toon Lowland Mesic Forest 'A'ali'i Lowland Dry Shrubland |
| 4 | 1,312 | 9 | 'Ohi'a Montane Wet Shrubland 'Ohi'a/Mixed Shrub Montane Wet Forest |
| 5 | 1,476 | 10 | Kukui Lowland Wet Forest |
| A | n/a | 1 | Lonomea Lowland Dry Forest |

Survey Participants

Lyman Abbott, TNCH, Ecological Research Assistant
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 Daniel Chung, TNCH, Zoological Research Assistant
 Samuel Gon III, TNCH, Ecologist
 Joel Lau, TNCH, Botanical Research Assistant
 David Smith, DOFAW, NARS Manager

DOFAW = State Division of Forestry and Wildlife,
 Department of Land and Natural Resources
 TNCH = The Nature Conservancy of Hawaii

NATURAL COMMUNITY FIELD OBSERVATION FORM

DATE: _____ TIME START: _____ ELEVATION: _____ END: _____
 OBSERVER(S): _____ STATION#: _____
 NC NAME: _____ QUAD NAME: _____
 MAR NAME: _____
 SUBSTRATE: _____
 ADJ HCS: _____

DESCRIPTION LINE:

| ASPECT | SLOPE | 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: _____

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

NAR NAME: _____ ISLAND: _____ QUAD NAME: _____
 DATE: _____ 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 | %COVER |
|--------|--------|---------|----------------------|-----------|------------------|--------|
| 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 | POPULATION AREA (M ²) |
|-------|-----------|---------------|----------|-----------|-----------------|-----------------------------------|
| 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 | %SENEC | VIGOROUS | SOL | 50-100 | 10-100 |
| PROST | DORMANT | | | | 100-1000 | 100+ |
| | | | | | 1000+ | |

APPENDIX 3
Mount Kaala 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 assigned to the natural community 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 | 'A'ali'i Lowland Dry Shrubland | Kukui Lowland Wet Forest | Lonomea Lowland Dry Forest | 'Ohi'a Montane Wet Shrubland | 'Ohi'a/Uluhe Montane Wet Forest | 'Ohi'a/'Oleapa and Lapalapa Montane Wet Forest | 'Ohi'a/Mixed Shrub Montane Wet Forest | Toon Mesic Forest Lama Dry Forest | Oahu Diverse Low- land Mesic Forest |
|--------|---|-----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|--|--|--------------------------------------|--|
| + | E <i>Abutilon sandwicense</i> | | * | ? | | | | | ? | |
| | E <i>Acacia koa</i> | * | | | | | | | | |
| | N <i>Acanthospermum australe</i> | | | | X | | X | | | |
| | E <i>Adenophorus hymenophylloides</i> | | | | X | | X | | | |
| | E <i>Adenophorus pinnatifidus</i> | | | | * | * | * | * | * | |
| | E <i>Adenophorus tamariscinus</i> | | | | * | * | * | * | * | |
| | E <i>Adenophorus tripinnatifidus</i> | | | | * | * | * | * | * | |
| | N <i>Adiantum hispidulum</i> | | * | | | | | | | |
| | N <i>Adiantum raddianum</i> | | * | | | | | | | |
| | N <i>Ageratina adenophora</i> | * | | | * | * | * | | | |
| | N <i>Ageratina riparia</i> | * | * | | | * | | | | |
| | N <i>Agrostis avenacea</i> | | | | X | | | | | |
| | N <i>Agrostis stolonifera</i> | | | | X | | X | | | |
| + | E <i>Alectryon macrococcus</i> var. <i>macrococcus</i> | | ? | ? | | | | | | ? |
| | N <i>Aleurites moluccana</i> | | * | * | | | | | * | |
| + | E <i>Alsinidendron trinerve</i> | | | | X | | X | | | * |
| | E <i>Alyxia oliviformis</i> | | | * | | | | | | * |
| | N <i>Anagallis arvensis</i> | | | | X | | 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

| Status | Taxon | 'A'ali'i Lowland dry Shrubland | Kukui Lowland Wet Forest | Lonomea Lowland Dry Forest | 'Ohi'a Montane Wet Shrubland | 'Ohi'a/Uluhe Montane Wet Forest | 'Ohi'a/'Olapa and Lapelepa Montane Wet Forest | 'Ohi'a/Mixed Shrub Montane Wet Forest | Toon Mesic Forest Lama Dry Forest | Oahu Diverse Low- land Mesic Forest |
|--------|---|-----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|---|--|--------------------------------------|--|
| N | Andropogon virginicus | * | | | * | * | * | * | | |
| E | Anoectochilus sandvicensis | | | | ? | | ? | ? | | |
| E | Antidesma platyphyllum | | | * | | | | | | |
| E | Antidesma pulvinatum | | * | * | | | | | * | X |
| E | Asplenium contiguum | | | | * | * | * | * | | |
| E | Astelia menziesiana | | | | * | | * | * | | |
| N | Athyrium japonicum | | * | | | | * | * | | |
| E | Athyrium microphyllum | | | | * | * | * | * | | |
| E | Athyrium sandwichianum | | * | | | | * | * | | |
| N | Axonopus fissifolius | | | | * | * | * | * | | |
| E | Bidens torta | * | | | * | | * | * | | |
| N | Blechnum occidentale | * | * | * | | * | | | * | |
| E | Bobea elatior | | | | | | | | | |
| + | E Bobea sandwicensis | | * | * | ? | | | | | X |
| + | E Bonamia menziesii | | | | | | | | ? | |
| E | Broussaisia arguta | | | | * | * | * | * | | |
| N | Buddleia asiatica | | * | | | | | | * | |
| I | Caesalpinia bonduc | | * | | | | | | | |
| N | Caesalpinia decapetala | | * | | | | | | | |
| + | E Caesalpinia kawaiensis | | | ? | | | | | ? | |
| E | Callistopteris baldwinii | | | | ? | ? | ? | ? | | |
| E | Canavalia galeata | | * | * | | | | | * | |
| N | Canna indica | | * | | | | | | * | |
| I | Canthium odoratum | * | * | * | | | | | * | |
| E | Carex alligata | | | | X | | X | | * | |
| E | Carex meyenii | * | * | | | | | | * | |
| E | Carex wahuensis | | * | | | | | | * | |
| N | Carica papaya | | * | | | | | | | |
| + | E Cenchrus agrimonioides var. agrimonioides | | ? | ? | | | | | ? | |
| N | Cenchrus echinatus | | | | X | | X | | | |
| N | Centaurium erythraea | | | | X | | X | | | |
| N | Centella asiatica | | | | X | | X | | | |
| N | Chamaecrista nictitans ssp. patellaria var. glabrata | * | | | | | | | | |
| + | E Chamaesyce herbstii | | ? | ? | | | | | ? | |
| E | Charpentiera obovata | | * | * | | | | | | |
| E | Cheirodendron platyphyllum | | | | * | * | * | * | | |
| E | Cheirodendron trigynum | | | | * | * | * | * | | |
| N | Chrysopogon aciculatus | | | | * | * | * | * | | |
| E | Cibotium chamissoi | | | | * | * | * | * | | |
| E | Cibotium glaucum | | | | * | * | * | * | | |
| E | Cibotium splendens | | | | X | | X | | | |
| E | Clermontia sp. | | | | | | | | | X |
| I | Cocculus trilobus | * | | | | | | | | |
| + | E Colubrina oppositifolia | | | ? | | | | | ? | |
| N | Commelina diffusa | | | | X | | X | | | |
| N | Conyza bonariensis | * | | | * | | | | | |
| N | Conyza canadensis var. | | | | X | | 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

Status Taxon

| Status | Taxon | 'A'ali'i Lowland Dry Shrubland | Kukui Lowland Wet Forest | Loomea Lowland Dry Forest | 'Ohi'a Montane Wet Shrubland | 'Ohi'a/Uluhe Montane Wet Forest | 'Ohi'a/'Olapa and Lapalapa Montane Wet Forest | 'Ohi'a/Mixed Shrub Montane Wet Forest | Toon Mesic Forest Lama Dry Forest | Oahu Diverse Low- land Mesic Forest |
|--------|--|-----------------------------------|-----------------------------|------------------------------|---------------------------------|------------------------------------|---|--|--------------------------------------|--|
| | pusilla | | | | | | | | | |
| E | Coprosma foliosa | | | | | * | | * | | * |
| E | Coprosma longifolia | | | | | | | * | | |
| E | Coprosma longifolia x C. ochracea | | | | * | | * | * | | * |
| E | Coprosma ochracea | | | | * | * | * | * | | * |
| N | Cordyline fruticosa | | * | | | | | | | |
| N | Crocasmia x crocosmiiflora | | | | ? | | ? | ? | | |
| E | Ctenitis rubiginosa | | | | | | * | * | | |
| + E | Ctenitis squamigera | | | X | | | | | X | |
| N | Cuphea carthagenensis | | | | | * | | | | |
| N | Cupressus sp. | * | | | | | | | | |
| E | Cyanea angustifolia | | | | X | | X | | | X |
| + E | Cyanea grimesiana ssp. grimesiana | | ? | | | | | | | |
| + E | Cyanea superba ssp. superba | | ? | ? | | ? | | | | |
| N | Cynodon dactylon | | ? | | | | | | ? | |
| E | Cyrtandra kalihii | | | | | | | * | | |
| E | Cyrtandra lessoniana | | | | | | | * | | |
| I | Cyrtomium caryotideum | | * | | | | | | | |
| + E | Cystopteris douglasii | ? | | ? | | | X | | ? | |
| N | Dactylis glomerata | | | | X | | | | ? | |
| + E | Delissea sinuata ssp. sinuata | | ? | ? | | | | | ? | |
| + E | Delissea subcordata | | ? | ? | | | | | ? | |
| N | Desmodium sandwicense | * | * | | | | | | | |
| E | Dianella sandwicensis | * | | | * | | * | * | | |
| I | Dicranopteris linearis | | | | * | * | * | * | | |
| + E | Diellia falcata | | | * | | | | | | |
| E | Diospyros hillebrandii | | * | * | | | | | | X |
| E | Diospyros sandwicensis | * | | | | | | | * | |
| + E | Diplazium molokaiense | | ? | | ? | ? | ? | ? | | |
| E | Diplopterygium pinnatum | | | | * | * | | * | | |
| + E | Dissochondrus biflorus | ? | ? | ? | | | | | ? | |
| I | Dodonaea viscosa | * | | | | | | | * | |
| E | Doodia kunthiana | * | | | | | | | | |
| E | Doryopteris decipiens | * | | | | | | | | |
| N | Drymaria cordata | | * | | | | | | | |
| E | Dryopteris glabra | | | | * | * | * | * | | |
| E | Dryopteris unidentata | | | | | | | | * | |
| E | Dubautia laxa ssp. hirsuta | | | | * | * | * | * | | |
| E | Dubautia laxa ssp. laxa | | | | X | | X | | | |
| E | Dubautia plantaginea ssp. plantaginea | | ? | | X | | X | | | |
| + E | Dubautia sherffiana | | | | ? | ? | | ? | | |
| E | Elaeocarpus bifidus | | | | | | | | | X |
| E | Elaphoglossum alatum | | | | X | | X | | | |
| E | Elaphoglossum crassifolium | | | | * | | * | * | | |
| E | Elaphoglossum hirtum var. | | | | * | * | * | * | | |

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|--------|--|-----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|---|--|--------------------------------------|--|
| | micans | | | | | | | | | |
| E | Elaphoglossum wawrae | | | | * | * | * | * | | |
| N | Epilobium billardierianum | | | | X | | X | | | |
| | ssp. cinereum | | | | | | | | | |
| E | Eragrostis grandis | * | | | | | | | | |
| N | Erechtites valerianifolia | | | | * | * | * | * | | |
| E | Erythrina sandwicensis | | * | | | | | | | |
| + | E Exocarpos gaudichaudii | ? | | | ? | ? | | ? | | |
| + | E Flueggea neowawraea | | ? | ? | | | | | | X |
| E | Freycinetia arborea | | | | * | * | | * | | X |
| + | E Gardenia brighamii | | | | | | | | | |
| + | E Gardenia mannii | | ? | ? | ? | ? | ? | ? | ? | |
| + | E Gouania meyenii | ? | | | | | | | ? | |
| + | E Gouania vitifolia | ? | | ? | | | | | ? | |
| E | Grammitis hookeri | | | | * | | * | * | | |
| E | Grammitis tenella | | | | * | * | * | * | | |
| N | Grevillea robusta | * | * | | | * | | * | | |
| E | Gunnera petaloidea | | | | X | | X | | | |
| E | Hedyotis acuminata | | | | | | | | | X |
| E | Hedyotis centranthoides | | | | * | | | | | |
| + | E Hedyotis degeneri var. coprosimifolia | ? | ? | ? | | | | | ? | |
| + | E Hedyotis degeneri var. degeneri | ? | ? | ? | | | | | ? | |
| E | Hedyotis hillebrandii | | | | | | | X | | |
| + | E Hedyotis parvula | ? | | | | | | | | |
| E | Hedyotis schlechtendahlana | | | | X | | X | * | | |
| E | Hedyotis terminalis | | | | * | | * | * | | |
| + | E Hesperomannia arbuscula | | ? | ? | | | | | ? | |
| + | E Hibiscus brackenridgei ssp. mokuleianus | | | ? | | | | | ? | |
| N | Holcus lanatus | | | | X | | X | | | |
| N | Hypochoeris glabra | ? | | ? | | | | | ? | |
| I | Hypolepis hawaiiensis | | | | * | * | * | * | | |
| E | Ilex anomala | | | | | | | | ? | |
| + | E Isodendrion laurifolium | | ? | ? | | | | | ? | |
| + | E Isodendrion longifolium | | ? | ? | | | | | ? | |
| + | E Joinvillea ascendens ssp. ascendens | | ? | ? | ? | ? | ? | ? | ? | |
| N | Juncus bufonius | | | | X | | X | | | |
| N | Juncus effusus | | | | | | * | | | |
| N | Juncus planifolius | | | | * | * | * | * | | * |
| N | Kalanchoe pinnata | | | | | | * | | | |
| E | Korthalsella latissima | | | | | | | * | | |
| N | Kyllinga brevifolia | | | | * | * | | * | | |
| N | Kyllinga nemoralis | | | | X | | X | | | |
| + | E Labordia cyrtandrae | | | | ? | ? | ? | ? | | |
| E | Labordia fagraeoidea | | | | * | * | * | * | | |
| + | E Labordia kaalae | | | | ? | ? | | ? | | |

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|--------|---|-------------------------------|--------------------------|----------------------------|------------------------------|---------------------------------|--|---------------------------------------|-----------------------------------|-----------------------------------|
| E | Labordia sp. | | | | | | | X | | |
| N | Lantana camara | * | * | | | | | | * | |
| N | Leucaena leucocephala | | * | | | | | | | |
| E | Liparis hawaiiensis | | | | | | * | | | |
| + | E Lipochaeta lobata var. lobata | ? | | | | | | | | |
| + | E Lipochaeta remyi | ? | | | | | | | | |
| + | E Lipochaeta tenuifolia | ? | | | | | | | | |
| + | E Lobelia hypoleuca | | | | ? | ? | ? | ? | | |
| + | E Lobelia niihauensis | ? | ? | ? | | | | | | |
| N | Lolium multiflorum | | | | X | | X | | | |
| I | Lycopodium cernuum | | | | * | | * | * | | |
| I | Lycopodium venustulum | | | | * | | | * | | |
| N | Lythrum maritimum | | | | | * | * | * | | |
| I | Machaerina angustifolia | | | | * | * | * | * | | |
| E | Marattia douglasii | | | | | | | * | | |
| E | Mariscus hypochlorus | | | | X | | X | | | |
| N | Mariscus meyenianus | | | | * | * | * | * | | |
| N | Mariscus meyenianus | | | | * | * | * | * | | |
| + | E Mariscus pennatiformis ssp. pennatiformis | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| E | Mecodium recurvum | | | | * | * | * | * | | |
| N | Medicago lupulina | | | | X | | X | | | |
| N | Medicago polymorpha | | | | X | | X | | | |
| N | Melia azedarach | | * | | | | | | * | |
| N | Melinis minutiflora | * | | | | | | | | |
| N | Mentha spicata | | | | X | | X | | | |
| E | Metrosideros polymorpha | * | | | * | * | * | * | | X |
| E | Metrosideros tremuloides | | | | * | * | * | * | | |
| I | Microlepia strigosa | | * | * | | | | | * | |
| E | Myrsine lessertiana | | | | * | | * | * | | X |
| E | Myrsine sandwicensis | | | | | | * | * | | |
| N | Nasturtium microphyllum | | | | | | * | * | | |
| N | Nasturtium sarmentosum | | | | X | | X | | | |
| I | Nephrolepis cordifolia | | | | | | | * | | |
| I | Nephrolepis exaltata | * | | * | | * | | | | |
| N | Nephrolepis multiflora | | * | | | | | | | |
| + | E Neraudia angulata var. angulata | | ? | ? | | | | | ? | |
| + | E Neraudia angulata var. dentata | | ? | ? | | | | | ? | |
| + | E Neraudia melastomifolia | | ? | ? | | | | | ? | |
| E | Nertera granadensis var. insularis | | | | * | | * | * | | |
| + | I Nesoluma polynesianum | ? | | ? | | | | | ? | |
| E | Nestegis sandwicensis | * | * | * | | | | | * | X |
| + | E Nothocestrum latifolium | | ? | ? | | | | | ? | |
| + | E Nototrichium humile | ? | ? | ? | | | | | ? | |
| I | Odontosoria chinensis | * | | | * | | | * | | |

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|--------|--|-----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|--|--|--------------------------------------|--|
| N | Oplismenus hirtellus | | * | | | | | | * | |
| I | Osteomeles anthyllidifolia | * | | | | | | | | |
| N | Oxalis corniculata | * | * | | | | | | | |
| N | Oxalis corymbosa | | * | | | | | | * | |
| N | Panicum maximum | | * | | | | | | | |
| N | Paspalum conjugatum | | * | | * | * | * | * | * | |
| N | Paspalum scrobiculatum | * | | | | | | | | |
| N | Paspalum urvillei | | | | * | * | | | | |
| N | Passiflora edulis | | * | | | | | | | |
| + | E Pelea christophersenii | | | | ? | ? | ? | ? | | |
| + | E Pelea cinerea var. cinerea | | ? | ? | | | | | ? | |
| + | E Pelea cinerops | | ? | ? | | | | | ? | |
| | E Pelea clusiifolia | | | | * | | * | * | | |
| | E Pelea oahuensis | | | | | | | * | | |
| + | E Pelea pallida | | | ? | | | | | ? | |
| | E Pelea penduncularis | | | | * | * | * | * | | |
| # | E Pelea sandwicensis | | | | X | | X | | | |
| | E Peperomia latifolia | | | | X | | X | | | |
| | E Peperomia macraeana | | | | * | * | * | * | | |
| | E Peperomia membranacea | | * | | | | | | | |
| | E Perrottetia sandwicensis | | | | * | | | * | | |
| N | Phlebodium aureum | | * | | | | | | | |
| | E Phyllostegia grandiflora | | | | * | * | | * | | |
| + | E Phyllostegia hirsuta | | | | ? | ? | ? | ? | | |
| | E Phyllostegia lantanoides | | | | * | * | | * | | |
| + | E Phyllostegia mollis | | ? | | | | | | ? | |
| | E Pipturus albidus | | * | * | * | | | * | * | |
| | E Pisonia brunoniana | | | | | | | | | X |
| | E Pisonia sandwicensis | * | * | | | | | | | X |
| | E Pisonia umbellifera | | * | | | | | * | | |
| N | Pityrogramma calomelanos | | | | X | | X | | | |
| N | Plantago major | | | | * | * | * | * | | |
| + | E Plantago princeps var. anomala | | | | ? | ? | ? | ? | | |
| # | E Plantago princeps var. longibracteata | | | | ? | ? | ? | ? | | |
| + | E Platydesma cornuta var. decurrens | | ? | | | ? | | ? | ? | |
| + | E Pleomele forbesii | ? | | ? | | | | | ? | X |
| | E Pleomele halapepe | | | | | | | * | * | X |
| I | Pleopeltis thunbergiana | * | * | | * | | * | * | | |
| N | Pluchea symphytifolia | | | | | * | | | | |
| N | Poa annua | | ? | | | | | | ? | |
| | E Polypodium pellucidum | | | | * | | * | * | | |
| N | Polypogon interruptus | | | | | | * | | | |
| | E Pouteria sandwicensis | | * | | | | | | * | X |
| + | E Pritchardia kaalae | | ? | ? | ? | ? | | ? | ? | |
| N | Psidium cattleianum | * | * | | | | | * | * | |
| N | Psidium guajava | * | * | | | | | * | * | |

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|--------|---|-----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|--|--|--------------------------------------|---------------------------------------|
| I | Psilotum nudum | * | | | | | | | | |
| E | Psychotria hathewayi var. hathewayi | | | | | | | * | | |
| E | Psychotria kaduana | | | | X | | X | | | |
| E | Psychotria mariniana | | | | | | | | | X |
| E | Pteridium decompositum | * | | | | | | | | |
| I | Pycnopus polystachyos | | | | X | | X | | | |
| + | Ranunculus mauianus | | | | ? | ? | ? | ? | | |
| E | Rauvolfia sandwicensis | | | | | | | | | X |
| N | Rhynchelytrum repens | * | | | | | | | | |
| + | Rollandia lanceolata ssp. calycina | | ? | | ? | ? | ? | ? | ? | |
| E | Rollandia longiflora | | ? | | ? | ? | ? | ? | | |
| N | Rubus argutus | | | * | * | * | * | * | * | |
| N | Rubus rosifolius | | * | * | * | * | * | * | * | |
| N | Sacciolepis indica | | | | * | * | * | * | * | |
| E | Sadleria cyatheoides | | | | * | * | * | * | * | |
| E | Sadleria pallida | | | | * | * | * | * | * | |
| N | Salvia occidentalis | | | | | | | | * | |
| E | Sapindus oahuensis | | * | * | | | | | * | X |
| E | Scaevola gaudichaudiana | * | | | | | | | | |
| E | Scaevola mollis | | | | * | * | | | | |
| + | Schiedea hookeri | ? | ? | ? | | | | | ? | |
| # | Schiedea kaalae | | ? | ? | | | | | ? | |
| + | Schiedea ligustrina | ? | | | | | | | ? | |
| + | Schiedea nuttallii | | ? | ? | | | | | ? | |
| + | Schiedea pubescens var. purpurascens | | | | | ? | | ? | ? | |
| N | Schinus terebinthifolius | * | * | * | | | | | * | |
| E | Selaginella arbuscula | | * | | | | | | * | |
| N | Setaria gracilis | * | | | | | | | | |
| N | Setaria palmifolia | | | | | * | | | ? | |
| + | Sicyos sp. A | | ? | ? | | | | | | |
| E | Smilax melastomifolia | | | | * | | * | * | | |
| N | Solanum americanum | | | | X | | X | | | |
| N | Spathodea campanulata | | * | | | | | | | |
| N | Spathoglottis plicata | * | | | | | | | | |
| E | Sphaerocionium lanceolatum | | | | * | | * | * | | |
| E | Sphaerocionium obtusum | | | | X | | X | | | |
| N | Sporobolus indicus | | | | X | | X | | | |
| N | Stachytarpheta jamaicensis | * | | | | | | | * | |
| E | Sticherus owhyensis | | | | * | | | * | * | |
| E | Streblus pendulinus | | | | | | | | * | |
| E | Strongylodon ruber | | * | | | | | | | |
| I | Styphelia tameiameia | * | | | * | * | * | * | * | |
| N | Syzygium cumini | * | * | * | | | | * | * | |
| E | Syzygium sandwicensis | | | | * | | * | * | * | |
| N | Taraxacum officinale | | | | X | | X | | | |
| + | Tetramolopium filiforme | ? | | | | | | | | |

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|--------|---|----------------------------------|-----------------------------|-------------------------------|---------------------------------|------------------------------------|--|--|--------------------------------------|--|
| | var. polyphyllum | | | | | | | | | |
| + E | Tetramolopium lepidotum | ? | | | | | | | | |
| | ssp. lepidotum | | | | | | | | | |
| E | Tetraplasandra oahuensis | | | | | | X | | | X |
| E | Thelypteris cyatheoides | | | | X | | X | | | |
| N | Thelypteris dentata | | * | | * | | | | * | |
| E | Thelypteris hudsoniana | | * | | | | | | | |
| N | Thelypteris parasitica | | * | * | | | | | * | |
| E | Thelypteris sandwicensis | | | | * | | | * | | |
| N | Toona ciliata var. australis | * | * | * | | | | | * | |
| E | Trematolobelia grandifolia | | | | | | | X | | |
| E | Trematolobelia macrostachys | | | | * | | | * | | |
| N | Triumfetta rhomboidea | | * | | | | | | | |
| E | Vaccinium calycinum | | | | * | | * | * | | |
| # | Vandenboschia draytoniana | | ? | | | | | | | |
| N | Verbena litoralis | | | | X | | X | | | |
| N | Veronica arvensis | | | | X | | X | | | |
| + E | Vigna o-wahuensis | ? | | ? | | | | | ? | |
| # | Viola chamissoniana ssp. chamissoniana | | | | ? | ? | | ? | | |
| I | Vittaria elongata | | | | X | | X | | | |
| N | Vulpia megalura | | | | X | | X | | | |
| E | Xiphopteris saffordii | | | | * | | * | * | | |
| N | Youngia japonica | | | | | * | | | | |

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APPENDIX 4
Mount Kaala Area
Bird Species List

The birds listed have been reported from visual and audio identification in or near the Reserve. The lists includes information on rare birds, compiled from the literature. Non-rare species listed were observed during the field survey. Because a comprehensive bird survey has never been conducted for Oahu, no other non-native bird information is available. Taxonomy follows the Checklist of the Birds of Hawaii by Pyle (1988).

| Status | Species | Common Name | Source |
|-----------------|--|---------------------------------------|--------|
| E | <u>Chasiempis sandwichensis</u> <u>gayi</u> | Oahu 'elepaio | * |
| N | <u>Copsychus malabaricus</u> | White-rumped shama | * |
| N | <u>Garrulax canorus</u> | Hwamei | * |
| E | <u>Hemignathus virens chloris</u> | Oahu 'amakihi | * |
| E | <u>Himatione sanguinea</u> <u>sanguinea</u> | 'Apapane | * |
| +E | <u>Paroreomyza maculata</u> | Oahu creeper | x |
| I | <u>Phaethon lepturus dorotheae</u> | Koa'e kea, white-tailed tropicbird | * |
| N | <u>Pycnonotus cafer</u> | Red-vented bulbul | * |
| +E ¹ | <u>Vestiaria coccinea</u> | 'I'iwi | x |
| N | <u>Zosterops japonicus</u> | Japanese white-eye | * |

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¹ 'I'iwi is listed endangered by the State of Hawaii for the islands of Oahu, Molokai, and Lanai (DLNR 1986)

