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Technical Report 59

STATUS OF NATIVE FLOWERING PLANT SPECIES ON
THE SOUTH SLOPE OF HALEAKALA, EAST MAUI, HAWAII

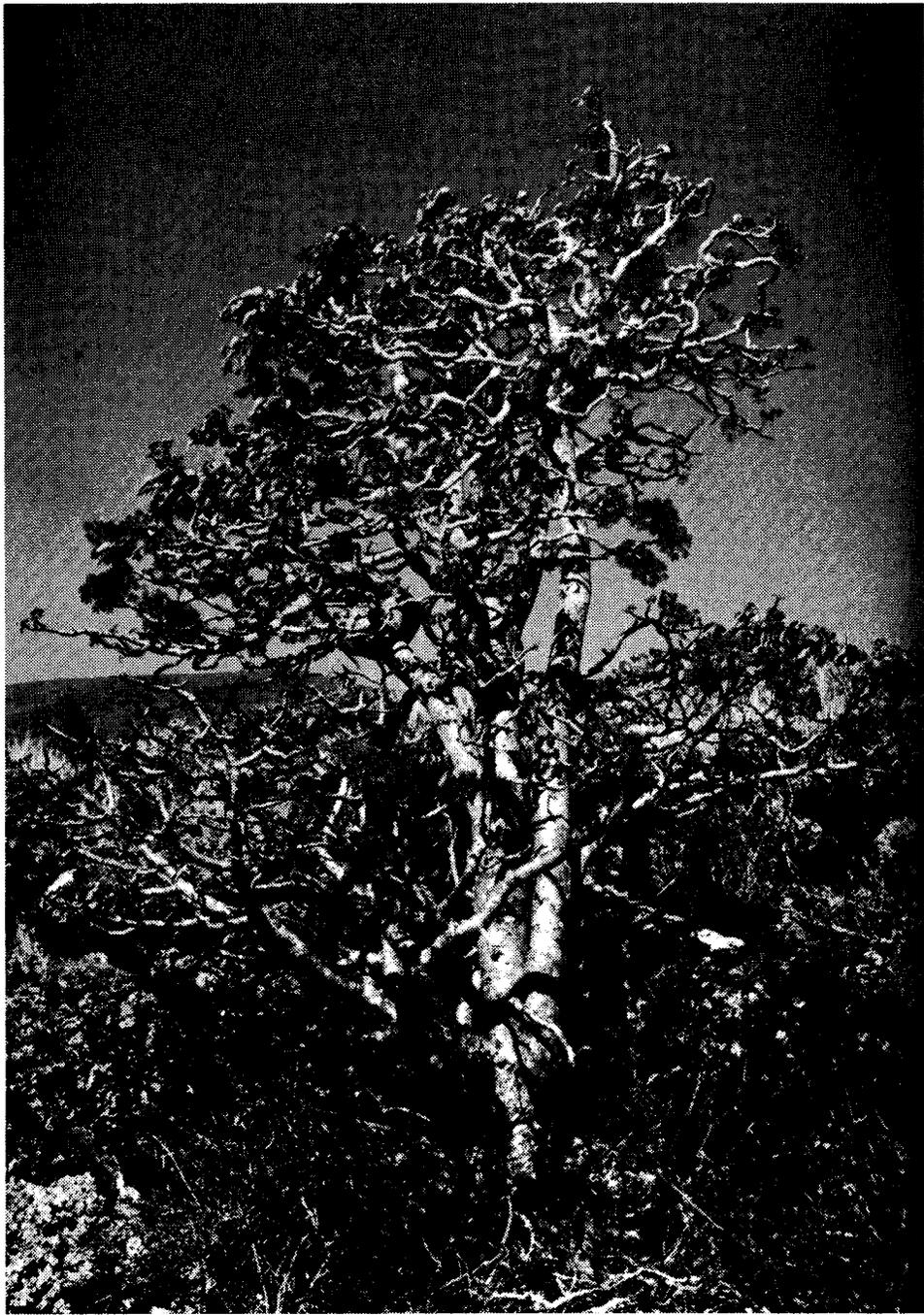
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Frontispiece. Reynoldsia mauiensis (Araliaceae), a summer deciduous tree species, growing at 1550 ft near the Auwahi/Kanaio district boundary, south slope of Haleakala, Maui, Hawaii.

ABSTRACT

In an attempt to provide a basis for conservation measures for the remaining leeward native vegetation of East Maui, an assessment was made of the past and present status of all flowering plant species known from the area. The unpublished 1920 field notes of C. N. Forbes provided a major source of information on past status. Present status was determined by field exploration. A total of 237 native species in 70 families and 139 genera once occurred in the study area, which extends from sea level to 3000m (10,000 ft). Of the native flowering plants of the study area 86% are endemic to the Hawaiian Islands; 28% are endemic or have infraspecific taxa endemic to the island of Maui. Forty-six (19%) of the species once present in the study area have neither been encountered by this survey nor recently noted by others and are considered extirpated. Of these, 23 species have surviving populations elsewhere in the Hawaiian Islands, though in some cases the study area populations represent endemic subspecific taxa. The remaining 23 species (10%) are apparently extinct. Of these extinct species, 20 species were endemic to East Maui. Extinct endemic species of the study area include: Canavalia forbesii, Cladocarpa hispida, Cyanea arborea, C. comata, Cyrtandra begoniaefolia, Gouania lydgatei, G. pilata, Hedyotis foliosa, Hibiscadelphus wilderianus, Pelea tomentosa, Phyllostegia hillebrandii, Schiedea implexa, Sicyos hillebrandii, Solanum haleakalaense, Stenogyne cinerea, S. glabrata, S. haliakalae, and S. vagans.

Major factors currently contributing to the continuing serious decline of native vegetation and flora of leeward East Maui include: browsing and grazing by feral goats and feral and domestic cattle; feeding and digging by feral pigs; and displacement of reproduction of native plant species by introduced plant species - especially Pennisetum clandestinum, Holcus lanatus, and Bidens pilosa. Although most native species consistently produce flowers and fruits, this survey found little or no evidence of successful reproduction of most woody species. Dodonaea eriocarpa and Wikstroemia monticola are the only native species which appear to be maintaining vigorous, abundantly reproducing populations in spite of habitat degradation.

Although Haleakala National Park appears to provide a relatively secure "refuge" for many species of the study area, the park by no means includes a representative sample of the vegetation and flora of leeward East Maui. Of the 237 species of native flowering plants recorded in the study area by this survey, only 108 species (46%) have also been recorded as naturally occurring within the park. However, in spite of the advanced deterioration of East Maui's native leeward vegetation, sites containing significant remnants of the former vegetation still exist outside the park and provide opportunities for preservation.

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INTRODUCTION

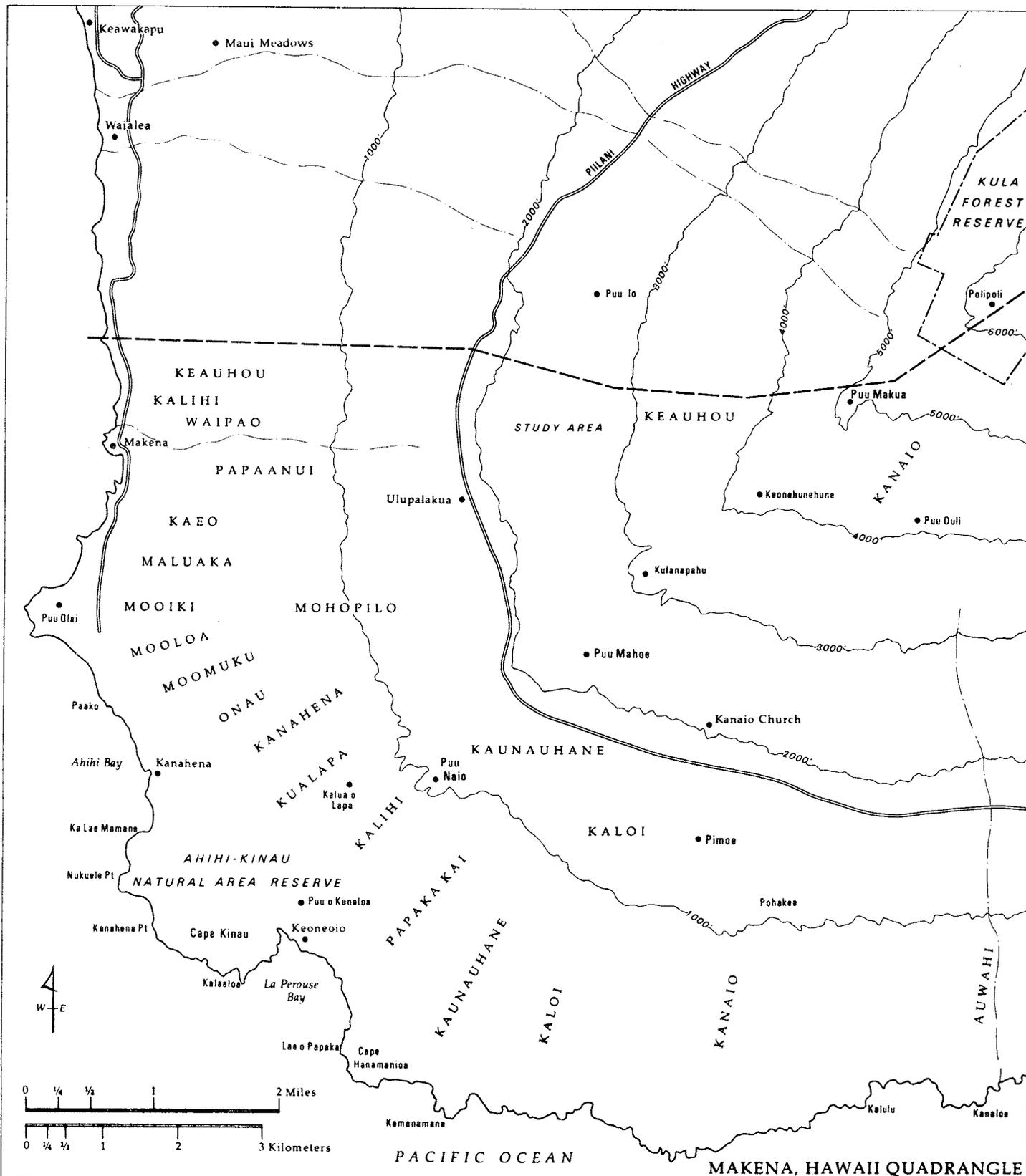
It has long been known that the so-called leeward dryland forest of Maui is one of the richest areas in native tree species in the state of Hawaii. Joseph Rock (1913), in his classic book, "Indigenous Trees of the Hawaiian Islands," identified the "Auwahi" region on the south slope of Haleakala as one of the most important botanical sites in the islands even though it had been seriously degraded by browsing of goats and cattle when he first saw it in 1910. The degradation has not abated and promises to completely obliterate what remnants still exist during the next 50-100 years unless serious action is taken. Although portions of Haleakala's leeward slopes have been set aside as conservation lands (the Kaupo Gap portion of Haleakala National Park, several State forest reserves - Kula, Kahikinui, and part of Kipahulu Forest Reserves), little has as yet been done to reverse the degradation of native vegetation in these areas.

This study, initiated in May, 1981, provides the basis for measures aimed at achieving meaningful conservation of what remains of East Maui's leeward native flora, both within and outside Haleakala National Park. Our approach for accomplishment of this objective has been to 1) compile background information on the area and available information on all native plant species known to occur or to have occurred on leeward East Maui, and 2) assess the current status of each of these species through field work.

METHODS

The project was initiated in May 1981. All available literature and information from people who were known to have good botanical knowledge of the area were used to develop a plan for field work. Rock's (1913) "The Indigenous Trees of the Hawaiian Islands" and the 1920 field notes of C. N. Forbes gave locations of many taxa. Written reports by Lamoureux (1966), Lennox (1967), and Hobdy (1973) were very helpful. Examination of aerial photographs and a helicopter reconnaissance were used to refine the plan for field work. The area covered was chosen to include the entire south slope from the southwest rift east to the eastern wall of Kaupo Gap (Figures 1-A, 1-B, 1-C). In some cases, taxa of the adjacent west slope were included, since much of that area is very similar ecologically and was better collected prior to 1910 than the south slope proper. (Also, some of the most intact lowland leeward vegetation on East Maui persists in that area.) Figures 1-A, 1-B, 1-C show the location of districts and other place names within the study area.

Figure 1-A: The study area is located south of Haleakala National Park on East Maui and is included on three U.S. Geological Survey topographic maps - the Makena, Lualailua, and Kaupo quadrangles (1:24,000). The easternmost is the Makena quadrangle which encompasses (west to east) the small districts of Kanahena, Kualapa, Kalihi, Papaka Kai, Kaunauhane, Kaloi and the larger districts Kanaio and western Auwahi.



BOUNDARIES:

STUDY AREA

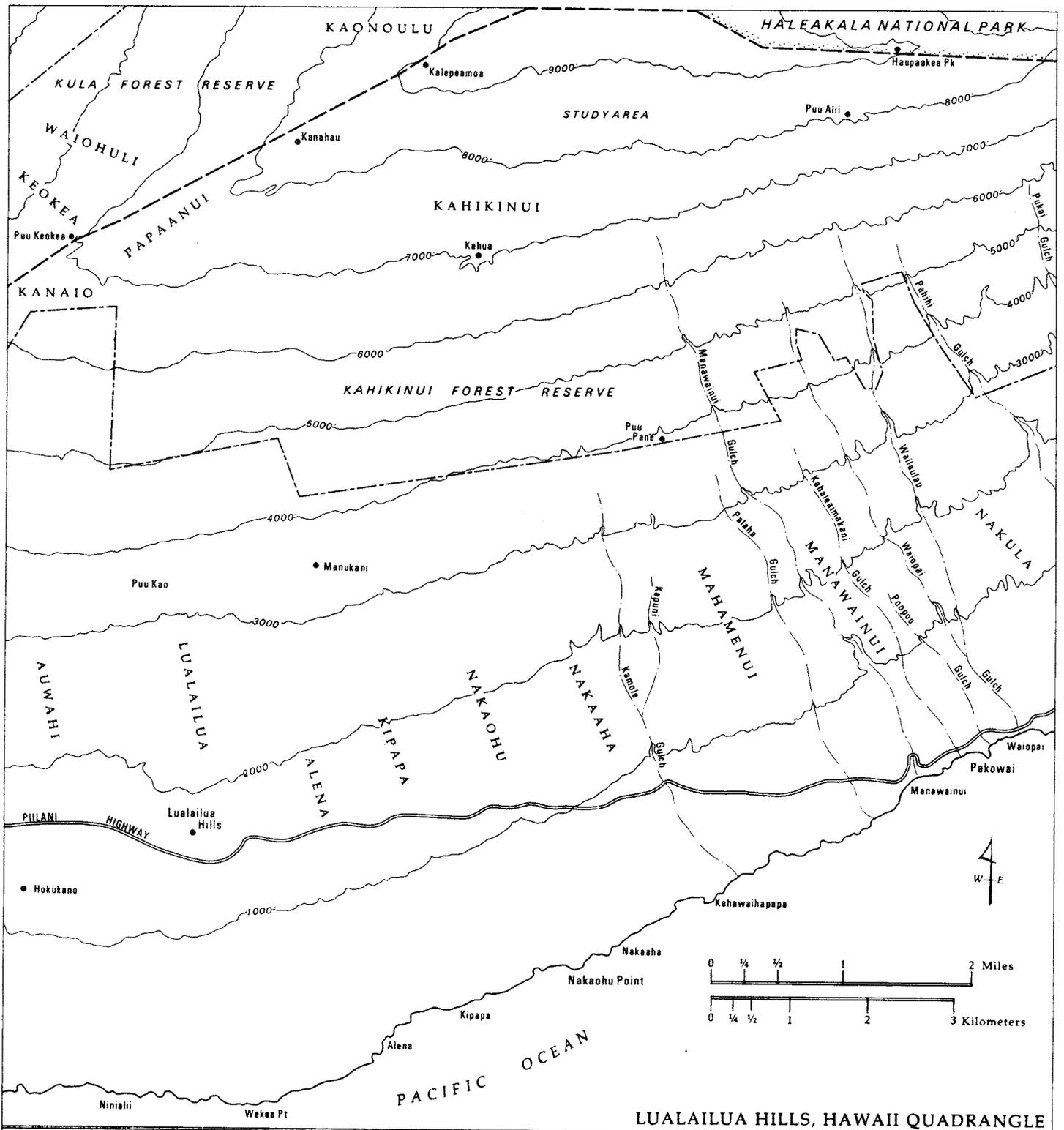
FOREST RESERVE

Manoa Mapworks

MAKENA, HAWAII QUADRANGLE

Figure 1-B: Luaala'ilua quadrangle.

The central region of the study area, Luaala'ilua quadrangle, encompasses (west to east) the districts of eastern Auwahi, Luaala'ilua, Alena, Kipapa, Nakaohu, Nakaaha, Mehamenui, Manawainui and the large upland areas of Kahikinui and western Nakula.



BOUNDARIES:

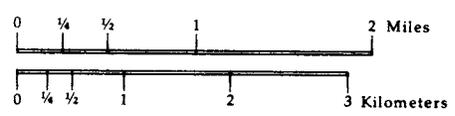
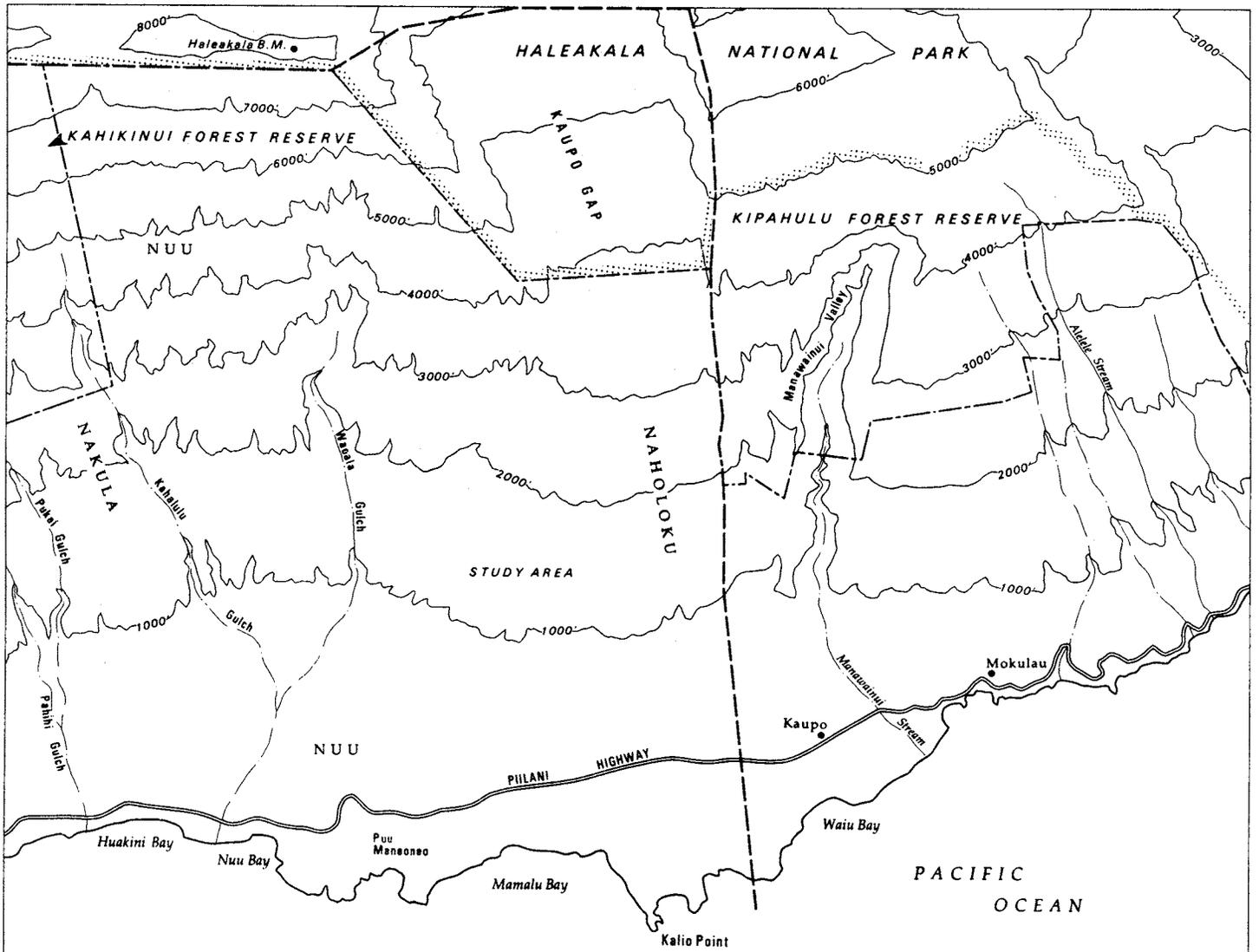
STUDY AREA ————

FOREST RESERVE - - - - -

NATIONAL PARK ······

Figure 1-C: Kaupo quadrangle.

The easternmost region of the study area, Kaupo quadrangle encompasses (west to east) the large districts of eastern Nakula, Nu'u and Naholoku. The latter area is referred to by this project by the more general district name, Kaupo.



KAUPO, HAWAII QUADRANGLE

BOUNDARIES:

- STUDY AREA - - - - -
- FOREST RESERVE - · - · - · -
- NATIONAL PARK ······

Field work was carried out between July 1981 and September 1984, but primarily from July 1981 through March 1982. Later field trips were taken mainly to refine information and make adequate collections of critical taxa. Survey efforts were concentrated in four general areas, chosen because they had been identified as centers of diversity: 1) the forested gulch and east wall of Kaupo Gap between elevations of 3800 and 5800 ft; 2) the three "forested" rough aa flows in Kanaio, Auwahi, and Lualailua between 1400 and 3000 ft; 3) the middle elevation (3000-4000 ft) or "kikuyu grass" zone of Auwahi, and 4) the upland ohia-koa forest of Kahikinui, roughly in the center of the study area.

Nearly all field work was done on foot, in two-person teams, with access from below from Highway 31 or above from the rim of Haleakala. Most field time was spent searching promising areas for native plant populations and especially for sites with high native plant diversity and potential for reproduction, areas suitable for concentration of future conservation efforts and/or intensive ecological studies. Locations were marked on U.S.G.S. 7.5' quadrangles for the area, elevation recorded from an altimeter, and notes taken on plant vigor, size, reproductive status, phenology, and apparent threats. For trees, each location was later compiled on a distribution map for each taxon. Voucher specimens were collected when appropriate material was available for critical taxa, except where such taxa were considered dangerously rare. All specimens have been deposited in the B. P. Bishop Museum herbarium (BISH). Good photographic documentation of the current status of the area was obtained.

An experiment to explore potential impacts of introduced rodents through predation of seeds (seeds counted and placed in plots, recounted at intervals of 1 week) of selected native trees was carried out in December, 1981. Results were not entirely conclusive, but in the case of some species provided a strong indication of whether or not seeds are eaten by rats. Mention of somewhat definitive results is made in the text where appropriate.

Information on propagation of native plants of the south slope was solicited from nurseries and botanical gardens throughout the islands. Available data on germination and propagation success were used to help assess in situ and ex situ reproductive potential and possibilities for ex situ preservation. Reports of living specimens in cultivation were recorded when available.

Throughout the text, elevations are given in feet because USGS quadrangles, the only detailed maps of the area, give elevations in feet. All other measurements are given in metric units.

LEEWARD FORESTS OF THE HAWAIIAN ISLANDS: A PERSPECTIVE

Rock (1913) contrasted the "leeward lower forest flora" with that of moister regions: "No two forest floras could be more different.. The plant covering of the leeward regions, as for example the Waianae mountains, Oahu, the southern slope of Haleakala, Maui, the west end of Molokai, etc., is the richest in species as far as tree growth is concerned. Nearly all trees growing on these more or less arid lava fields have developed extremely hard, close-grained wood. Only four or five species, as Reynoldsia, Erythrina, Nothocestrum, etc., are soft-wooded, and possess exceedingly thin bark, while those of hard wood possess a usually rough, scaly bark of perhaps half an inch or more in thickness. The striking flora gives the region a most peculiar aspect.. It is in these peculiar regions that the botanical collector will find more in one day collecting than in a week or two in a wet region.. It may be of interest to know that not less than 60 per cent of all the species of indigenous trees growing in these islands can be found and are peculiar to the dry regions or lava fields of the lower forest zone, which in certain localities gradually passes into the middle forest region.."

Rock (1913) further compared Hawaiian leeward lower forests with those elsewhere in the world: "These dry or mixed forest regions occur, however, in other tropical countries, as in East Java and India, and are peculiar in so far as they are composed of periodically deciduous trees. In Hawaii only three or four species lose their leaves in the dry season, as Erythrina [sandwicensis], Reynoldsia sandwicensis, Kokia drynarioides, and Sapindus saponaria... Strange to say, these mixed forests have hardly any native undergrowth, with the exception of a few ferns and grasses.."

By the time of Rock's botanical explorations, much destruction of Hawaii's leeward forests had taken place through clearing, burning, and introduction of livestock. "The slopes of Kula, where once a beautiful dry forest existed, are now bare owing to cattle... At Ulupalakua native vegetation has disappeared entirely..." (Rock 1913). Deterioration of these forests has continued up to the present. Carlquist (1970) states that "areas of dry forest are now so few that we have difficulty in constructing a picture of this vegetation." Fosberg (1972), referring to "dryland sclerophyll forest," states that whereas "large areas.. were originally covered by an open scrub forest..", only "a few scraps and traces.. remain, mostly on rough lava flows, on the two largest islands, and even these are mostly in a sad state of degradation from overgrazing."

Botanical literature regarding Hawaii's leeward forests is extremely limited. The only substantive published work is for Oahu by Egler (1942,1947), Hatheway (1952), and Wirawan (1974) and for the coastal lowlands of the island of Hawaii by

Mueller-Dombois (1981b). Although the native flora is reportedly surviving in at least one such area, the so-called Mokuleia forest area of the northern Waianae Mountains of Oahu (Wirawan 1974; Mueller-Dombois 1981a), much of the leeward forest flora is being lost without documentation.

VEGETATION ZONATION ON THE SOUTH SLOPE OF HALEAKALA

The vegetation of the Hawaiian Islands does not lend itself well to a comprehensive classification. Any classification scheme for Hawaiian vegetation inevitably has serious shortcomings, partly because of 1) tremendous inter- and intra-island variation in substrate, topography, precipitation, and available genotypes; and 2) the fragmentation and severe modification of native vegetation, especially at lower elevations. The classification system which is probably used most frequently in Hawaii today is that of Ripperton and Hosaka (1942), which is quite satisfactory for agricultural and other introduced vegetation, but gives little detail for native vegetation. Of the existing systems, we find Rock's (1913) simple classification the most useful for providing a framework in describing vegetation zonation on Haleakala's south slope. Still, we feel that a more detailed local classification scheme is desirable to do justice to the tremendous variation in environment and vegetation which exists between sea level and 10,000 ft.

Four vegetation zones are recognized on the basis of major differences in environmental conditions and in physiognomy of vegetation. Our use of the concept of vegetation zones corresponds roughly with that of Billings (1949). Our scheme of vegetation zonation on the south slope agrees fairly closely with the classifications of Rock (1913) and Ripperton and Hosaka (1942) (Table 1). Within each of these zones, subzones are recognized to reflect relatively subtle, but significant, differences in environment and species composition.

High-Elevation Shrubland/Rockland Zone

This zone encompasses a 6000 ft range in elevation (4000-10,000 ft), over which the vegetation exhibits relatively little physiognomic and floristic variation. Microphyllous, sclerophyllous shrubs, adapted to wide temperature ranges and high moisture stress, dominate. The major vegetation contrasts involve differences in height and density of vegetation rather than large differences in species composition. We recognize three subzones - Alpine Rockland, Subalpine Shrubland, and Montane Shrubland.

Alpine Rockland Subzone

The Alpine Rockland subzone above about 8000 ft on Haleakala has very sparse vegetation due to the combination of harsh climatic and edaphic conditions. Median annual precipitation is approximately 1250mm (State of Hawaii 1982); relative humidity is generally below 40% and often as low as 5-10% (Blumenstock and Price 1967); solar radiation, including ultraviolet-B, is very high (Caldwell, Robberecht, and Billings 1980); mean annual temperature is 8.6°C at Haleakala's summit (Whiteaker 1983). Substrate consists of only slightly weathered lava flows with almost no soil formation. Our Alpine Rockland corresponds to Whiteaker's (1983) High-altitude Desert communities of Haleakala. The boundary between subalpine and alpine in Hawaii as elsewhere is generally agreed to be the "timberline" (Fosberg 1959). Erect plants of Sophora chrysophylla occur as high as 9000 ft on Haleakala's west slope, but the question of whether they qualify as timber is an open one. Above 8000 ft, few "trees" on the south slope surpass 3m in height. This subzone is, however, essentially an attenuated version of subalpine shrubland, and contains few unique elements. Tetramalopium humile, Agrostis sandwicensis, and perhaps Trisetum glomeratum are most abundant in this zone. Dubautia menziesii becomes the dominant shrub at the highest elevations. This subzone has probably been less modified by browsing than others, partially due to inherent sparsity of vegetation, and introduced plant species are less apparent here than elsewhere.

Subalpine Shrubland Subzone

The Subalpine Shrubland subzone (6000-8000 ft) of Haleakala bears considerable resemblance to that of Mauna Kea and Mauna Loa on the island of Hawaii, described by Hartt and Neal (1940), Fosberg (1959), and others. Much or all of this zone usually lies above the temperature inversion layer which generally accompanies the trade winds and fluctuates between the 5000 and 7000 ft level (Blumenstock and Price 1967) and has a climate similar (high solar radiation, low humidity) to that of the Alpine Rockland. The lower portion of the zone is often immersed in clouds and is substantially more moist. Substrate weathering and soil formation in this zone are moderate.

Santalum haleakalae is a unique element on Haleakala. Coprosma montana, Sophora chrysophylla, Styphelia tameiameia, and Vaccinium reticulatum are the dominant shrubs. Metrosideros is sporadic and somewhat rare in the lower part of this zone, usually found along gulches. Deschampsia australis and Pteridium aquilinum are the dominant natives in the understory. Holcus lanatus, Hypochoeris radicata, and Sporobolus africanus are abundant introduced species. Native vegetation of this zone has been remarkably resilient to long-term browsing pressure, largely due to the leathery

Table 1. Generalized classification of zones and subzones of remnant native vegetation on the south slope of Haleakala, Maui, Hawaiian Islands, in relation to classification systems of Rock (1913) and Ripperton and Hosaka (1942).

Vegetation ZONES and Subzones (this study)	Approximate elevational limits (ft)	Designation of Rock (1913) Ripperton & Hosaka	
HIGH-ELEVATION SHRUBLAND/ROCKLAND			
Alpine rockland	8000-10,000	Upper forest region	E2
Subalpine shrubland	6000-8000	Upper forest region	E1-E2
Montane shrubland	4000-6000	Middle forest region, dry/semi-dry	E1
MIDDLE-ELEVATION MESOPHYTIC CLOUD-BELT FOREST			
Mesophytic forest	4000-6000	Middle forest region, semi-dry/wet	D2-D3
DRYLAND FOREST/SHRUBLAND			
Upper dryland forest	3000-4800	Lower forest region, leeward	C2
Middle dryland forest	2000-3000	Lower forest region, leeward	B-C2
Lower dryland forest	1000-2000	Lower forest region, leeward	B
Seasonal dryland forest	strand-1000	Lowland region, dry	A
STRAND	0-ca.20	Strand vegetation	

foliage of many species and the ability of many of them to reproduce vegetatively. Nevertheless, Styphelia, one of the most browsing-resistant shrub species, has been locally eliminated by continually high goat populations. A long history of feral pig activity continues at present and strongly disrupts the native grass cover and elements such as Sisyrinchium.

Montane Shrubland Subzone

The Montane Shrubland subzone occurs between 4000 and 6000 ft on relatively poorly weathered Hana lavas and is dominated by Dodonaea eriocarpa, Styphelia tameiameia, and other species of the Subalpine Shrubland zone, with scattered individuals of Metrosideros polymorpha. Metrosideros is locally abundant and may have originally been much more prominent in this zone. Feral goats have apparently greatly altered the vegetation. There may be little justification for separating this subzone from Subalpine Shrubland since most species are common to both. The abundance of Osteomeles anthyllidifolia and the large stature of Dodonaea and Styphelia in Montane Shrubland are its best distinguishing features.

Middle-Elevation Mesophytic Cloud-Belt Forest Zone

The Mesophytic Cloud-Belt Forest (4000-6000 ft) is dominated by Metrosideros polymorpha (ohia) and Acacia koa (koa) and occurs on relatively well-weathered Kula series lavas. Although median annual rainfall is approximately 1000-1250mm (40-50 in., State of Hawaii, 1982), this forest is below the trade-wind inversion and under a cloud-bank much of the time. Microhabitats and vegetation approaching rain forest (with Cheirodendron trigynum, Ilex anomala, and Pelea clusiaefolia) occur in the deep gulches which dissect this zone. Acacia tends to occur on ridges adjacent to the gulches. Metrosideros dominates near the upper forest line (ecotone with subalpine shrubland) and on broad slopes. Individuals of Santalum closest to S. haleakalae occur in the upper parts of this zone growing with Acacia koa as low as 5500 ft.

The former understory of Cibotium glaucum and Sadleria pallida has been completely destroyed by pigs, goats and cattle except for a few relatively inaccessible temporary survivors (Fig. 3). Acacia seems to have been particularly hard hit by browsing because of the tendency of browsing animals to move along ridgetops. Neither Acacia nor Metrosideros is reestablishing significantly. Although Acacia koa reproduces both vegetatively and by seedlings, goats and cattle eliminate new growth. Dodonaea, a native relatively resistant to browsing, seems to be increasing in some areas where Acacia has

been eliminated. Where the forest is open, introduced grasses, especially Sporobolus africanus, dominate the understory. Gulch microecosystems have not felt the full impact of browsing and introduced grasses until now and comprise some of the most interesting native south slope vegetation. Important species of the zone include: Acacia koa, Metrosideros polymorpha, Cheirodendron trigynum, Dodonaea eriocarpa, Gouldia hillebrandii (upper sections), G. terminalis (lower sections), Pelea clusiaefolia, P. grandifolia, and Ilex anomala.

A considerably wetter version of the above zone occurs east of Kaupo Gap on the Manawainui planeze as a result of trade-wind rains. The Acacia forest vegetation is very similar there in spite of the higher rainfall. The introduced grass Melinis minutiflora is well-established as understory in much of the Acacia forest of this area.

Dry Forest and Shrubland Zone

Dry forests of the south slope extend from just above sea level up to 4800 ft, rarely higher. This area is particularly rich in native tree species, some of which are narrowly distributed, while others are broadly distributed (e.g., Euphorbia celastroides, Myoporum sandwicense). Semi-closed dry forest covers a relatively small area today. The extent and location of closed canopy dry forest on East Maui prior to human contact is unknown. Closed stands of trees may have naturally occurred in areas of greater soil development while shrubs and seasonal herbs probably dominated on rocky areas with little soil. Arid conditions as well as the sparsity of soil in the lowlands below 2000 ft west of Manawainui drainage contribute to the rarity of dense tree stands outside gulches. Between the Manawainui drainage and the Kaupo lava flow, however, the substrate is much older and has relatively advanced soil development. Dry forest tree species may have grown in continuous stands from near sea level to 7000 ft in this area at one time. The native vegetation of this area has been nearly completely replaced by introduced species - predominately Prosopis pallida and range grasses - except in gulches and in rocky areas where occasional relicts of native communities persist. These lands now support gently sloping pastures in their lower sections. In the upper sections, steep ridges and valleys are scarred with nearly continuous actively eroding surfaces.

The low-elevation rocky areas west of Manawainui drainage support native vegetation that has been more resistant to replacement. Though native tree species such as Erythrina, Nothocestrum, Rauvolfia and Reynoldsia grow well on rocky substrates, the native vegetation of these rocky areas may be best termed shrublands.

Although the remnants of this broad zone could perhaps best be characterized as having species distributed according

to environmental tolerances along an elevational climatic gradient, substrate differences complicate the situation. Adjacent lava flows at the same elevation usually differ in age and resultant edaphic condition, and not surprisingly also in composition and abundance of native species. Nevertheless, there are recognizable species assemblages characteristic of a given elevation, and the most useful approach is to divide this zone into four subzones - Upper, Middle, Lower and Seasonal Dryland Forest.

Available rainfall data suggest that the upper part of the zone receives an annual median of 750-1000mm (30-40 in) based on map of State of Hawaii (1982). The cloud bank appears to have a quite significant influence on the upper part of the zone (above the 3000 ft level) and little influence below this level, although data are lacking. Our field experience in the upper part of the zone included several rainless days when afternoon fog resulted in sufficiently heavy condensation that fruticose lichens (e.g. Usnea, Ramalina, Teloschistes spp.) on the trees were saturated and dripping. Annual precipitation at 1000-3000 ft is 250-750mm (10-30 in) based on map in State of Hawaii (1982), but mostly in the 250-500mm range. Below 1000 ft, annual precipitation is in the neighborhood of 250mm (10 in) with 86-100% of it falling in the November-April period.

Upper Dryland Forest Subzone (3000-4800 ft)

The Upper Dryland Forest subzone contains the largest number of tree species of any zone on the south slope. The best current example of this zone survives primarily in Auwahi, but also in the neighboring Kanaio district, as was the case in 1910 when Rock (1913) explored the area. Since many characteristic tree species of Auwahi still exist, or have been recorded historically, as scattered individuals at this elevation throughout much of the south slope, we suspect that this rich mixture of tree species may have once had a much greater distribution. In this subzone, introduced kikuyu grass is a major factor interfering with reproduction of native species.

The lichen flora of this subzone and the one below it is notable, especially in the Auwahi, Kanaio, and Lualailua districts. Dr. C. W. Smith (pers. comm.) has noted 100+ species in 40+ genera of lichens while collecting in a single gulch in central Auwahi at 3200 ft. Smith noted that at this site many native lichen species grew even on stems of the introduced shrub Lantana camara.

Flowering plant species characteristic of this subzone include:

<u>Alectryon macrococcum</u>	<u>Planchonella auahiensis</u>
<u>Charpentiera obovata</u>	<u>P. sandwicensis</u>
<u>Euphorbia celastroides</u>	<u>Pleomele auwahiensis</u>
<u>mauiensis</u>	<u>Santalum freycinetianum</u>
<u>Myrsine lanaiensis</u>	<u>auwahiense</u>
<u>Osmanthus sandwicensis</u>	<u>Streblus sandwicensis</u>
<u>Ochrosia haleakalae</u>	<u>Tetraplasandra meiantra</u>
<u>Pelea multiflora</u>	<u>Xylosma hawaiiense hillebrandii</u>
<u>Pisonia brunoniana</u>	<u>Zanthoxylum kauaense</u>
	<u>Z. hawaiiense</u>

Middle Dryland Forest Subzone (2000-3000 ft)

This subzone is apparently too dry for introduced kikuyu grass to thrive, so that native plants may have more potential for reproduction than in the Upper Dryland Forest. Species characteristic of this subzone include:

<u>Alphitonia ponderosa</u>	<u>Pelea mucronulata</u>
<u>auwahiensis</u>	<u>P. hawaiiensis</u>
<u>Antidesma pulvinatum</u>	<u>Planchonella spathulata</u>
<u>Bobea cf. sandwicensis</u>	<u>Pleomele auwahiensis</u>
<u>Dodonaea eriocarpa</u>	<u>Strebulus sandwicensis</u>
<u>Drypetes phyllanthoid</u>	
<u>Osmanthus sandwicensis</u>	

also a diverse lichen flora

Lower Dryland Forest Subzone (1000-2000 ft)

Some native species of this subzone undergo foliage reduction in hot, arid summer months. Perhaps moderated by its upslope elevation, there are fewer annuals and more evergreen native species here than in the subzone below. Species characteristic of this subzone include:

<u>Acacia koaia</u>	<u>Nothocestrum latifolium</u>
<u>Canthium odoratum</u>	<u>Nototrichium sandwicense</u>
<u>Cassia gaudichaudi</u>	<u>Osteomeles anthyllidifolia</u>
<u>Diospyros ferrea</u>	<u>Rauvolfia mauiensis</u>
<u>sandwicensis</u>	<u>Reynoldsia mauiensis</u>
<u>Erythrina sandwicensis</u>	<u>Sida fallax</u>
<u>Myoporum sandwicense</u>	
<u>Nesoluma polynesianum</u>	

Seasonal Dryland Forest Subzone (strand-1000 ft)

At the lower elevations of leeward East Maui, the phenology and life cycles of the plants are keyed to a very

severe and prolonged dry season and a variable wet season. That tendency is most pronounced in this subzone below 1000 ft. Erythrina, the dominant tree of remnants of this zone, is summer deciduous. Some species are annuals, including the native Sicyos spp. and the introduced Bidens spp. (B. pilosa and B. cynapifolia), surviving the six month dry season as seeds and germinating with the first major rains in November or December.

The best remaining example of this subzone is Puu o Kali on Haleakala's west slope. Other fairly good remnants occur in Kanaio, Auwahi, Lualailua, and Alena. Species characteristic of this subzone include:

<u>Acacia koaia</u>	<u>Dodonaea eriocarpa</u>
<u>Achyranthes splendens</u>	<u>Erythrina sandwicensis</u>
<u>Capparis sandwichiana</u>	<u>Euphorbia celastroides mauiensis</u>
<u>Cassia gaudichaudi</u>	<u>Myoporum sandwicense</u>
<u>Diospyros ferrea</u>	<u>Sida fallax</u>
<u>sandwicensis</u>	

Strand Zone

The Strand zone (sea level to about 50 ft), although seemingly less disturbed, has much less diversity than many other strand areas of the Hawaiian Islands, such as those reported by Tabata (1980) for Oahu, largely because the coast is bordered mostly by rough lava cliffs. In bays and flats where either sand or alluvial deposits from intermittent streams have accumulated, a more typical Hawaiian strand community is found. Saline conditions, continual wind, limited moisture, intense sunlight and sparse and shifting substrate characterize this environment. Plant species from the Seasonal Dryforest Subzone can sometimes be found growing in or quite near saline conditions. Native shrub species as Capparis, Dodonaea, Euphorbia celastroides mauiensis, and Myoporum some examples of these. On the other hand, Bidens mauiensis, Heliotropium curassavicum, Ipomoea brasiliensis, Jacquemontia sandwicensis, Panicum nubigenum, Scaevola taccada serices, Sporobolus virginicus and others seem largely restricted to the Strand zone.

Brackish water pools within the strand near La Perouse Bay and in the Nu'u District are unique microecosystems supporting Cyperus laevigatus, Ruppia maritima, Scaevola taccada, and Sesuvium portulacastrum.

The best areas of native strand vegetation are found on the far eastern and western edges of the study area. From the southwestern flank at Cape Kinau-Ahihi Bay to Kanaio beach in the Kanaio district one can find fairly intact, continuous native strand vegetation. Eastward beyond this point, the sea cliffs and limited substrate preclude most vegetation until the

Kaupo district where some native strand vegetation can still be found. The strand vegetation of Kaupo district resembles and is in a sense an extension of the windward coastal vegetation of northern and western East Maui.

The major current threat to the strand ecosystem of southern East Maui appears to be the damage caused by off-road recreational vehicles. As pointed out by Tabata (1980), passage by these vehicles disperses and compacts the substrate, as well as directly destroying native vegetation.

AN OVERVIEW OF CLIMATE, GEOLOGY AND SOILS OF THE STUDY AREA

Median annual precipitation on leeward East Maui ranges from less than 250mm on the Kihei coast to over 3000mm in eastern Kaupo Gap. Most (45-70%) of the annual precipitation falls from December through February (State of Hawaii 1982). In general, rainfall increases with elevation up to the level of the trade-wind inversion (Blumenstock and Price 1967), at about 6000ft, where median annual precipitation exceeds 1250cm. Daily buildup of cloud cover reaching down to ground level is usual in the 4000-6000ft zone, so that fog drip may greatly augment precipitation falling as rain.

Hosmer (1912) cited the "possible influence which a forest cover might exert on the local climate" on East Maui: "...the moisture bearing clouds that bring rain to the Kula District are of two kinds: (1) the trade wind clouds that pour over Kahikinui Ridge, and (2) and probably more important, the Naulu clouds that, forming out of a clear sky over the island and channel of Kahoolawe, drift in and collect on the Kula side of the Haleakala Ridge from above Ulupalakua over to and beyond a point above Erewhon. Just how heavily laden with moisture

Table 2. Mean January and July high and low temperatures for 1982, a representative year, at three sites on the west side of East Maui, Hawaiian Islands, and probably indicative of conditions at comparable elevations on the south slope. (Source: U.S. Department of Commerce 1982)

Station	Elevation(m)	January mean(°C)		July mean(°C)	
		High	Low	High	Low
Kahalui	12m	26.6°	19.1°	31.2°	27.2°
Kula Hospital	950m	21.3°	10.7°	24.0°	14.2°
Haleakala Ranger Station	2147m	14.2°	5.0°	18.7°	9.7°

these Naulu clouds are is a point on which opinions differ but in general I understand that there is frequently, if not usually, sufficient moisture so that water will condense on a rough woolen coat or on a man's beard.. The argument.. is that were a large enough stand of forest present the slightly cooler surface thus presented would be sufficient to tip the delicate balance of other natural factors and cause some of the moisture to be precipitated." Although the quantitative effect of forest fog drip has not been measured on the south slope, it has been demonstrated elsewhere in Hawaii (e.g., in Haleakala Crater by Kobayashi (1973); on Mauna Loa, by Juvik and Ekern 1978) and in other parts of the world.

Mean annual temperature on East Maui ranges from 24-25°C at the coast to 8.6°C at the summit of Haleakala. Mean January and July high and low temperatures for a representative year (1982) for three locations on leeward Haleakala and the isthmus of Maui are given (Table 2).

Stearns and Macdonald (1942) and Macdonald et al. (1983) give good overviews of the geology of the area from which much of the following information was extracted. Two major units of volcanic rock are exposed on the south slope - the older, more eroded, Kula series, and the younger Hana series. A third series, the Honomanu series, possibly the oldest rocks exposed on East Maui, is visible only in the lower walls of Manawainui Gulch, east of Kaupo Gap. Potassium-argon dates for Honomanu series rocks of 0.69-0.83 million years have been reported in recent literature (see Macdonald et al. 1983).

The Kula series is exposed from the crater rim to the sea in the central portion of the study area, from the vicinity of Puu Pane (just west of Manawainui Gulch) east to the Hana series flow in Kaupo Gap. This section of the south slope is highly eroded, with deep gulches, some of which attain depths of 500ft. The Kula series is also exposed on the Manawainui planeze and in the 2000ft deep Manawainui Gulch east of Kaupo Gap. The east and west walls of Kaupo Gap are also part of the Kula series. Kula lavas have been dated at 0.41-0.86 million years (see Macdonald et al. 1983).

From Puu Pane west to the southwest rift, a veneer of Hana series lavas overtop the Kula series. Gulches are much less developed in these areas than on the Kula surfaces. The Hana series is composed of "very permeable thin 'a'a and pahoehoe flows of basalt, picritic basalt, basaltic andesite, and andesite poured out in rapid succession..." (Stearns and Macdonald 1942). Where the flows filled valleys, they have an aggregate thickness of more than 1000ft; elsewhere they form a veneer 10 to 200ft thick over older lavas. The Hana lavas are so permeable that most rain sinks into them and percolates to the older rocks. Scattered cinder cones of Hana series age are scattered across the south slope - including Puu Pane,

Manukani, Lualailua, and Puu Mahoe. Puu Ouli is a cinder cone of Kula age surrounded by Hana lavas.

Crandell (1983) dated four flows (using radiocarbon dating and age estimates based on degree of weathering and erosion) along Route 31 between Ulupalakua and the mouth of Manawainui Gulch at less than 2000 years old. These include a 900 yr-old flow (supported by radiocarbon dating) on the southwest rift SW of Puu Mahoe; a "<1000?" yr-old portion of the Puu Mahoe flow; a flow in Kanaio labelled as "1000-2000? yrs"; and a flow just east of Lualailua Hills labelled as "1000? yrs." These newer flows were superimposed on older flows labelled as "<10,000" or "<20,000 yrs." The youngest flow on the southwest rift, just above sea level near La Perouse Bay, dates back 200 years to about 1790 A.D. One of the newer cinder cones, Puu Pimoe, is dated by Crandell as "about 1000?" yrs.

Extensive and thick Hana series flows fill the formerly deep valley called Kaupo Gap. Crandell (1983) dates two flows along Route 31 between the villages of Nuu and Kaupo as ">1000" and "<10,000" yrs. He dates a third flow in that vicinity as "<20,000" yrs. Macdonald et al. (1983) cite a major discrepancy in potassium-argon dates of two recent investigators for the main Kaupo flow (31,000-33,000 vs. 320,000 years).

Little information is available in the literature on soils of the south slope because of their relatively low value for agriculture. The most recent survey, by Foote et al. (1972), included the following units for the south slope: "very stony land", "Puu Pa very stony silt loam", "cinder land", "Oonapuka extremely stony silt loam", "Waiakoa extremely stony silty clay loam", "lava flows-aa", "rock outcrop", "rock land". Sparsity of soil on the south slope is partially due to the youth of the area, partially to low rainfall and steep slopes which inevitably result in "natural" soil loss. There is no question, however, that erosion has been greatly accelerated in the past two centuries by feral animals. This is especially the case on older substrates of the Kula series, where there has been more time for soil development. The middle and upper slopes of Nuu appear to present as spectacular an example of accelerated erosion due to goat browsing as exists anywhere.

HISTORY OF LAND USE AND DEGRADATION OF NATIVE ECOSYSTEMS

Recent evidence based on study of bird and terrestrial mollusc fossils (Olson and James 1982a, 1982b; Kirch 1982) strongly suggests that the ancient Hawaiians had a greater impact on the native biota than was previously suspected. It has been fairly well accepted for some time that the pre-Cook Hawaiian population was large. On Maui, numbers probably ranged from 45,000-60,000 (Schmitt 1971), comparable to the population of the 1970's, but self-sufficient. Not only was the island of Maui independent of products from other islands,

but some prehistorians have suggested that the population of each ahupua'a, the Hawaiian land division extending from the coast inland, was economically self-sufficient (Earle 1977). By 1650 A.D., the ahupua'a structure is believed to have been firmly established and the population size at peak levels (Tuggle 1979). This implies that the carrying capacity of the environment to support a human population had been reached (or at least closely approached) or probably exceeded at that time.

Chapman and Kirch (1979) report on the results of seven excavations in the Kahikinui and Honuaula land divisions within the study area. They state: "The absence of any truly 'early' (i.e. pre-A.D. 1450 in date) sites in the excavated sample from southeast Maui is in keeping with an interpretation of later prehistoric expansion into this somewhat harsh and ecologically marginal region....not in any absolute sense, but simply in terms of contrast with other regions on Maui.. better endowed in hydrologic and edaphic resources for indigenous exploitation. Further development of such an ecological model of.. agricultural expansion into dry leeward slope environments may be possible when Chapman's extensive survey data for Kipapa/Nakaohu are analyzed."

Chapman and Kirch (1979) further state: "As the low elevations or coastal areas of Kahikinui and Honuaula are not conducive to agriculture (in terms of low rainfall and poor edaphic conditions), it may be a pattern of transience between coast and inland slopes existed. In other words, persons who normally resided in an upland agricultural habitat may have utilized the coastal shelters as temporary or seasonal bases..."

Green (1834, in Chapman and Kirch 1979) stated: "The district of Kahikinui is small and poor.. [providing a] scanty means of living. The country is one vast bed of lava, and the few inhabitants are obliged to go far into the country to cultivate."

Clark (1980) states regarding the leeward shore of East Maui: "Fishing is good along the coast and in former times Hawaiians lived in isolated communities near the ocean wherever fresh water could be found. The populations were migratory, living on the ocean during the summer months when they caught and dried fish and moving upland during the wet winter months. The ruins of a number of villages are located throughout the area."

This survey noted numerous Hawaiian structures during the course of field work including housesites, terraces, platforms, fishing shrines, canoe houses, modified water holes, as well as numerous unidentified stone structures, some of which were probably associated with agriculture. These sites were observed in nearly every district in the study area, mostly below 2500ft. Numerous structures near Kepuni gulch and a

series of large stone platforms and terraces, partially adapted within the historic period as cattle enclosures, in the Lualailua and Alena districts were the most extensive sites encountered.

Intensive agriculture by the Hawaiians may have been, as Chapman and Kirch suggest, conducted on a seasonal basis, using the winter rainy season to produce food crops - most probably 'uala (sweet potato - Ipomoea batatas) or kalo (dryland taro - Colocasia esculenta) though ko (sugar cane - Saccharum officinarum) and 'ulu (breadfruit - Artocarpus utilis) may have also been grown. Fiber plants such as wauke (paper mulberry - Broussonetia papyrifera) and mamaki (Pipturus sp.) occur in the study area. The former is a Polynesian introduction and hence a relict of Hawaiian cultivation. Hawaiians also most likely harvested hardwoods for construction, tool and weapon making as well as for other ethnobotanical uses.

In their highly detailed study of Hawaiian culture and agriculture in relation to environment, Handy and Handy (1972) state regarding Kaupo: "Indeed, no taro is now grown in Kaupo except for a few dry-taro plants around home sites; but formerly great quantities of dry taro were planted in the lower forest belt from one end of the district to the other. Now the district is almost wholly ranch land."

Regarding Kahikinui, they state: "We are told by an old informant, born in Kanaio in the next district, that the Hawaiians formerly living along the coast of Kahikinui had their plantations of dry taro and other edibles inland in the forest zone, where the forests along the southern wall of Haleakala came much lower and where rainfall was more plentiful than it is today. Here, as in Kaupo, cattle grazing over all the higher country have deforested the land."

Regarding Honuaula, Handy and Handy (1972) state: "In Honua'ula (Red Earth), as in Kaupo and Kahikinui, the forest zone was formerly much lower and rain more abundant before the introduction of cattle. The usual forest-zone plants were cultivated in the lower uplands above the inhabited area... Formerly there was much dry taro in the forest zone."

Regarding Kula, they state: "Kula was always an arid region, throughout its long low seashore, vast stony kula lands, and broad uplands. Both on the coast, where fishing was good, and on the lower westward slopes of Haleakala, a considerable population existed. So far as we could learn Kula supported no Hawaiian taro.. Kula was widely famous for its sweet-potato plantations. 'Uala was the staple of life here."

Much of the post-1778 damage to native ecosystems can be attributed to introduced animals and plants. Domestic livestock brought by Vancouver and other early ship captains

and ranchers flourished on drier parts of Maui and other islands. Cattle, along with feral goats, probably had their major impacts before 1900. Purposeful clearing of forest by hand probably was not so prevalent on Haleakala's south slope as on the more arable west slope, although early ranchers may have burned native vegetation to favor the spread of forage grasses. During the years 1778-1822, the exportation of Hawaiian sandalwood to China may have had a significant impact on native forests (Rock 1913). We have not been able to obtain concrete evidence to substantiate this possibility for the southern slopes of Haleakala. However, R. Sylva (pers. comm.) has found several stone-lined pits near the coast in the Kaupo district. These pits may have been sandalwood pits, used to standardize the amount of sandalwood paid for taxes, or in the purchase of a required item, such as a small ship. Information and photographs of this site have been given to the Anthropology Department at the B.P. Bishop Museum.

Hosmer (1912) described the demise of the mid-elevation forest on the slopes toward Kula from the southwest rift: "Prior to about 25 years ago there was a belt of heavy forest with dense undergrowth in the Kula District between the elevations of 3500 and 5000 feet, that is throughout the section immediately above the corn belt. Gradually this forest was opened up by grazing until now it has practically disappeared save as its former extent can still be traced by dead stubs, small groups of trees in certain steep-sided gulches where they are protected from cattle, and scattered groves of Mamane."

The leeward forests of Haleakala were scarcely explored by 19th century botanists, probably due to the apparent sparsity of vegetation and the harsh environmental conditions. Hillebrand and Lydgate (ca. 1870) and Mann and Brigham (1864-5) collected dry forest species on the western slope and at least to Ulupalakua, within the land region Hillebrand refers to as Honua'ula. None of these collectors seem to have reached far beyond the southwest rift. Joseph F. Rock in 1910 was the first botanist to explore and document the Auwahi-Kahikinui area in detail. Rock visited this area periodically for ten years until his departure for China. In 1939, Rock revisited this area, touring Auwahi with William Kaiakamelie Sr., the Hawaiian cowboy from Ulupalakua Ranch who guided Rock on his first visits. Gerritt Wilder and G. C. Munro collected on the southern slopes at Ulupalakua and Auwahi at about this time.

Charles N. Forbes, botanist for the B.P. Bishop Museum, collected over a wide area of the south slope in 1920 from Kaupo west to the southwest rift. Forbes collected from many areas, such as the Acacia/Metrosideros forests of Manawainui, that have remained otherwise unexplored until this decade. Many of his specimens made on an uninterrupted forty-one day collecting trip through this area have been described as new taxa. Forbes' collection notes give us valuable ecological

observations in certain areas that were not otherwise biologically explored until recently (See condensed Forbes field notes, Appendix III.) Otto Degener also added some important historical collections mostly above Ulupalakua in 1927.

Current major landowners include the State of Hawaii (Kula and Kahikinui Forest Reserves, Polipoli State Park, and other holdings); the U.S. Government (Haleakala National Park); the Hawaii Home Lands Commission; Ulupalakua, Kaupo, Haleakala, and Kaonoulu Ranches; and the James Campbell Estate (Armstrong 1973).

Major land uses include livestock raising below 4000 ft and conservation land above this elevation. Goat hunting is a major activity in certain areas - especially in upper Kahikinui. Pig hunting is practiced most frequently in the Kula Forest Reserve/Polipoli State Park area. A large part of this latter area has been planted with coniferous trees.

ADVERSE IMPACTS ON NATIVE FLORA AND VEGETATION

Anthropogenic Fire

There is reason to believe that anthropogenic fire has been a major factor in the decline of native ecosystems of the area. Kirch (1982) referring to Hawaiian dryland forest states: "By the time of early European contact, only remnant pockets of this lowland vegetation remained.. The primary tool that effected these great modifications of the prehuman vegetation was undoubtedly fire."

Fire potential, whether natural or anthropogenic, at a particular site is related to the continuity and abundance of fuel. Very rocky sites are protected from fire to the degree to which fuels are scarce and/or discontinuous. Fire effects have therefore undoubtedly been much less significant in the relatively rocky area west of Manawainui drainage than on the older volcanic surface to the east of that drainage. In fact, the lowland sites with deep soil east of Manawainui drainage are almost totally denuded of native vegetation. The only remaining native plant species, such as Chenopodium, Waltheria, Wikstroemia, etc., are species that are particularly mechanically resistant, fire-adapted and/or possess anti-herbivore compounds in foliage. These sites were probably heavily exploited by the Hawaiians with fire and agriculture for at least eight centuries and their pristine vegetation is unknown. Components of these long replaced lower elevation deep soil ecosystems may or may not be represented today as rare elements in adjacent more damage-resistant ecosystems on aa lava. Menzies (1920) suggested that the Hawaiians would commonly use fire as a means of stimulating the growth of pili (Heteropogon contortus), a coarse indigenous grass preferred

for thatching shelters. Degener and Degener (1968-Fl.Haw.), however, stated that in dry areas, such thatch lasted for 10 to 20 years with little repair. McEldowney (1979) working in the lowlands near Hilo, Hawaii, has suggested that the Hawaiians may have used fire as a tool to encourage the production of Tacca leontopetaloides and Sadleria for pig fodder and famine foods. Whether Hawaiians on the south slope used fire for Heteropogon production or for other agricultural purposes is not known.

Evidence of past fire is present but not abundant in upland areas on the south slope today. One area where charred stumps of large trees are present is on the Wailaulau-Pahihi planeze at ca. 4000ft. Forbes noted in area of the Manawainui drainage in 1920: "Far mauka of Puu Pane. Ohia dominant, some koa touched by fire."

Feral Goats

Goats (Capra hircus) were introduced to all Hawaiian Islands soon after Capt. James Cook's 1778 visit (Tomich 1969). Marques (1905) stated that the rate of their increase was sufficiently rapid that 26,500 goat skins were exported from the islands in 1850. Wilkes (1845) reported seeing "a few goats" near the summit of Haleakala in 1841. It may be safe to surmise that feral goats on Maui have been at least as numerous as today for 100-150 years. Forbes' 1920 field notes record "goats common in the uplands" above Lualailua (see Appendix III).

The adverse impacts of feral goats on native Hawaiian vegetation have been cited by many, including Yocum (1967), Baker and Reeser (1972), and Spatz and Mueller-Dombois (1973). Abundant literature exists on the damage of feral goats to native vegetation and watersheds throughout the world (e.g., Coblenz 1980). There have been dissenting views, however. For example, Kramer (1971) stated regarding the goats on Maui: "...there is little indication that those on state lands are doing noticeable damage, and animals on private lands are adequately controlled by landowners."

Although probably most numerous in the 4000-7000ft zone in the central and eastern portions of the study area, goats are apparently nowhere uncommon on the south slope of Haleakala - even near the coast. Goats were encountered and heavy browsing noted throughout the portions of the study area which we traversed. We saw goats on almost every trip we took along the Auwahi-Kanaio boundary at 1600-3400ft on the rugged, kikuyu grass-free flows below Puu Ouli. From the summit of Puu Pane in October 1981, we observed several dozen goats interspersed with domestic cattle in grassy (Sporobolus africanus) meadows. Goats were abundant in the koa forest zone at 4000-5800ft in the Manawainui drainage. In a helicopter reconnaissance in August 1981, we saw hundreds of goats - especially in the

steep, eroded gulch country of Nu'u and Nakula. Through 1983, exceptionally high concentrations of goats occurred in western Kaupo Gap within Haleakala National Park.

Of the introduced ungulates, there can be little doubt that feral goats are having the most destructive impact on native vegetation on the south slope as a whole under present conditions. Their most obvious impact is in the entire Acacia and Acacia-Metrosideros zone. Reproduction of native species was found to be almost entirely lacking in this zone except for Dodonaea. Our observations suggest that goat impacts are rapidly leading to loss of the forest and continued deterioration of the watershed. That abundant reproduction of Acacia, at least, would be occurring without browsing pressure has been clearly shown by its response when protected from browsing within the Healan'i enclosure (Scowcroft and Hobdy 1986). Feral goats have a less obvious but nevertheless substantial impact at relatively low elevations on aa lava at 300-2800ft in the Kaunauhane, Kaloi, Kanaio, Auwahi and Lualailua districts, where the rough crumbly aa lava excludes most grazing by domestic cattle. The native vegetation of these areas is generally much more intact than in low elevation areas of greater soil development. Feral goats, however, thrive in such areas and seldom encounter man. Several large herds of predominately black feral goats were seen and heard regularly in the western part of the study area. Browsing damage and broken branches of shrubs and trees were commonly noted. Feral goats probably eliminate the occasional native tree seedlings that do survive seasonal drought and competition from introduced plant species.

Cattle

Tomich (1969) reviews the rather solid evidence for the rapid buildup of huge populations of feral cattle (Bos taurus) on the island of Hawaii following their introduction by Vancouver in 1793 due to the legal protection given them by Kamehameha I. He suggests, based on a quote from Bloxam (Bernice P. Bishop Museum, 1925), who visited Maui in 1824-25, that cattle may have populated Maui at a slower rate. Wilkes (1845) reported seeing "bullock tracks" near the summit of Haleakala in February 1841. As early as 1856, Hillebrand (in an address to the Royal Hawaiian Agricultural Society) warned of the consequences of overpopulation by cattle in the islands (Tomich 1969).

Although cattle are generally thought of as grazers, not browsers, there seems to be little question that cattle browse woody species under certain conditions (e.g., Baldwin and Fagerlund 1943, Cuddihy 1984). Early 20th century foresters recognized the problem and major corrective action was gradually taken. Lyon (1919), writing about Oahu, stated that "cattle have been the greatest factor in pushing the forests back to their present narrow limits, and at certain vital

points cattle are still allowed to penetrate the remaining forests." Judd (1918), reviewing the effects of cattle and goats on Hawaiian forests, stated: "The continued grazing of cattle today in the native forest for the pecuniary benefit of a fewis very short-sighted." In the 1920's, most ranches of the Hawaiian Islands were fenced to separate domestic cattle from feral cattle and the latter removed from forest areas (Tomich 1969).

Forbes (field notes) encountered feral cattle in Kipahulu Valley, Koolau Gap, and below Hosmer's Grove in 1919-20. Cattle were grazed on private lands throughout much of what is now Haleakala National Park until the 1920's. Tomich (1969) states that "uncontrolled cattle were known on Maui until about 1930, in the Kula Forest Reserve, particularly in Puu Keokea and Polipoli areas." He adds that "these cattle were finally extirpated under incentive permits," but feral cattle were still encountered in Kula and Kahikinui Forest Reserves as of 1983. Tomich (1969) states that "on Hawaii there may be as many as 2000 head of stray or feral cattle today." The problem continues to exist on Maui as well, in some Acacia koa and Metrosideros forests, although the State Department of Land and Natural Resources (DLNR) has made laudable efforts to eliminate it. There are vast areas of little biological value on the south slope where cattle are economically managed. However, relatively small numbers of domestic and semi-feral cattle in areas of native vegetation still do appreciable damage.

Feral Pigs

Although pigs (Sus scrofa) are more numerous in areas of moist forest on East Maui, they are present throughout much of the upper south slope area. Several individuals told us they currently hunt pigs regularly on the south slope. We saw pigs in the kikuyu grass zone on several occasions. One of us (ACM) was charged but not harmed by a feral pig in the upper Auwahi district at 3600ft in January 1984 while making voucher collections for this survey.

Although none of us observed pigs below 3000ft elevation, they were abundant at low elevations earlier in this century, according to Mr. Willie Fong (pers. comm.) of Kula. Fong related to one of us (RAH) how he hunted pigs along the government road near the Auwahi-Kanaio boundary while employed by Ulupalakua Ranch. In 1917, Fong was hired to capture pigs, which were sold live to camps. These pigs thrived in lower Auwahi/Kanaio/Lualailua due to the former abundance of Opuntia, Fong related. Partners caught 20-30 pigs per week over a period of at least several months.

In their rooting for invertebrates and vegetable material, feral pigs upturn the ground surface disturbing and destroying existing plant cover. Introduced species, especially grasses, replace native species in these pig rootings and become

well-established (Spatz and Mueller-Dombois 1975, Jacobi 1981). Pigs are potential long distance dispersers of propagules of introduced species on their hooves and coats and through their digestive tracts. By disturbing the integrity of native understory, pigs may threaten reproduction of overstory tree species.

Pigs seem to be most abundant in relatively moist subalpine shrubland and in montane cloud-belt forest. At 6000ft in the Manawainui drainage, large areas of soil had been recently disturbed by pigs, eliminating the last vestiges of the native grass Deschampsia australis. Similar damage was seen near Kahua, in Kula Forest Reserve, and in eastern Kaupo Gap.

Axis Deer

Axis deer (Axis axis) were first introduced to the Hawaiian Islands in 1867 on Molokai from their native range in India and Ceylon (Tomich, 1969). Despite objections by some biologists and ranchers, axis deer were introduced to East Maui in 1959-60 in the Puu o Kali and Makena areas (Kramer 1971). Within eight years, this population had grown from the original eight individuals to an estimated 85-90 animals. In a 1981 aerial survey by the DLNR, 102 animals (actual count, including a herd of 44 animals) were seen on the lower southwestern slopes of Haleakala (M. Ueoka, pers. comm.). The majority of the animals forage primarily on introduced plant species such as Leucaena, Prosopis, and range grasses. However, the range of the axis deer on East Maui is apparently gradually expanding, and it could prove a threat to native vegetation at some time in the future. Experienced observers have noted axis deer in low numbers in and above the Kahikinui Forest Reserve (T. Rodrigues and others, pers. comm.). Graf (1959) noted that axis deer on Molokai had expanded from their original range in the dry lowlands into the "rain-zone" of the East Molokai uplands. At the time of this report, axis deer appear to have minimal impact on native vegetation on Haleakala.

Introduced Rodents, Birds, and Insects

Black or roof rats (Rattus rattus) probably arrived in Hawaii about 100 years ago (Atkinson, 1977) and now occupy a wide range of habitats from sea level to high elevation (Tomich 1969). Rats (Rattus exulans) introduced in the 4th century A.D. by the Polynesians to Hawaii also occupy a wide elevational range (Tomich 1969, C. P. Stone, pers. comm.). In Haleakala National Park, trapping by resource management personnel at 7000-10,000ft, for the primary purpose of protecting Hawaiian dark-rumped petrel colonies from predation by mongooses and feral cats, consistently results in trapped black rats (R. Nagata pers. comm.). The impact of introduced rodents on island biotas has not been fully documented but is

believed to be substantial. The greatest impacts are thought to be on woody forest plants with large seeds (Clark 1981, Best 1969, Daniel 1973). Rats eat (and render non-viable) seeds of Santalum haleakalae (Loope and Crivellone unpublished). Seeds of other south slope species are probably eaten by rats. Our inconclusive experiments (in which seeds were placed in plots and checked weekly) suggested (very tentatively in some cases) that seeds of the following genera are eaten at times by rodents: Alectryon, Canthium, Diospyros, Nothocestrum, Planchonella, Santalum, and Wikstroemia. Little or no rodent predation was found for Alphitonia, Alyxia, Bobea, Erythrina, Myoporum, Nesoluma, Ochrosia, Osmanthus, Osteomeles, Rauvolfia, Reynoldsia, and Xylosma. Field evidence was noted of rodent-gnawed seed casings of Alectryon (Kanaio), Planchonella (Kaupo), and Pleomele (Kanaio). Rats and mice may have a devastating impact on native arthropod species.

Introduced birds are important vectors for dispersal for introduced plants. For example, the rapid spread of Lantana camara throughout Hawaiian lowlands has been attributed to two introduced birds, the spotted dove (Streptopelia chinensis) and the common myna (Acridotheres tristis), which reportedly feed on the berries (Perkins and Swezey 1924). Chukars (Alectoris graeca chukar), pheasants (Phasianus colchicus torquatus), and peacocks (Pavo cristata) are the most conspicuous introduced bird species on the south slope. Their impact on native vegetation has not been determined. Peacocks appear to cause locally significant disruption of understory vegetation.

Though some introduced insects have been effective in controlling aggressive weed species such as Opuntia, Eupatorium and Lantana, others have harmed native plant species. Perhaps the best documented insect threat to native tree species is the black twig borer, Xylosandrus compactus, in the tribe Xyleborini of the Coleoptera (Hara and Beardsley 1979, Samuelson 1981, Gagne 1976, Obata 1973a). Native shrubs and trees subject to infestation of X. compactus include Acacia, Alectryon, Antidesma, Charpentiera, Claoxylon, Coprosma, Diospyros, Drypetes, Gouldia, Hibiscadelphus, Ilex, Mezoneuron, Myrsine, Perrottetia, Pelea, Pipturus, Santalum, Sapindus, Streblus, Vitex, and Wikstroemia. Where populations of these species have already been reduced from other causes, predation by this beetle may tip the balance against their ultimate survival. Another insect threat to native plant species is Cryptophlebia illepidia (Family Tortricidae), a moth known to attack the seeds of Acacia koa, Acacia koaia, Alectryon, Dodonaea, Mezoneuron.

Displacement by Introduced Plants

Wirawan (1974), Mueller-Dombois (1981a, 1981b), and others have recognized that displacement by introduced plant species, especially grasses, may present formidable difficulties for reproduction of native Hawaiian plant species. This is

certainly the case for leeward East Maui, where dense mats of kikuyu grass (Pennisetum clandestinum) present a major obstacle to reproduction of native plants, especially in the upper dryland forest subzone, where the highest concentration of rare native trees occurs. Other introduced plant species have serious impacts in other zones. Kikuyu grass and some of the other more noteworthy introductions of the south slope are discussed below.

Pennisetum clandestinum ("kikuyu grass")
Poaceae - grass family

Kikuyu grass is an aggressive, mat-forming perennial grass that spreads by stolons and rhizomes. In many locations on the south slope of Haleakala, kikuyu grass is so dense that it virtually prevents establishment of other species - both native and exotic. A native of Kenya, this grass has now achieved a pan-tropical distribution in moderately moist, frost-free (or nearly frost-free) areas (Holm et al. 1977).

Whitney et al. (1939) state: "It was introduced into Hawaii from California about 1924.. so far as is known, it does not produce seed here.. It makes its most vigorous growth in cool moist regions in deep loose soils where it is very persistent, forming a deep sod. It withstands grazing and trampling very well.. Ranchers disagree somewhat as to its value for fattening, some contending that it is too succulent and that animals tire of it, especially in pure stands. It is very aggressive and where it is well adapted tends to choke out most other grasses. One rancher uses it to choke out guava. It is being widely planted because of the rapid rate at which it covers the ground."

Kikuyu grass now flourishes at elevations from sea level to over 2000m (Hosaka 1958). Lennox (pers. comm.) stated that kikuyu grass was introduced to Maui as a pasture grass in the 1940's - at the time of the Procecidochares-induced decline of pamakani (Eupatorium adenophorum). Kikuyu grass slips were planted along the Kula pipeline road, above Kaupo, and in other localities. Mitchell (1945) reports it as being present already in the Kaupo Gap area of Haleakala National Park.

Kikuyu grass proved to be extremely satisfactory as a pasture grass and by the 1960's had formed a continuous cover over a large area on the south slope. Its progressive spread is described in a report on the Auwahi Forest by Lennox et al. (1970): "The ground area covered by kikuyu grass has greatly increased since 1967 - in Area A from an estimate of 70% to 90% while in Area B from 25% to 70%. The area in annuals and herbaceous growth has decreased accordingly." At this time the devastating effects of kikuyu grass in preventing dry forest establishment became very apparent. Whether or not its spread is now nearly complete is a subject of sufficient interest to warrant a brief review of its status on Haleakala in relation to what is known about its ecology and physiology.

In its native habitat in Kenya, it occurs at elevations of over 2000m (6600ft) and where precipitation exceeds 900mm (Mears, 1970). Well-established plants can withstand drought, but the species does not thrive in very dry sites. Light frosts will kill only the exposed (above ground) parts of the plant, enabling the perennial root system to produce rapid above-ground growth with the return of warm weather (Mears 1970). Kikuyu grass can do well in moderate shade. It does best on soils of high fertility and is often associated with volcanic soils.

Flowering and seed-set are considered rare for this species, but flowering occurs commonly in Hawaiian lawns at 1200-1400m (Holm et al. 1977). Flowering is stimulated by repeated defoliation. Mears (1970) reports that kikuyu grass has been known to spread from seeds germinating in dung pats. We have frequently observed young kikuyu grass plants originating in cow dung on the south slope of Haleakala.

At Auwahi on the south slope, this grass thrives in the zone between 2800 and 4400ft, which largely corresponds to the cloud belt. Below 2800 ft, where Lantana camara dominates the ground cover, kikuyu grass is apparently deterred by drought. It survives in moister depressions in otherwise dry pastures. At 2500ft, it occurs occasionally in relatively moist, shaded sites under trees. Kikuyu grass occurs in the same elevational zone in eastern Kaupo Gap, where precipitation is relatively high, but seems to be absent or sparse in western Kaupo Gap and on the dry slopes westward to the vicinity of Puu Pane. Above 4500ft in Haleakala Crater, the exotic Holcus lanatus and the native Deschampsia australis are the dominant grasses, although kikuyu grass manages to survive (but not flourish) as high as 10,000ft on Haleakala, where freezing temperatures are frequent.

Kikuyu grass is sensitive to repeated burning, based on observations in Africa (Rattray 1960). However, this probably has little application for preservation of native vegetation on Maui because of high susceptibility of the native flora to fire. The grass partially cures and will carry a fire during dry periods. A large fire occurred within kikuyu grass-dominated vegetation with remnant Styphelia shrubs on Kaupo Ranch just below the boundary of Haleakala National Park in early December of 1981. Kikuyu grass recovered vigorously during the first two years after the fire, whereas most native Styphelia shrubs were killed (R. Nagata, pers. comm.). Gardner and Davis (1982) and Plucknett (1970) report that substantial damage is done to kikuyu grass by numerous organisms in various parts of the world - insects, a phycomycete fungus, and a leaf spot disease. Gardner (1984) has reported the rust Phakopsora on kikuyu in Hawaii but it has little apparent detrimental effect.

Chemical control measures for kikuyu grass have been fairly effective in various parts of the world (Gardner and Davis 1982). Gardner and Kageler (1983) determined that the herbicide Roundup (glyphosate) showed promise of giving effective control of kikuyu grass in Hawaii Volcanoes National Park without seriously damaging most associated native species.

Bidens pilosa

Asteraceae - Sunflower family

Bidens pilosa, a weed of Neotropical origin that is now common in tropical and subtropical areas throughout the world, was first collected in the Hawaiian islands in the 1840's (St. John 1973). C. N. Forbes noted it as very common in parts of the study area in 1920. This species is an annual that thrives at lower elevations on the south slope of Haleakala during moist periods and survives drought periods as seeds stored in the soil. It develops rapidly from seed with the onset of wet weather and forms dense monospecific stands in shaded sites where moisture relations are favorable - generally under trees. Bidens appears to be a major competitor of tree seedlings - especially seedlings of Canthium, Diospyros, Erythrina, Myoporum, Nothocestrum, Rauvolfia, and Reynoldsia - below the zone of kikuyu grass (below 2800ft) on the south slope. Stands of Bidens are typically so dense that a high percentage of the plants are stunted.

After the rainy season in March and April of 1982, Bidens appeared to occupy over 90% of the sites available for tree seedling establishment in the Kanaio/Auwahi area at 1000-1500ft. Tree seedlings were largely confined to sites with extremely shallow soils or in rock crevices. Severely stunted tree seedlings often occurred in the understory of Bidens stands. In such cases, it was found impossible to uproot Bidens plants without uprooting the tree seedlings. The same sites were revisited in early September 1982. All Bidens was dead at that time and very few seedlings survived.

Bidens pilosa also has a great impact on native annual plants in the study area. At Puu o Kali, the area where native annuals (Panicum spp., Sicyos spp.) are doing best, large numbers of native Sicyos and introduced Bidens seedlings were noted as germinating and growing to maturity under Erythrina trees. Annual Panicum spp., rather uncommon at present, must have been much more abundant prior to establishment of Bidens pilosa and other annual weeds in such areas in the Hawaiian Islands.

Eupatorium adenophorum ("Maui pamakani")

Asteraceae - Sunflower family

Eupatorium adenophorum is a somewhat woody herb, native to Mexico. It was brought to Hawaii prior to 1900 and quickly spread on Maui (where it came to be called "Maui pamakani")

coming to dominate large areas of pasture land by 1915 (Lennox 1967, see Plates 89,108,147,173 in Rock 1913; see field notes of C. N. Forbes, Appendix III). Maui pamakani spreads by seedlings and vegetatively, forms pure stands, and can attain a height of up to 2m. The 3000-4000ft forest zone in western Auwahi became occupied with such a dense growth of Eupatorium that the rancher built a network of stone walls in that area to prevent cattle from hiding during drives (Lennox 1967). In 1945-1947 a stem gallfly (Procecidochares utilis), intentionally introduced from Mexico as a biological control, almost eliminated Eupatorium from the area during a severe drought. Pemberton (1951) states regarding Ulupalakua ranch: "The ranch occupies about 65,000 acres, of which 25,000 are covered by Pamakani. This weed pest is not eaten by stock and available grazing is greatly depleted. ...However during the past year the fly has made such headway that the weed appears to be dying out over large areas, which are again accessible on horseback. The ranch is engaged in restoring these areas by sowing grass seed. During the past several months everything that will grow is green from abundant rain. In spite of this, there are great brown areas of dead pamakani foliage on the mountainside. It was impossible to find a single pamakani plant not heavily attacked by the fly." Lennox speculates that this protection from cattle for 30 years may have been a factor contributing to the relatively intact state of the Auwahi forest as compared to the forests of adjacent areas. On the other hand, it must be recognized that Rock (1913) considered the "500 acres" of dry forest of Auwahi far superior to adjacent areas apparently prior to effects of any length of added protection due to Eupatorium invasion.

Although the biological control of Eupatorium provided by the stem gall-fly has been and continues to be very effective (Bess and Haramoto 1958, 1959, 1972, Pemberton 1964), Eupatorium adenophorum is still locally very common and robust on rocky slopes in eastern Kaupo Gap at elevations of 4000-6000ft. Elsewhere on the south slope, it is confined to low numbers of heavily browsed (by goats) individuals. Although it may have interfered significantly with dry forest tree seedling establishment in the early 20th century, its effect is now minor except perhaps in eastern Kaupo Gap.

Lantana camara

Verbenaceae - Verbena family

Lantana camara is a thicket-forming woody shrub, a native of the Neotropics, that has become established in tropical countries throughout the world. It was introduced to the Hawaiian Islands in 1858 (Hillebrand 1888) and by 1902 had become so widespread in the islands and of such great concern to ranchers that it was the first plant in the United States to be targeted in a program of biological control. Williams (1931) notes that 23 species of insects were introduced from

Mexico in 1902 for Lantana control and that eight became successfully established.

In spite of partially successful biological control, Lantana still forms dense thickets at low elevations (50-3000ft) on the south slope. It dominates most areas in this zone where sufficient soil (depth of several cm) exists to support the root system of a shrub. Even though it is repeatedly defoliated, it persists in thickets that make passage by livestock or humans difficult.

A Lantana cover may on occasion provide sufficient protection from herbivores to allow establishment of native tree seedlings. Seedlings of Diospyros ferrea at 1600-2000ft in Kanaio were noted to survive the dry seasons of 1983 and 1984 under Lantana.

Opuntia megacantha
Cactaceae - Cactus family

This large cactus was introduced from Mexico about 1800 (St. John 1973), apparently as a forage plant for cattle. Cattle, as well as feral pigs, eat its succulent fruits. By the early 1900's, it was abundant at lower elevations on the south and west slopes of Haleakala (see Willie Fong, pers. comm., above under "Feral Pigs"). Two biological control organisms, introduced in 1949-51, have greatly reduced the abundance of the plant - the most successful being the pyralid moth, Cactoblastus cactorum (Fullaway 1954, Pemberton 1964, Zimmermann 1958). Stunted specimens survive on the south slope, but currently present virtually no threat to survival of native vegetation there. Opuntia is still present in greater numbers in pastures on the west slope in the vicinity of Kula, however.

Other introduced plants

Each zone on the south slope has its characteristic introduced plant species (Table 3), many of which displace native species.

ILLUSTRATION OF VARIOUS ASPECTS OF SOUTH SLOPE ECOLOGY

Figures 2-26 illustrate photographically many aspects of the biology of leeward Haleakala, discussed in preceding sections.

Table 3. Characteristic introduced species of each vegetation subzone of the south slope of Haleakala, Maui, Hawaiian Islands.

Vegetation Subzone	Characteristic introduced species
Alpine rockland (8000-10,000ft)	<u>Hypochoeris radicata</u>
Subalpine shrubland (6000-8000ft)	<u>Holcus lanatus</u> , <u>Hypochoeris radicata</u> , <u>Rumex acetosella</u> , <u>Sporobolus africanus</u> , <u>Anthoxanthum odoratum</u> , <u>Danthonia</u> sp.
Montane shrubland (4000-6000ft)	<u>Sporobolus africanus</u> , <u>Anthoxanthum odoratum</u> , <u>Hypochoeris radicata</u> , <u>Holcus lanatus</u> , <u>Eupatorium adenophorum</u> , <u>Danthonia</u> sp.
Mesophytic cloud-belt forest (4000-6000ft)	<u>Eupatorium adenophorum</u> , <u>Hypochoeris radicata</u> , <u>Melinis minutiflora</u> , <u>Sporobolus africanus</u> , <u>Holcus lanatus</u>
Upper dryland forest (3000-4800ft)	<u>Pennisetum clandestinum</u> , <u>Schinus terebinthifolius</u> , <u>Bocconia frutescens</u> , <u>Bidens pilosa</u> , <u>Eupatorium adenophorum</u>
Middle dryland forest (2000-3000ft)	<u>Lantana camara</u> , <u>Bidens pilosa</u> , <u>Solanum sodomeum</u> , <u>Abutilon grandifolium</u> , <u>Melinis minutiflora</u> , <u>Rhynchelytrum repens</u> , <u>Opuntia megacantha</u>
Lower dryland forest (1000-2000ft)	<u>Lantana camara</u> , <u>Bidens pilosa</u> , <u>Leucaena leucocephala</u> , <u>Solanum sodomeum</u> , <u>Abutilon grandifolium</u> , <u>Rhynchelytrum repens</u> , <u>Opuntia megacantha</u>
Seasonal dryland forest (50-1000ft)	<u>Prosopis pallida</u> , <u>Leucaena leucocephala</u> , <u>Cenchrus ciliaris</u> , <u>C. echinatus</u> , <u>Indigofera suffruticosa</u> , <u>Bidens pilosa</u> , <u>Lantana camara</u> , <u>Rhynchelytrum repens</u> , <u>Opuntia megacantha</u>
Strand (0-50ft)	<u>Prosopis pallida</u> , <u>Leucaena leucocephala</u> , <u>Bidens pilosa</u> , <u>Atriplex semibaccata</u>



Figure 2. This view toward the coast from the middle dryland zone of the Kanaio district, East Maui, illustrates the rugged nature of the south slope terrain with Hana lavas. An area of remnant native vegetation at 2200-2600ft in the foreground is dominated by Osmanthus sandwicensis, Bobea sandwicensis, and Antidesma pulvinatum. The trees in the left foreground are Nesoluma polynesicum.



Figure 3. Remnant of mesophytic cloud-belt forest at 4500ft above Puu Pane, south slope of Haleakala, Maui, Hawaii. Surviving trees are Metrosideros polymorpha and Acacia koa. Stumps are Cibotium glaucum and Sadleria pallida tree ferns killed by browsing of cattle, goats and pigs.



Figure 4. This view shows typical terrain on the west slope of Haleakala, East Maui, where relatively deep soils have developed on the older Kula lavas. Kula Sanitarium provides a landmark at right of center. Pasture land in foreground, once occupied by dryland forest, is now essentially devoid of dry forest remnants. Relatively recent Puu o Kali lava flows (at upper center), superimposed on Kula lavas, harbor some of the best remnants of seasonal dryland forest in the Hawaiian Islands.

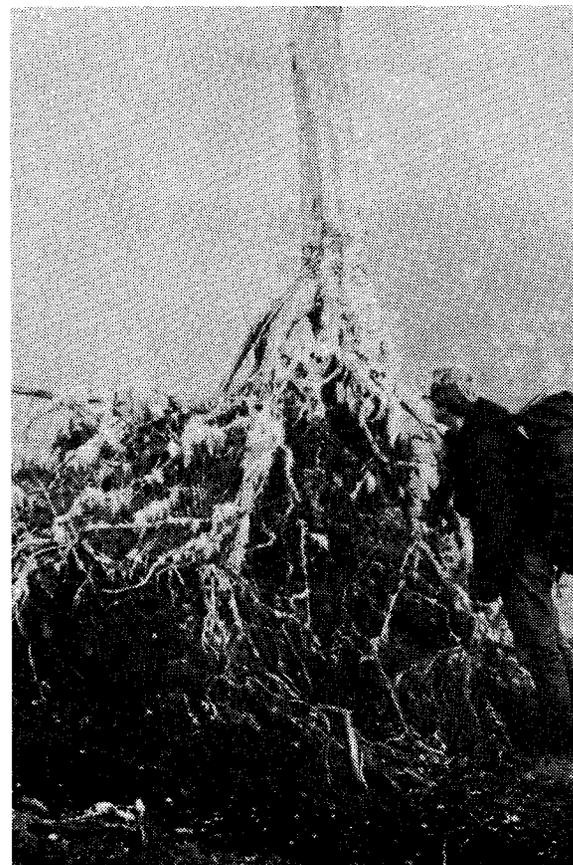


Figure 5. Root system of 'ohi'a (Metrosideros polymorpha - Myrtaceae) tree exposed by massive soil erosion. Elevation ca. 4500ft, above Puu Pane, Manawainui district, East Maui, Hawaii.

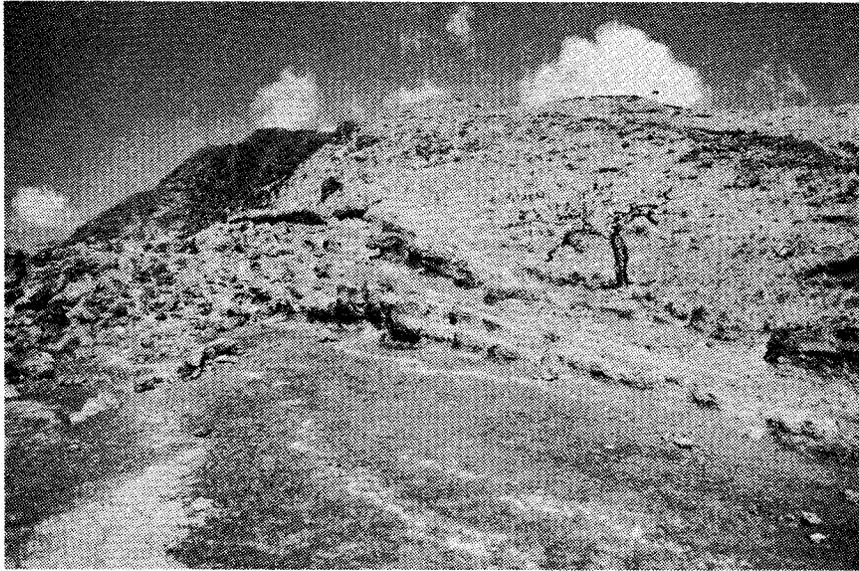


Figure 6. Severe degradation of vegetation and soil erosion caused by decades of browsing, grazing and trampling by feral goats. Ridgeline above eastern Kaupo Gap, Haleakala National Park, Maui, Hawaii. Dead tree at right center is Sophora chrysophylla (Fabaceae).



Figure 7. Former Styphelia (Epacridaceae) shrubland in which most shrubs have been killed by goat browsing. Western Kaupo Gap, elevation 4000ft, Haleakala National Park, Maui, Hawaii.



Figure 8. Landscape denuded by feral goats, western Kaupo Gap, Haleakala National Park, Maui, Hawaii. Native plants survive in this area primarily on cliff faces.

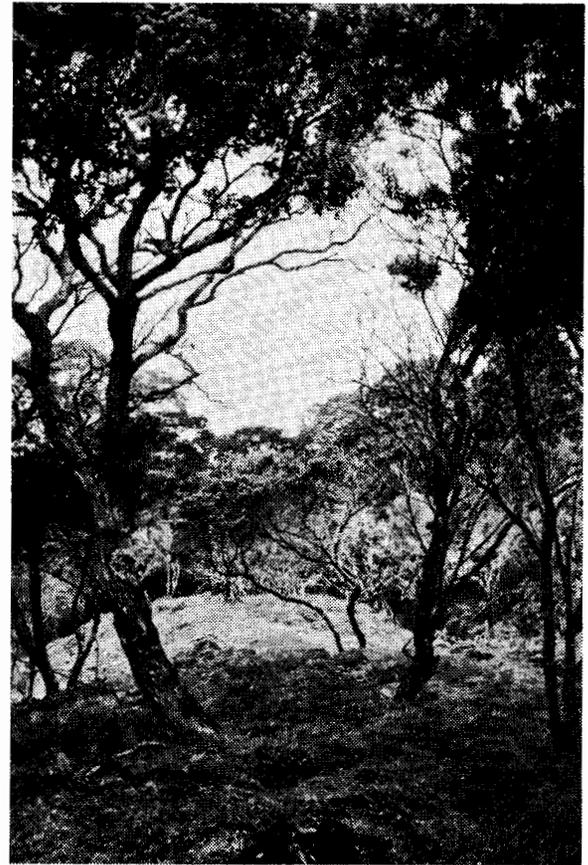


Figure 9. Feral mammals such as goats, pigs and cattle use ridgetops for access to the upper elevation forests. The animal traffic greatly disturbs these ridgetops causing erosion, establishment of pasture grasses and apparent successional replacement of Acacia and Metrosideros with Dodonaea.

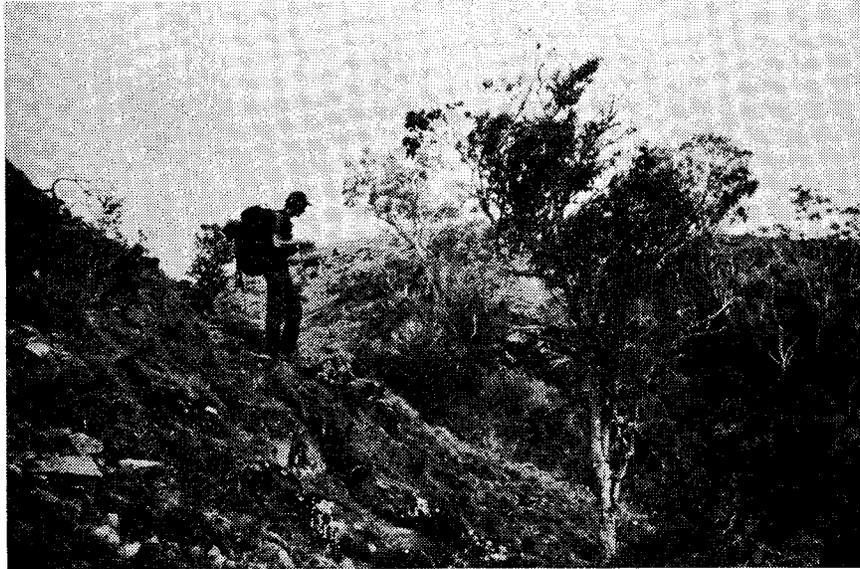


Figure 10. Isolated trees (Streblus sandwicensis, Moraceae, in foreground) are all that remain of what may once have been a closed-canopy forest in this part of Kepuni Gulch, Mehamenui, at 3200ft, East Maui, Hawaii.



Figure 11. Kay Kepler examines damage caused by semi-feral cattle between Manawainui and Poopoo drainages, leeward East Maui, at ca. 4700ft elevation. This disturbance may have profound long-standing effects on the hydrologic capabilities of forest reserves.



Figure 12. Rat-gnawed fruit of Alectryon macrococcum (Sapindaceae) from Kanaio district, East Maui, Hawaii. Photo by Carmelle Crivellone, National Park Service.

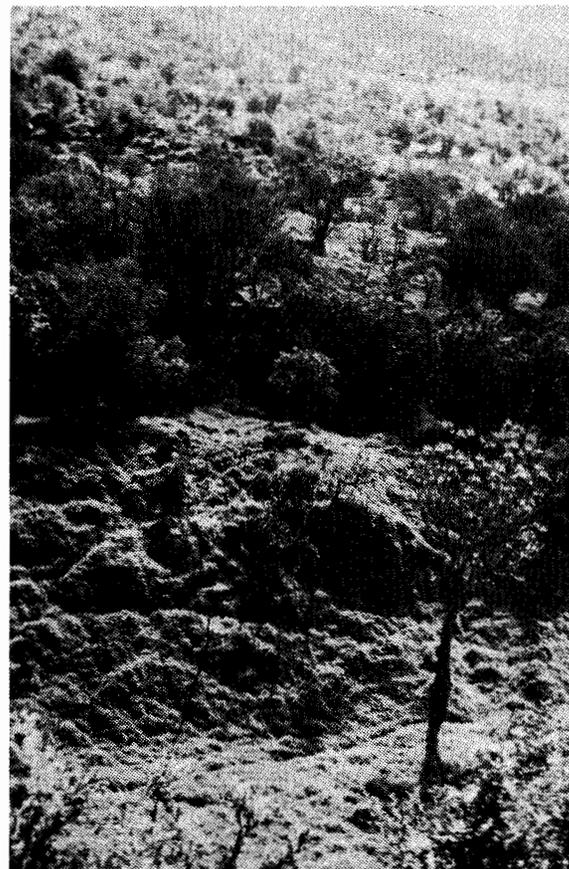


Figure 13. Upper dryland forest at 3800ft in Auwahi district, East Maui, Hawaii. Although this area contains the greatest assortment of tree species on the south slope of Haleakala, introduced kikuyu grass (Pennisetum clandestinum) forms a continuous mat which prevents reproduction of all native species.

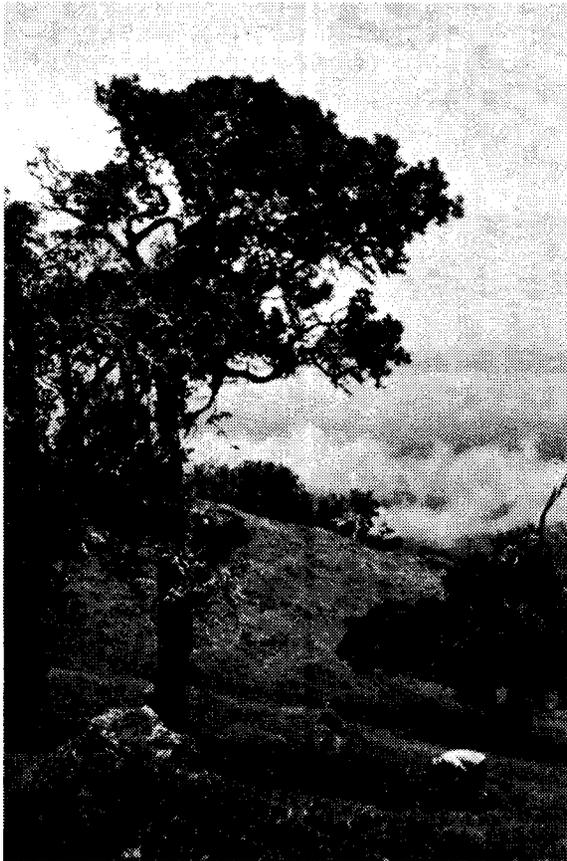


Figure 14. Upper dryland forest at 3600ft in Auwahi. Large tree at center is 12m specimen of Santalum freycinetianum var. auwahiense (Santalaceae). Note continuous ground cover of kikuyu grass, Pennisetum clandestinum.

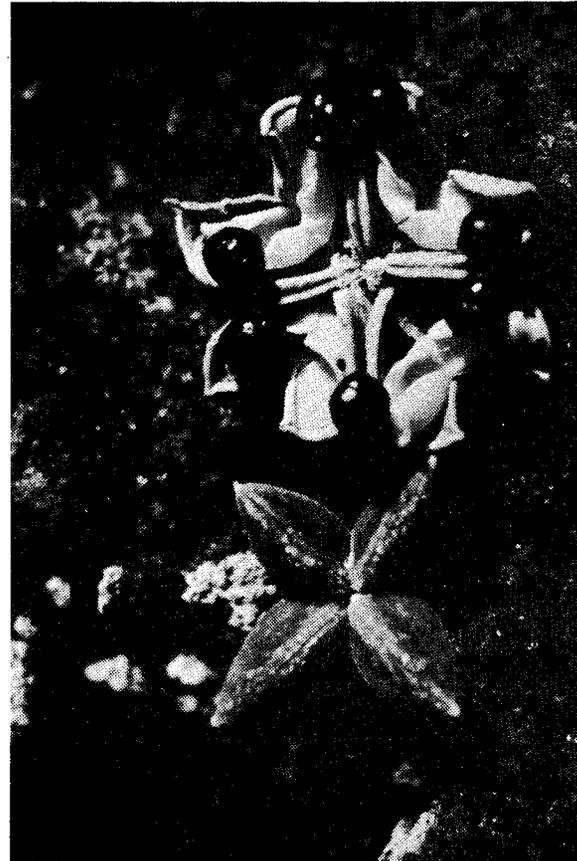


Figure 15. Pelea hawaiiensis (Rutaceae), a characteristic tree species of leeward forest of the Hawaiian islands, now greatly reduced in numbers, is marked by fine, dense pubescence on its fruits. The capsules of this species are shown here before and after dehiscence.



Figure 16. Shown here at 1700ft elevation in the Kanaio district, Bonamia menziesii (Convolvulaceae) is a rare, sporadically occurring liana found in the lower dryland forests of East Maui. This individual supports itself on the introduced shrub Lantana camara (Verbenaceae).



Figure 17. Saplings of Acacia koa (Fabaceae) within Healani enclosure, East Maui, east of Kaupo Gap at 4000ft after 4 1/2 years of protection from feral goats. No successful koa reproduction occurred outside the enclosure. January 1981.



Figure 18. Looking upslope from near the coast toward Kaupo Gap in Haleakala Crater, East Maui. The Haleakala National Park boundary (just below cloud level) in the gap reaches only as low as 3850ft, and the park lacks much of the diversity of the middle-elevation cloud-belt forest, dryland forest, and strand of leeward East Maui. Only about half the flowering plant species of leeward Haleakala are found in the park.



Figure 19. Newly constructed fence in upper Kahikinui district, south boundary of Haleakala National Park, to prevent ingress of feral goats and pigs. Photo by Peter Sanchez, National Park Service, January 1985.



Figure 20. Upper dryland forest remnant in Haleakala National Park, Maui. The following species are found on this steep west-facing ridge in Kaupo Gap at 4700-5100ft: Planchonella sandwicensis, Pleomele auwahiensis, Pelea grandifolia, Pelea hawaiiensis, Psychotria mauiensis, Nothocestrum cf. latifolium, Osmanthus sandwicensis, and Zanthoxylum kauaense.



Figure 21. Vegetation recovery in fenced feral goat enclosure in western Kaupo Gap, Haleakala National Park, Maui, at 4000ft. Although understory is still dominated by the introduced grasses Sporobolus africanus and Rhynchelytrum repens after seven years of protection, the native shrubs Dodonaea eriocarpa, Styphelia tameiameia, and Osteomeles anthyllidifolia are gradually becoming established. Native species may eventually regain dominance. Enclosure was established in 1977. Photo by Peter Sanchez, National Park Service, January 1985.



Figure 22. The extremely rare Lycopodium manni (Lycopodiaceae) growing on Acacia koa in Manawainui gulch, East Maui, at 4400ft.

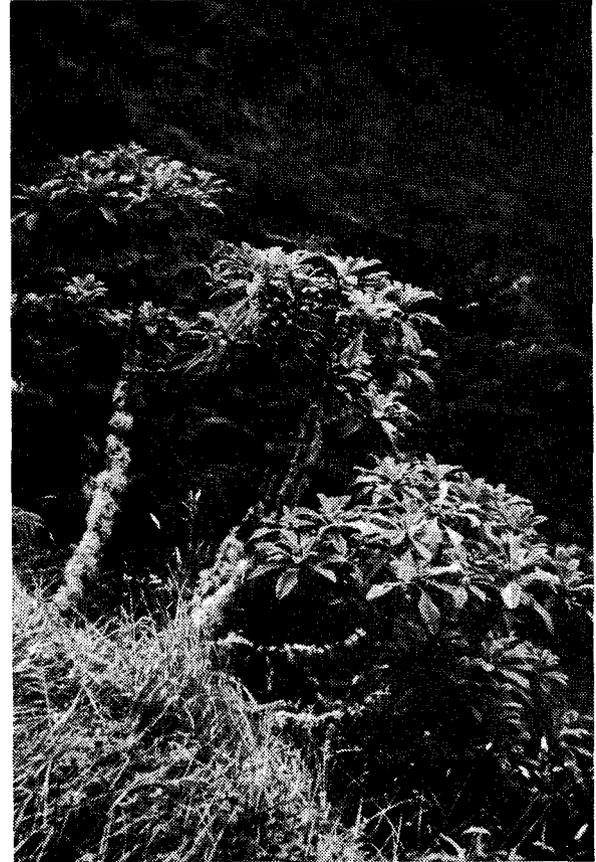


Figure 23. This undescribed and very rare Cyanea sp. (Cyanea sp. nov. St. John ined. - Lobeliaceae) at 5300ft in Manawainui gulch, East Maui, died during the course of this study. Only one known individual remains.

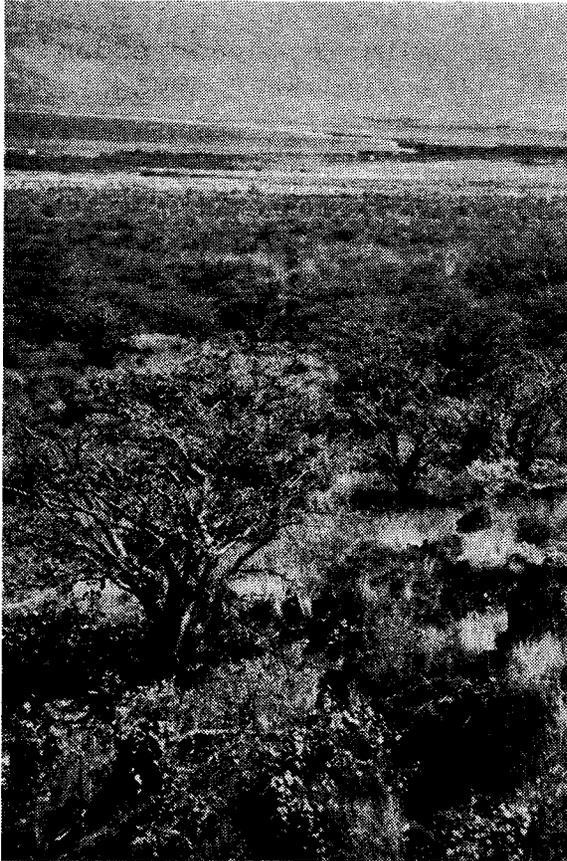


Figure 24. The Puu o Kali lava flows above Kihei at 600-1200ft contain by far the best example of seasonal dryland forest on leeward East Maui. Erythrina sandwicensis is the dominant tree species, with a rich understory of endemic shrubs and vines.

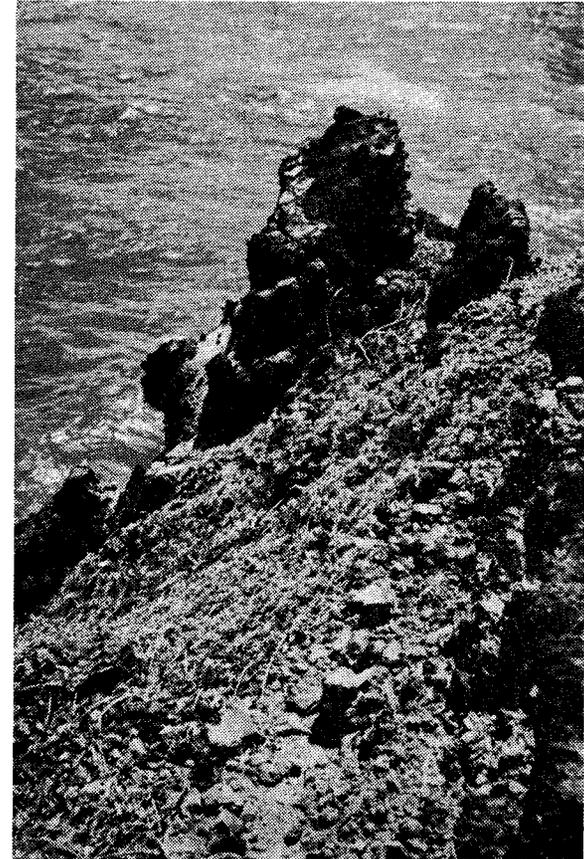


Figure 25. Scaevola coricea (Goodeniaceae), once apparently common in coastal zones around the Hawaiian Islands, is now extremely restricted. This population, located within the study area in the Kaupo district, East Maui, is one of only two surviving relict populations of this species on Maui.



Figure 26. In an attempt to determine the relative vulnerability of native tree seeds to destruction by introduced rodents, field trials were conducted as part of this study. Though the results with many species were inconclusive, there was good evidence that some species are preferentially selected, and may be substantially affected by this form of predation.

STATUS OF INDIVIDUAL NATIVE FLOWERING PLANT SPECIES
ON THE SOUTH SLOPE OF HALEAKALA

The following are status accounts of all native flowering plants species of the study area, the leeward slopes of East Maui. Distributions in parentheses are given in the abbreviated form, as follows: E = endemic, occurring only in the Hawaiian Islands; I = indigenous, also naturally occurring elsewhere than in the Hawaiian Islands; in indicating distributions within the Hawaiian Islands, K = Kauai, O = Oahu, Mo = Molokai, L = Lanai, WMa = West Maui, EMa = East Maui (Ma = Maui), Kah = Kahoolawe, H = Hawaii. Hawaiian names are also given along with the Latin binomial and distributions. Pukui and Elbert (1971) was used as a reference for the spelling, and orthography used in Hawaiian plant names. Locality names are printed without orthographic marks so that there will be no confusion when referencing maps, etc.

These accounts provide the following information where possible and appropriate: an evaluation of the taxonomy; general status in the Hawaiian Islands; use by ancient Hawaiians; information on past distribution and abundance in the study area and on East Maui; present distribution (including elevational range) and abundance; notes on habitat and biotic impacts; notes on occurrence (or absence) of reproduction in the study area; notes on success of various workers at ex situ cultivation of the species. Voucher specimens are listed by the collector and collection number.

In many instances, we have used the taxonomic treatment and distributions given by St. John (1973) or by St. John's more recent publications. Family names are followed by a reference to the page number of St. John's (1973) treatment. Exceptions to this rule include Alyxia and Dubautia/Railliardia and others. We have also included accounts of two Polynesian introductions, Broussonetia papyrifera and Tephrosia purpurea, simply because we regarded them as interesting.

DICOTYLEDONES

AIZOACEAE SJ155

Sesuvium portulacastrum (L.) L. 1759 (I:Tropics) 'Ākulikuli

Stemmermann (1981) notes of this species: "Grows in coastal wetlands and other coastal areas including mud flats and areas of solution pitted sandstone, which are periodically exposed to saltwater or salt spray....Found near the coast throughout the Pacific."

Sesuvium portulacastrum is relatively common along the south slope in the coastal strand and slightly inland in moist depressions. It is not usually found in rough lava but rather in sand, silt or mud substrates.

Voucher: ACM #585, #593

AMARANTHACEAE

Achyranthes splendens Mart. ex Moq. 1849 (E:L,WMa,EMa)
var. splendens (E:EMa)

A recent monograph of the genus Achyranthes by St. John (1979b) increases the number of endemic Hawaiian species from three (with three varieties) to eight. The three varieties of A. splendens (vars. splendens, reflexa and rotundata) were raised to the species level. A. splendens sen. str., the only species on Maui, is found on East and West Maui and Lanai.

Hillebrand (1888) noted that this species was "common in Kula, back of Lahaina, ridges of Wailuku.." Given this 19th century distribution, it is likely that this species occurred on the south slope at that time, but we have encountered no record for the area.

Achyranthes splendens is common but scattered locally in the Puu o Kali area, north of Ulupalakua (Puu o Kali quadrangle) on the west slope of Haleakala at 800-1500 ft. Specimen plants from this site are being grown at Ho'omaluhia Park on windward Oahu and Maui Botanical Garden. Plants grown from seed collected at Puu o Kali showed considerable morphological variation (ACM). Obata (1972) notes excellent germination and pot culture of this species.

Charpentiera obovata Gaud. 1829 (E:H.I.) Pāpala

Of the five endemic species of Charpentiera in the Hawaiian Islands (Sohmer 1972), C. obovata seems to be the one most commonly associated with dry forest. Rock (1913) noted:

"This is a tree 15 to 35 feet in height, and reaches its best development in the dry regions." This species is still fairly common in intact areas of lower dry forest throughout the Islands.

Forbes collected C. obovata on the south slope of Haleakala in 1920 at Kanaio (#1797M), above Lualailua (#1931M), and at Manawainui (#1878M). In his field notes, Forbes noted this species "not uncommon" at "Auahi...forest west of camp" and further east noting, "Charpentiera infrequent" for "middle Auahi".

Charpentiera obovata shows a wide distribution across much of the south slope at 2300-4200 ft elevation. Widely scattered solitary trees occur as far west as Puu Mahoe (2750 ft); in Kanaio, western Auwahi, and Lualailua below the kikuyu zone; and in gulches of Manawainui, Waiopai, Wailaulau and Pahihi at the easternmost part of its south slope distribution. It is still fairly common at 3200-4000 ft in Auwahi, but the area is overrun with kikuyu grass and most trees are senescent. Wind pollination seems probable. Viable seeds are produced, but there appears to be no current establishment of seedlings in the field.

Specimen plants of C. obovata are growing at the Maui and Honolulu Botanical Gardens as well as at Waimea Arboretum. Obata (1972) reports successful propagation from seed, seedlings, and cuttings. Hobdy reports that seedlings are very slow growing.

Voucher: RAH/LLL #201; ACM #549, #550

Charpentiera ovata Gaud. 1829 (E:H.I.)

Pāpala

Hillebrand (1888) notes of this species: "Kauai; Oahu! on the main range; Maui. In appearance much like Pisonia umbellifera, with which it shares the same name, 'Papala'." Although locally common in windward lower to middle elevation wet forests of East Maui, C. ovata is known to us from a single individual on the eastern wall of Kaupo Gap in Acacia koa forest at 4000 ft, just outside Haleakala National Park boundaries.

Voucher: Joel Lau #1002

Nototrichium sandwicense (Gray in Mann) Hbd. 1888
var. sandwicense (E:K,O,Mo,WMa,EMa,L,H)
var. leptopodum (E:EMa)

Kulu'i

St. John's (1979a) revision recognizes eight varieties of N. sandwicense, of which two occur on Maui. The variety leptopodum is restricted in the study area to Nakaohu, Kaloi,

and Auwahi districts whereas the variety sandwicense is "common on the drier lowlands of Kauai, Oahu, Molokai, Maui, Lanai, and Hawaii." Varieties were not distinguished during the present survey.

Rock (1913) referred to N. sandwicense as "peculiar to the very dry districts" and "not uncommon on Maui." He pointed out that although it "is usually only a shrub several feet high in the lowlands," it "becomes a small tree of about 15 to 20 feet in height in the lower forest zone at 2000 to 3000 feet altitude."

Nototrichium sandwicense is fairly common on the Kanaio/Auwahi flow at 1200-2700 ft and on the Lualailua flow at 1100-1600 ft. Scattered individuals occur among the exotic shrubs between these flows and in steep gulches to the east of Lualailua. It is locally abundant on the western slope in certain areas of the Puu o Kali flow at 700-1400 ft.

Goats and cattle seem to preferentially browse Nototrichium. Most individuals observed had high browse lines and damaged stems. Seedlings and young plants were seen only on the Puu o Kali flows.

This species is easily grown from cuttings (Sylva, pers. comm.). A healthy plant is in the Maui Botanical Garden.

Voucher: RAH #133; ACM #218, #363, #558

ANACARDIACEAE

Rhus sandwicensis Gray 1854 (E:H.I.)

Neneleau

Rock (1913) stated that R. sandwicensis "is strictly of the lowland and lower forest zone between 600 and 2000 feet elevation, and may be found in more or less isolated clusters -- On Maui it grows on the windward (Kailua) and leeward slopes of Haleakala (at Auahi)..." Forbes (1920) collected this species in Auwahi (#2111M) with this note: "a small clump but only one flowering specimen observed." Degener (1949) reported that "stands have been decimated during the last thirty years by a fungus disease... The wood is used to make saddle trees on Hawaii ranches, and was formerly made into ox yokes."

A single population of Rhus is known on the south slope, at 3200 ft in Auwahi. This population, located just east of the former Nature Conservancy enclosure on a Lantana dominated slope, apparently dies back above ground from time to time (Lennox, pers. comm.). In December, 1981, this stand was vigorous, with numerous small individuals (root suckers?), saplings and mature plants. No fertile plants were noted.

Rhus sandwicensis may regenerate primarily by root suckers. Numerous root sprouts appeared at a Kauai site where

a population had recently been burned (Hobdy, pers. comm.). Areas of this species bulldozed on windward O'ahu responded with numerous vegetative saplings (ACM).

Vigorous specimen plants grow at Maui Botanical Garden, originally transplanted as seedlings from Iao Valley on West Maui. It is also found at Puu Mahoe Arboretum near Ulupalakua, source unknown. Obata (1973a) reports poor germination.

APIACEAE (UMBELLIFERAE)

Sanicula sandwicensis Gray 1854 (E:Ma,H)

Never common since botanical exploration began on East Maui, this species is now rare. Hobdy reports knowledge of six small populations of S. sandwicensis on the extreme western edge of our study area, above 7000 ft in the Kula Forest Reserve. Otherwise, we did not encounter this species within the study area.

APOCYNACEAE

Alyxia olivaeformis Gaud. 1829 (E:H,I) Maile
var. lanceolata Hbd. 1888 (E:O,Mo,L,E/WMa)
var. myrtillifolia Gray ex Hbd. (E:L,E/WMa) Maile-lau-li'i

Hillebrand (1888) states: "The fragrant and glossy branches of the Maile are in great favor with the natives in decorating their houses and 'lanais' on festive occasions. The same name 'Maire' is applied in Tahiti to Alyxia stellata." St. John (1975a, 1976b) reduces the four varietal taxa to forms as well as adding ten other forms. St. John (1975a) remarks: "All botanists who have studied it have agreed that there is but one native species in Hawaii, yet there is conspicuous variability in the number, size, and shape of the leaves. The Hawaiians have recognized and named several of the varieties. Neal stated that their total was five varieties, three of which had special leaf shapes." Consult St. John (1975a) for an excellent discussion of cultural usage of this species in lei-making.

In eastern Kaupo Gap at 4900-5400 ft in Haleakala National Park, Alyxia occurs in Myrsine/Acacia forest. Specimens collected at this site may be referred to var. lanceolata.

In a goat-denuded, rocky area of western Kaupo Gap at 3900 ft just below the national park boundary, a single Alyxia plant was found growing epiphytically in a Metrosideros tree. The specimen (ACM/LLL #424), though perhaps referable to var. myrtillifolia, has larger leaves and differing habit.

Alyxia olivaeformis var. myrtillifolia sen. str. occurs in Auwahi and Kanaio at 2400-4000 ft, scattered but locally common. Here it is often quite striking with small revolute leaves and dense globose habit, growing primarily on aa lava. It is rare above Lualailua Hills at 2300-2500 ft. Forbes in 1920 collected this variety as far east as the Nakaaha district (#1941M). Rock noted of this variety: "...occurring in the dry forests, usually climbing over trees, and sometimes strangling them to death." Though we observed many individuals of the var. myrtillifolia in Auwahi/Kanaio, we saw no evidence to confirm Rock's observation.

Vouchers: E. Kaupo- ACM/LLL #410
W. Kaupo- ACM/LLL #424
Auwahi/ Kanaio- RAH/LLL #179

Ochrosia haleakalae St. John 1978 (E:EMA)

Hōlei

Rock (1913) remarked: "The Holei, which has become rather scarce, inhabits the dry districts.. and is only abundant on the island slopes of Maui, at an elevation of 2500 ft, back of Makawao, slopes of Haleakala, and on the lava fields of Auahi... The natives knew how to extract a yellow dye from the bark and roots, wherewith to stain their tapa or paper clothing." Rock, in a number notebook (Bishop Museum), noted: "Fruits bright yellow and much larger than given by Hillebrand. I also observed purplish-black ones still larger."

Until 1978, all Hawaiian Ochrosia populations were assigned to one species, O. compta. St. John (1978a) recognized 11 species from the five major islands. Ochrosia haleakalae is endemic to the south and west slopes of East Maui. St. John cited 18 specimens, 8 from the west slope (mostly near Makawao), 9 from Auwahi, and one from "Maui".

This survey found O. haleakalae fairly common, though quite localized, in the 2800-4000 ft zone of Auwahi (and edge of Kanaio), most common at 3000 ft. Hobdy told us of seeing a single tree of Ochrosia while fighting a range fire on the Wailaulau/Pahihi planeze. This species has apparently been extirpated from the western slope of Haleakala.

The trees at the central Auwahi site are, for the most part, quite vigorous despite browsing of lower foliage and trampling of roots near the surface by domestic cattle. Saplings, probably root suckers, were seen near several trees. In one case these were dead, perhaps the result of competition with kikuyu grass.

A few small seedlings were noted in the Auwahi district at ca. 3400 ft. Abundant flowering and fruiting were seen. The creamy white flowers are sweetly fragrant, and the color and odor perhaps adaptations to pollination by Lepidoptera. Fruits

that fell to the ground were soon stripped of the fleshy pulp by insects, leaving the tough, woody endocarp that protects two flat ovate seeds. The mechanism for dehiscence is unknown, since the woody endocarp is tightly fused at one end.

Reports of germination and seedling survival of Ochrosia vary, ranging from good to poor (Hobdy, Lennox, K. Nagata, pers. comm.; Obata, 1973b). Seedlings planted at Auwahi (Lennox) died within two years. Wahiawa Botanical Garden has several Ochrosia trees in cultivation that flower and produce viable fruits.

As first noted by J. F. Rock, in the Auwahi district there is great variability in fruit color and considerable variability in fruit shape and size. Most trees had smooth, yellow, ovate-shaped fruit. In a few individuals, fruits were larger and dark red, while large, fleshy, dark purple fruits are produced by a number of trees. Foliage of the "types" did not seem to differ consistently.

Vouchers: RAH/LLL #205; ACM #100, #563, #564

Rauvolfia mauiensis Sherff 1947 (E:EMA)

Hao

Prior to Sherff's (1947) revision, the Rauvolfia populations on Maui were included within wide-ranging R. sandwicensis A. DC. 1844 (Hillebrand 1888, Rock 1913). Rauvolfia mauiensis sensu Sherff is endemic to East Maui (St. John 1980a). Forbes collected (#1922M) this species in the Nuu area in 1920, noting it "common on the aa."

Rauvolfia mauiensis is currently found at 300-2400 ft from the SW rift eastward as far as Kipapa. It is common and vigorous on the rough aa of the Kanaio/Auwahi and Lualailua flows.

The species appears to reproduce only by seed. We noted no vegetative reproduction. Many trees were found in fruit and flower throughout the year from June 1981 through September 1982. In all cases when a tree was in flower or fruit, old but intact seeds were found underneath. Non-flowering and fruiting trees consistently lacked an accumulation of stored seeds in the litter. Hundreds of seedlings were noted in the Auwahi area in late-March, 1982. They were all (one exception) dead by September, probably due to a combination of low soil moisture and overwhelming competition from Bidens pilosa.

This species is in cultivation at Maui and Wahiawa Botanical Gardens and at Lyon Arboretum. Lyon Arboretum (K. Nagata) and Obata (1973b) report poor germination, whereas Hobdy had good results from Auwahi seed. Obata (1973b) reports good seedling growth.

Voucher: RAH/LLL #153; ACM/LLL #258; J. Lau #1007

AQUIFOLIACEAE

Ilex anomala H. & A. 1832 (E:H.I.)

Kāwa'u

Rock (1913) noted that this species was "one of the most common forest trees on all the islands, and is more or less confined to the rain forest, though occasionally met with in the drier districts." Forbes collected it (#2156M) above and west of Puu Ouli in 1920.

Ilex is still locally common in the Metrosideros/Acacia forests of Kahikinui (Manawainui to Pahihi) and the Manawainui planeze (E of Kaupo Gap). It occurs sparsely in eastern Kaupo Gap of Haleakala National Park, becoming quite common with increasing elevation and moisture in the upper part of the Gap near Paliku. Reproduction by seed was noted in several sites, although browsing by feral mammals and competition from introduced grasses prevent successful establishment in most areas outside rain forests. This species does not reproduce vegetatively.

Obata (1973a) reports mixed germination success with this species.

ARALIACEAE

Cheirodendron trigynum (Gaud.) Heller 1897 (E:H.I.exc.K)

'Ōlapa

Cheirodendron trigynum is the second most common wet forest tree in the the Hawaiian Islands (after Metrosideros polymorpha). Hillebrand (1888) stated that "the natives..knew how to prepare a blue dye from the bark or leaves."

Our survey found this species to be still fairly common, but sparsely reproducing, on the south slope of East Maui in mesic forests above 3200 ft. At the west end of the study area in the Ulupalakua/Polipoli area, very large trees can be found in open pasture lands up to drier scrub above 6000 ft, especially in protected gullies. Large, scattered trees of Cheirodendron also occur throughout the upper elevation dry forest in Auwahi and Kanaio districts. The species is more abundant further east, in the mesic Metrosideros/Acacia koa forests above Puu Pane, east to Wailaulau. It occurs sparsely in upper eastern Kaupo Gap near Paliku. Seedlings and saplings were noted only in steep, relatively inaccessible sites in Metrosideros/Acacia forests. This species was not observed to reproduce vegetatively.

Cheirodendron trigynum was observed to produce regular and abundant quantities of fruit and seed in the study area. Germination success reported by various workers is mixed, with some reporting vigorous saplings grown from seed without

special technique. Obata (1971) notes that this species and several others "were at their cultural optimum only greenhouse plants, but failed to survive outdoor plantings."

Reynoldsia mauiensis Sherff 1952 (E:Ma) 'Ohe, 'ohe-makai
var. mauiensis
var. macrocarpa Deg. & Sherff 1952 (E:EMa)

Hillebrand (1888) states: "On all islands here and there, on open exposed forehills up to about 1500 ft. The tree has the shape and the habit of the 'Wiliwili'..., loses its leaves in winter and flowers in early summer before the reappearance of the leaves." Rock (1913) remarks: "It is peculiar to the very dry districts of the lowland zone and especially on aa lava fields, where the heat is intense and the rain is very infrequent... On Maui, it is not uncommon on the lava fields near Ulupalakua on the southern slopes of Haleakala." It has been collected frequently on the lower south slope by Rock, Forbes, Degener and others. Although our review tentatively lists this species as endemic to Maui sensu Sherff, St. John's (1980b) recent review supports the concept of a single variable species. Degener and Sherff (1952) also described a var. macrocarpa apparently endemic to the study area based on Degener #21,997, collected along Highway 31 in Kanaio district in 1952.

This survey noted Reynoldsia primarily on the three rough lava flows-Kaunauhane, Auwahi/Kanaio, and Lualailua/Alena at 800-2800 ft. Between these flows and in the large gulches to the east, a few individuals can be found. On the western slope, a single large individual was found below Puu o Kali at ca. 1300 ft.

Numerous Reynoldsia seedlings were observed in the wet spring of 1982, but most died soon afterward. However, a few saplings were observed. Rodents seem to eat Reynoldsia fruits, at least occasionally. Rat or mongoose droppings in the field contained intact seeds.

Specimen plants of this species are in cultivation at Wahiawa, Lo'i-kalo and Koko Crater Botanical Garden on Oahu and at Maui Botanical Garden. Propagation from seed and cuttings gives poor to fair success (pers. comm.; Obata, 1973b).

Tetraplasandra kawaiiensis (Mann) Sherff 1952 (E: K,L,E/WMa,H)
var. intercedens Sherff 1952 (E:EMa) 'Ohe'ohe,

Tetraplasandra kawaiiensis is distinguished from other species in this endemic Hawaiian genus by a scurfy golden-brown pubescence on the inflorescence and lower surfaces of leaflets. The young emerging leaves are entirely coated with this pubescence. Sherff (1955) recognized seven varieties,

including the var. intercedens which is endemic to southwestern East Maui. Rock (1913) refers to this species as Pterotropia dipyrena. His Plate 145 shows it growing in the last remnants of native mixed forest above Ulupalakua. He noted: "It is, however, still most numerous on.. Mt. Haleakala... In the former locality above Ulupalakua it is the only species alive, as can be seen by the picture, all the rest of the vegetation having been killed by cattle, goats and sheep. On the lava fields of Auahi.. the writer found some very big trees in company with Pelea multiflora, Bobea hookeri, Alectryon macrococcus, Xanthoxylon sp., Tetraplasandra meiandra, and many others. It is more or less peculiar to the dry districts.. It is a hardy tree and can stand the ravages of cattle and other enemies better than any other Hawaiian tree."

Hillebrand (1888) states, based on Lydgate's knowledge, that this species occurs on the southern slope of Haleakala at 3000-4000ft. Forbes collected it twice in 1920, on the SW rift above Kula (#2169M) and at Auwahi (#1973M). He noted of the Kula collection: "common in the dying forest in apparently good condition, perhaps young.. Generally tall, straight trees 30-35 ft high." Regarding the Auwahi collection, Forbes noted: "Forest above house. Very large trees. Pterotropia [T. kawaiensis] are at least 80 ft high and 1.5 ft in diameter.. About 14 trees seen."

Closely allied varieties, var. nahikuensis and var. dipyrena are found on East Maui in Nahiku and in Waihoi Valley at 2000-3000ft. The species is also present in high elevation rainforest of the north slope below Puu Alaea.

Our survey found T. kawaiensis to be extremely rare on the south slope. The total population may be as few as several dozen individuals. Most of these trees are at 4000-5000 ft in Auwahi and Lualailua. Only a few trees survive on the SW rift at Papaanui ridge at 5400 ft. Although flowering and fruiting occur abundantly, there is no sign of reproduction.

Tetraplasandra meiandra (Hbd.) Harms 1898
var. mauiensis Sherff 1952 (E:EMa)
var. leptomera Sherff 1952 (E:EMa)

'Ohe

Rock (1913) notes of T. meiandra: "Varieties.. occur both in extremely wet forests and in exceedingly dry or mixed forests. It is in the latter regions that they reach their best development. They are associated with Pterotropia, Alectryon, Pelea, Xanthoxylon, Hibiscadelphus, etc..." The species and its forms grow at altitudes of from 1000 to 4000 feet, and are either small shrubs or medium-sized trees in the wet forests, and larger trees in the dry regions (on lava fields). Regarding this species at Auwahi, he states: "It is a handsome tree of 50 feet or more in height, with a trunk of almost two feet in diameter. The trunk is perfectly straight

and vested in a smooth gray bark. The branches are thick and ascending, bearing at their ends large leaf-whorls, underneath which are umbels with small greenish flowers."

Sherff (1955) recognized 25 varieties of T. meiantra, many of which are very narrow endemics, some represented by a single population or even a single specimen. Tetraplasandra meiantra var. leptomera is represented by a single Forbes south slope collection (#1930M) from "Laumau forest," apparently in the Lualailua district. Forbes noted for the habitat where the collection was made: "Osmanthus dominant, Dracaena second. Open scattered trees and much Eupatorium."

The common variety of T. meiantra on the south slope was designated var. mauiensis by Sherff. Although most collections are from Auwahi (Rock, Forbes, Munro), it has been collected as far east as Kipahulu Valley (Forbes #1713M).

Tetraplasandra meiantra is currently rare on the south slope, but is more common than T. kavaiensis. Whereas the latter species is found in the 4000-5000 ft zone, T. meiantra occurs at Auwahi at 2800- 4000 ft. Tetraplasandra meiantra flowers and fruits abundantly. Numerous root suckers are produced, but are browsed.

Obata (1973b) notes poor germination rates, but good growth in cultivation.

ASTERACEAE

Argyroxiphium sandwicense DC. 1836 (E:EMa,H) 'Āhinahina
ssp. macrocephalum (Gray) Meyrat 1983 (E:EMa)

Rock (1913) observed: "The steep slopes in the upper part of Kaupo gap are covered with this most beautiful plant.. Wild goats are doing great damage to it, as they devour it eagerly, and so also do wild cattle.." Silverswords have since been eliminated from Kaupo Gap, as well as from most areas where much other vegetation exists. Silverswords are thriving, however, within a large portion of Haleakala Crater where vegetation is extremely sparse and where feral goats are rarely found.

Argyroxiphium sandwicense is no longer found within the study area, although probable habitat exists.

Argyroxiphium virescens Hbd. 1888
var. virescens (E:EMa)

Rock (1913) stated: "Of great interest is the green sword-plant, Argyroxiphium virescens, which is peculiar to Haleakala...It usually grows on the edge of cliffs in company

with the silversword...It has been observed in the crater of Haleakala itself, but not on ash fields, as its cogener, but in Kaupo gap along dry streambeds between rocks, together with Lobelia hypoleuca [=L. grayana], Dubautia plantaginea var., Raillardia sp., etc."

Argyroxiphium virescens grew in cool, relatively moist habitat, probably at 6500-7500 ft. In areas such as Puu Nianiau, its range overlapped with Argyroxiphium sandwicense (Rock 1913). Argyroxiphium virescens survived near Puu Nianiau and in adjacent Koolau Gap until the mid 1930's (Lamb 1935, 1936). The last known collection of A. virescens was made by St. John and Mitchell in 1945 (#21, #153) at "pass N of Kuiki" near Paliku cabin in the eastern crater. It is now believed extinct.

Artemisia australis Less. 1831 (E:O,Mo,E/WMa) Hinahina-kuahiwi

Artemisia australis is a characteristic species of coastal and low elevation cliffs on windward East and West Maui. It occurs less abundantly in similar habitats on tall bluffs just above the sea on the coast of southern Haleakala - usually not above several hundred feet above sea level. However, this same apparent species occurs as a small disjunct population in eastern Kaupo Gap of Haleakala (Stemmermann et. al.1981) in small ravines and on cliff walls at ca. 5000 ft.

Artemisia mauiensis (Gray) Skotts. 1927 (E:EMA) var. mauiensis
var. diffusa Skotts. 1937

Artemisia mauiensis is locally common on cliff walls in Haleakala crater and less common on the outer slopes. On the south slope, this species occurs on steep walls at 6500-8000 in the head valleys of drainages from Manawainui eastward as well as on walls in craters near Kahua cabin ca. 7000 ft. It is also present on the walls of west Kaupo palis in and near Haleakala National Park down to 3700 ft. Forbes collected typical A. mauiensis from Auwahi in 1920 (#2093M), noting: "Shrubby, 1 1/2 ft tall somewhat prostrate.. very strong odor. 1 seen."

Skottsberg (1927) described var. diffusa from the type and only collection made by Rock (#8677) in 1910 from "beyond Auwahi." Degener (1939-Fl.Haw.) stated: "It bears certain characters in common with A. australis.. It is perhaps best interpreted as a hybrid, though Skottsberg maintains that the differences in this plant from A. mauiensis are not greater than could be expected from a change of environment.. this controversial plant might even be an archaic type representing the ancestor of A. mauiensis before it had spread into arid, light-drenched Haleakala and become strongly modified."

Our survey located a population of Artemisia within koa forest at 5300 ft in Manawainui drainage which has characteristics allying it with var. diffusa - glabrescent leaves, wooly only when young and not as finely divided as A. mauiensis sen. str., with larger and more lax inflorescences.

Voucher: var. mauiensis- ACM/LLL #431
cfr. var. diffusa- ACM #98, #304

Bidens mauiensis (Gray) Skotts. 1920 (E:L,W/EMa) Ko'oko'olau

According to Sherff (1937), this species is restricted to East and West Maui and Lanai and has five varieties. In this report, varieties are not recognized. Hillebrand (1888) noted, for the range of B. mauiensis: "Isthmus of Maui and mountain slopes above Maalaea." Numerous collections have been made from West Maui, especially on the eastern and northeastern coastal areas, from the 1860's to the present. Within the study area, Forbes (in 1920) collected B. mauiensis at Manawainui gulch (#1919 M), where it still can be found today. Gillett, who reviewed the genus in Hawaii, collected Bidens mauiensis (1966-#1872) in the same area with the herbarium note: "growing on an arid hot rocky hillside about 50m above the sea at the east end of the bridge crossing Manawainui gulch on the south slope of Haleakala... Growing with indigenous Euphorbia and associated dryland weeds."

Gillett and Lim (1970) characterize the range of Bidens mauiensis as follows: "This species occurs on the island of Maui near the seacoast, slightly above sea level on extremely arid, hot, sandy or rocky hills." This species is scattered at various coastal sites throughout the study area and may have once been more abundant. Sylva (pers. comm.) has observed a few plants near La Perouse Bay in the Kalihi district and several hundred individuals of this species at Kailio point in the Kaupo district. Hobdy also reports this species at Kanaio beach in the Kanaio district. Our survey encountered this species at and near Manawainui drainage at 50-150 ft.

Voucher: ACM/LLL #256

Bidens micrantha Gaud. 1829 (E:O,Mo,L,E/WMa,H) Ko'oko'olau
ssp. kalealaha Nagata & Ganders 1983 (E:L,E/WMa)

On East Maui, Hillebrand and Lydgate collected this species at "Kula, Maui" (ca. 1869). Forbes (1920) collected it above Lualailua hills (#1987M) and "east of Puu Keokea, south slope of Haleakala" (#2148M). Hatheway and Greenwell in 1950 collected B. micrantha on the south slope (#470) with this note: "5 ft. shrub, leaves shiny. Precipitous headwall of small canyon 200 yds. west of Kahua cabin, south slope of Haleakala. Elev. 7000 ft. Apparently these plants are highly

palatable to feral goats which have almost destroyed the climax subalpine woodland of this region. Persists in inaccessible places." Ganders and Nagata (1983) state of the distribution of this taxon: "Leeward slopes and inner crater walls of Haleakala, East Maui, from 750-2300m elevation, and at least formerly on leeward Lanai."

Within the study area, B. micrantha was observed at 5200-6400 ft, primarily on drainage headwalls between Manawainui and Wailaulau. This species also occurs abundantly with Dubautia platyphylla in several deep pit craters south of Kahua cabin at ca. 6840 ft. Within Haleakala National Park, it occurs sporadically along cliff walls in western Kaupo gap at 6000-6400 ft and on the inner walls of the crater at ca. 7200-7600 ft.

Voucher: ACM #302, #569

Dubautia linearis (Gaud.) Keck 1936 (E:Mo,L,E/WMa,H) Na'ena'e

Although similar to D. reticulata in leaf shape and arrangement and in some flower characters, habit and habitat differences as well as minor but consistent morphological characters suffice to establish the two as allopatric species (G. Carr, per. comm.). In the study area, D. linearis is a species of dry, rocky sites, usually on lava flows at low to middle elevations.

Hillebrand and Lydgate collected D. linearis ca. 1869 from "Haleakala south" and from "Brown Hill, Kula." The U.S. Exploring Expedition botanists in the 1840's collected this species near the crater of Haleakala. Rock collected it in 1910 at Auwahi at 2500 ft and Forbes added collections from Kanaio (#1785M) and Auwahi (#2092M).

Dubautia linearis was encountered by our survey only in the Auwahi and Kanaio districts at 1400-3200 ft. Populations are localized and often highly concentrated, with rounded 1-2m shrubs dominating small areas. During the September-October flowering period, the profusion of golden-yellow flowers is visited by large numbers of lycaenid butterflies and native Hylaeus bees.

Voucher: ACM/LLL #263

Dubautia menziesii (Gray) Keck 1936 Na'ena'e

This high elevation species is a conspicuous element of the subalpine shrubland and alpine desert of Haleakala at 7000-10,000 ft. On the south slope, however, D. menziesii has been eliminated from part of its probable former range due to browsing animals. It persists from above the Kula Forest

Reserve on the southwest rift eastward to Manawainui, becoming scarcer eastward due to increasing feral animal populations. It has also survived within Haleakala National Park in western Kaupo Gap. At this latter site, the species is extremely small-leaved with small flower heads growing on steep cliff walls out of reach of goats. The individuals of D. menziesii at this site also express characters of D. linearis, a lower elevation species (G. Carr, pers. comm.).

Voucher: ACM #568, #572, #581

Dubautia plantaginea Gaud. 1830 (E:O,L,Mo,E/WMa,H) Na'ena'e

Dubautia plantaginea, a species found in a variety of moist environments on East Maui and elsewhere, has been collected in E. Kaupo Gap by Rock, Degener, and others. Forbes collected it in 1920 east of Puu Pane (#1835M) and near Puu Ouli (upper Auwahi- #2135M). This species currently survives on the south slope in two sites - E. Kaupo Gap in Haleakala National Park, where Stemmermann et al. (1981) recorded it as "occasional," and in the Acacia/Metrosideros forest between Manawainui and Pahihi drainages at 4500-5500 ft in moist, fern-covered gulches. Relict populations of this shrub/tree are also known from the western slope of Haleakala, growing with small stands of Acacia koa on gulch sides.

Voucher: ACM #305

Dubautia platyphylla (Gray) Keck 1936 (E:EMa) Na'ena'e

This uncommon East Maui endemic is found on the west and northwest slopes of Haleakala, in Koolau Gap, above Paliku, and at a few other moist sites in Haleakala crater. Forbes collected it in 1920 (#2003M) just above the forest line above Lualailua Hills with the note: "practically lacking, a few on sides of gulches." Wendte (in 1899) and Degener (in 1927) collected it in Kaupo Gap.

Dubautia platyphylla is still found on the south slope, scattered in the 5400-7000 ft zone from Kula Forest Reserve east to the Manawainui drainage. Within this range it is especially common in several pit craters south of the Kahua cabin at 6900 ft. It is also present in eastern Kaupo Gap at 5500 ft.

Dubautia reticulata (Sherff) Keck 1936 (E:EMa) Na'ena'e

Prior to the 19th century, this tree-like East Maui endemic probably occurred in a nearly continuous range at 5000-7000 ft around Haleakala. Rock's (1913) Plates 213 and 214, labeled Raillardia menziesii, are actually D. reticulata -

showing robust, tree-sized individuals. The range and abundance of this species have been drastically reduced in the past two centuries by feral and domestic herbivores, so that it survives primarily on the northern slopes of Haleakala. Forbes collected D. reticulata in 1920 above Puu Ouli on the south slope in the last remnants (now completely gone) of the diverse mesic forest on the rift zone above Ulupalakua.

Our survey located this species in the narrow remaining band of cloud-belt forest between Pahihi and Manawainui gulches at 4500-5500 ft, primarily on the sides of steep streamcourses. These individuals grow sympatrically with Dubautia plantaginea and are smaller than D. reticulata elsewhere on East Maui. No more than a few hundred plants are present.

Vouchers: ACM #233, #237, #316

Dubautia scabra A. DC. 1838 (E:Mo,L,E/WMa,H)

Na'ena'ena

Sherff (1935b) noted two collections of this species from the south slope of Haleakala: one by Rock (#8602a) in 1910 from Kaupo Gap (identified by Sherff as var. munroi Sherff 1933) and one by Degener (#4230) in 1927 (identified as var. leiophylla Gray 1862) with the note: "In comparatively dry, shrubby region often subject to fog, north mauka (inland) of Ulupalakua Maui."

Although D. scabra is still fairly common in some areas of windward north and northeastern East Maui, it was not seen in this south slope survey.

Gnaphalium hawaiiense Deg. & Sherff in Sherff 1949 (E:EMa,H)

'Ena'ena

The only Maui record of this species is based on a Forbes collection from a low elevation site near Kamana (#2125M) in 1920. (See also G. sandwicense.)

Gnaphalium sandwicense Gaud. 1830
(E:Kure, Midway, O, Mo, L, E/WMa, H)

'Ena'ena

This species thrives in hot, dry, exposed sites, often on barren lava substrates. It occurs in the alpine zone of Haleakala, including the upper south slope at 9000-9500ft. Widely disjunct populations are also found at 1500-2300 ft in Kanaio on rough aa flows with Dubautia linearis, Lipochaeta lavarum, Canthium odoratum, and Dodonea eriocarpa. The alpine populations closely fit the description of G. sandwicense given in Degener and Degener (1960-Fl.Haw.) (white wooly-canescant with tightly clustered heads, rarely

branched). The lower Kanaio populations exhibit some characters similar to the related G. hawaiiense (less woolly-canescens, greener, more lax and branching inflorescences, more vegetative branching-ACM #231).

Vouchers: ACM #231; ACM/LLL #265; RAH/LLL #144

Note on the genus Lipochaeta:

The genus Lipochaeta, considered endemic to the Hawaiian Islands, is comprised of two distinct sections, one diploid and the other tetraploid (Gardner 1976, 1977). Though superficially similar, the two sections differ in chromosome number, leaf flavonoid chemistry and floral characters, primarily the number of lobes in the disc flower corolla (Gardner, 1976, 1977).

Lipochaeta is considered to be derived from the genus Wedelia, found in Latin America and on Pacific Islands (Gardner 1976). This theory has been supported by greenhouse hybridization and cytological study of the two genera, including intergeneric hybridization (Rabakonandrianina 1980; Rabakonandrianina and Carr 1981).

The L. rockii species complex which includes a number of segregate taxa found in the study area is tetraploid ($n=26$), hence belongs to section Lipochaeta. Lipochaeta kamolensis and L. lavarum, other taxa of the study area, are diploids ($n=15$) belonging to section Aphanopappus.

Hillebrand (1888) recognized 11 Hawaiian Lipochaeta species, with several varieties. Sherff (1935b) listed 25 species, with numerous varieties. St. John (1973) lists 27 species with numerous varieties, many authored by Sherff. Gardner's (1979) monograph included 23 species (one new) and maintained few varieties. St. John (pers. comm.) has a review of this genus near completion, with at least one new species from the south slope. Discrepancies in the taxonomic treatments of this genus result partly from the importance that various workers assign to variance in certain morphological characters - especially leaf shape, size and degree of dissection.

Lipochaeta forbesii Sherff 1933 (E:EMa)

Nehe

var. forbesii

var. sherffii Deg. & Clay 1949

The type for this species is a 1920 collection by Forbes (#1916M) during his 41 day collecting trip across the study area. In his field notes, Forbes recorded: "A shrub, densely branched, 4 ft. high, flowers bright yellow orange." Based on field note information, the type locality on aa lava was probably in the Nuu district, just east of Hawelewele gulch.

Degener and Clay described var. sherffii (1949, 1950 in Fl. Haw.) from a Degener collection (#19292) made in 1948. The location cited is "between Kepuni and Palaha gulches, Maui. A few plants growing on aa lava inaccessible to cattle, at 1500 feet elev." This site is about 6km west of the 1920 Forbes type collection of the species sensu strictu.

Kimura and Nagata (1980) note of the species: "On the south slopes of Haleakala, Maui in the arid lava fields grows this erect, brittle-stemmed shrub with thin five-lobed leaves.."

Gardner (1979) considers this species as a taxonomic synonym of L. rockii (see below).

This survey found L. forbesii present but quite rare in several districts east of Lualailua Hills at 900-1500 ft. Existing populations are subject to browsing damage by domestic cattle.

Lipochaeta kamolensis Deg. & Sherff in Sherff 1951 (E:EMa) Nehe

Gardner (1979) retained L. kamolensis as a distinct species, even though it is known only from a small area on Haleakala's south slope. Degener's type collection (#19288), made in 1948, notes: "Very rare, among lantana and grass on side of Kamole gulch, southernmost central eastern Maui." Gardner relocated the population in the mid-1970's, noting: "Known only from Kamole gulch, 240m. Flowering Dec.-Feb. Extant." This population is sympatric with the larger distribution of L. rockii sensu Gardner (L. forbesii of Sherff).

Upon analyzing 32 characters, Gardner and La Duke (1978) suggest that L. kamolensis is most closely related to L. subcordata (of N. Kona, Hawaii) and L. bryanii (known only from Kahoolawe type material, probably extinct).

This survey noted this species in a small area above the main highway between Kepuni and Kamole gulches at 750-950 ft. This area is highly impacted by cattle and very little native vegetation remains. Lipochaeta kamolensis persists there in small depressions and along cattle trails.

This species is growing in cultivation at Maui Botanical Garden.

Voucher: ACM #557

Lipochaeta lavarum (Gaud.) A. DC. 1836
(E:Molokini, Mo, E/WMa, H)

Nehe

var. lavarum (E:as above)
var. ovata Sherff 1933 (E:EMa)

Sherff (1935b) recognized nine varieties of L. lavarum including var. ovata, endemic to the study area. Sherff cites a collection by Rock (1910-#8674) from Kahikinui as the type specimen, and another by Forbes (1920-#2015M) from near Puu Ouli as belonging to this variety. Sherff (1935b) states however: "Forbes #2020M from much the same vicinity in southeastern Maui (Kamana, south slope of Haleakala) has foliage not really separable from that of L. lavarum proper. Thus L. lavarum is seen to be present in the vicinity whence came my type....The ovate-leaved form however is known from nowhere else in the Hawaiian Islands and appears best considered as an endemic variety."

Gardner (1979) recognized none of Sherff's nine varieties of this species. Gardner states of the ecology of L. lavarum: "Usually in dry, exposed areas, often along margins of old aa and pahoehoe lava flows. Flowering throughout year."

Lipochaeta lavarum is still quite common in rocky areas where native vegetation persists on both leeward East and West Maui, from near sea level up to about 2500 ft on Haleakala. The var. ovata leaf type is found primarily in the upper part of the elevational range. When this species occurs near the coast or at low elevations, the leaf form is much narrower and characteristic of the species at other sites. After prolonged rainy periods the broad silvery leaves of the upland populations of L. lavarum can appear quite distinctive. Even in these upland populations though, some plants with narrower leaves can still be found. This survey has made a good series of vouchers showing the variation in this species.

Voucher: RAH/LLL #180; ACM #347, #348, #349, #361, #595, #596

Lipochaeta lobata (Gaud.) DC. 1836

Nehe

var. makenensis Deg. & Sherff 1960 (E:EMa)

Degener and Degener (1957 - Fl. Haw.) note of L. lobata: "This nehe, like most of its somewhat weak varieties, bursts into growth during the rainy season, becoming sere and dormant as the dry season advances....This shrub may well have been more common before cattle, weeds and homesites encroached upon its dry lowland terrain."

This variety is based on a 1959 Degener collection (#25133) from an arid lava flow at 40 ft elevation near Makena. The variety makenensis is considered a taxonomic synonym of L. rockii by Gardner (1979). Hobdy (pers. comm.) has collected a series of Lipochaeta (#2019, 2020, 2021) from a

site north of Makena at low elevation that may correspond with this taxon. This species was noted and collected by this survey at an elevation of 30ft on aa lava near apartment buildings in Makena.

Lipochaeta rockii Sherff 1933 (E:Mo,Ma)
var. dissecta Sherff 1933 (E:WMa/EMa)

Nehe

Gardner's (1979) treatment merges ten previously recognized taxa, making them synonyms of L. rockii, and recognizes no varietal taxa. He gives the range of L. rockii as western Molokai, south and central Maui, and Kahoolawe at 30-500m. Gardner states: "With respect to leaf morphology, L. rockii is the most variable species in the genus. Most populations have plants that vary from nearly entire to deeply dissected five-lobed leaves....Generally one finds that the plants in a particular population are either petiolate or they are sessile, but not plants of both types. This geographical separation of morphological types suggests that with time, perhaps additional differences will be accumulated such that distinct varieties might be recognized.."

Lipochaeta rockii var. dissecta of Sherff (1935b) is marked by narrowly dissected leaves and was thought restricted to West Maui (St. John 1973), but also occurs on East Maui. It is found on Haleakala primarily on the west and southwest slopes at 700-1300 ft. It is also common locally on aa lava fields SW of Puu o Kali at ca. 700-1100 ft and less common in relict populations bordering cane fields below Pukalani at ca. 600-750 ft growing with Dodonaea and Abutilon menziesii (Hobdy, J. Tavares, pers. comm.).

Lipochaeta mauiensis St. John 1984

Nehe

This species, apparently endemic to the study area, was collected by Gardner (#378) in 1975 "5.5 mi. SE of Ulupalakua Ranch office, on exposed aa.."

This species was not noted by our survey.

Notes on the genus Tetramolopium:

Tetramolopium is endemic to the Hawaiian Islands and New Guinea, restricted in this latter locality to a single species. Lowrey (in litt.) in his upcoming review of this genus recognizes eleven Hawaiian species in three sections with a number of subspecies. Two of the three species of the study area belong to the section Sandwicense. Lowrey (in litt.) states: "Unfortunately, two of the four species of section Sandwicense have been extirpated: T. conyzoides and

T. arenarium. The two remaining species have extinct infraspecific taxa and the remaining populations of the extant taxa have very restricted distributions. Most of the taxa in this section occurred in the lower dry forest or dry forest scrub communities in the Hawaiian Islands. The great amount of extinction in sect. Sandwicense is due to the overgrazing and clearing of these plant communities....Thus many features of the distribution and ecology of this group of species will never be known."

Tetramolopium arenarium (Gray) Hbd. 1888 (E:Ma,H)
ssp. arenarium (E:Ma,H)
ssp. ined. Lowrey (E:Ma)

Lowrey (in litt.) notes of this extinct species: "These taxa were upright shrubs probably inhabiting dry forest communities on both islands....A mixed collection of both subspecies was made at Kula by Hillebrand. It is not known whether the taxa were actually sympatric there....Remnants of dry forest vegetation can still be found at these localities today." Sherff (1935b) noted that on the collection "Hillebrand 22" (Gray, Kew) from Kula, an elevation of 2500 ft is given.

No collections of this species have been made in the past century.

Tetramolopium conyzoides (Gray) Hbd. 1888 (E:L,Mo,Ma,H)

Lowrey (in litt.) notes the superficial similarity of this species to Conyza and states of distribution: "The species has been collected on Maui, Molokai and Lanai. It is probably extinct....The species was probably a component of the dry forest community."

According to Sherff (1935b), T. conyzoides has been collected on East Maui at Kula by Hillebrand and Lydgate ca. 1860, and by Lydgate in 1884. It has not been collected on East Maui since.

Tetramolopium humile (Gray) Hbd. 1888 (E:EMa,H)
ssp. ined. Lowrey (E:EMa)

According to T. Lowrey (in litt.), this species is the sole representative of the section Alpinum. Lowrey (in litt.) notes: "The altitudinal range of this species is from 1900 meters to about 3300 meters. At the upper end of its range, T. humile occurs on xeric barren cinder slopes or in rock crevices. It is found in more mesic habitats having denser but still open vegetation at the lower end of its range. Here the species occurs in open patches of the community, often in rock crevices."

It survives on the south slope in otherwise barren sites above 8500 ft, locally common in restricted areas.

BEGONIACEAE

Hillebrandia sandwicensis Oliver 1866 (E:K,O,Mo,E/WMa)
Aka'aka'awa, Pua-maka-nui

This species is the only member of an endemic Hawaiian genus. It occurs in shady and moist locations, typically along stream banks at middle to high elevations. Rock (1913) states: "A handsome plant growing along streambeds and waterfalls.. It is common on Kauai and Molokai and can still be found on Oahu. On Maui, the writer found it at about 6000 feet elevation in the Crater of Haleakala in the Koolau Gap, where it grew over six feet high.."

Hillebrandia was collected on the south slope by Forbes (#1838M) at Waihualele gulch, above Puu Pane in 1920. Forbes describes the forest type as "remnant of a dense forest overgrown with Eupatorium...Acacia koa, Metrosideros polymorpha, a few Cheirodendron..." Forbes (1920) also noted of the species in the Nuu/Waiopai area, "Hillebrandia common in the gulches." Olson collected Hillebrandia in eastern Kaupo Gap of Haleakala National Park at 3900 ft in 1937. It has since been extirpated from this area. Higashino and Mizuno (1976) reported it at Healani and Nuanualoa streams on the Manawainui planeze. We found Hillebrandia to be rare but present at about a dozen sites between Manawainui and Wailaulau drainages at 4000-5500 ft.

Voucher: ACM #311

BORAGINACEAE

Heliotropium curassavicum L. 1753 (I:H.I., America) Kipukai

This species, characteristic of Hawaiian strand vegetation, was found throughout the study area along the coast where surveyed. Though nowhere common, it is widely distributed.

Voucher: ACM #592

BRASSICACEAE (CRUCIFERAE)

Cardamine konaensis St. John 1945 (E:Ma,H)

Although some question exists regarding the status of C. konaensis as an endemic species, St. John (1945, 1973) regards it as endemic to Maui and Hawaii. On West Maui, it is

known from a number of valley drainages including Wainee, Kauaula, and Iao valleys; on East Maui, this species can be found on the north and northeast slopes at 5000-6000ft.

Mitchell (1945) notes C. konaensis in Haleakala National Park at "Waikekeehia, Kaupo, 1st and 2nd cove, Kuiki pass and Kuiki, trail from Paliku up gully to Kuiki," and "Koolau Gap, Ainahou 5200-6200 feet." We have been unable to find it in any of the locations listed by Mitchell. However, C. konaensis was seen once (but not collected, ACM, 7/82) on this survey, at the base of a small waterfall at 4450 ft in decadent koa forest, just west of Wailaulau gulch. Associated species were Clermontia kakeana, Cyrtandra sp., Perrottetia, Pilea peploides, and numerous ferns.

CAPPARIDACEAE

Capparis sandwichiana DC. 1820 Mai'apilo, puapilo
var. zoharyi Deg.&Deg. 1961 (E:"Midway to Hawaii")

This shrub, usually found in the coastal strand, occasionally grows as high as 2000 ft above sea level on lava flows in the study area. It is currently uncommon except on the coast between La Perouse and Kanaio beach, and on certain lava flows near Puu o Kali on the western slope.

Neal (1965) states that the Hawaiians used Capparis as a treatment for broken bones. The Hawaiian name Mai'a-pilo means "foul-smelling banana," in reference to the odoriferous fruit.

Obata (1973a) reports excellent germination.

Voucher: ACM #582, #601

CARYOPHYLLACEAE

Schiedea haleakalensis Deg. & Sherff in Sherff 1942 (E:EMA)

Degener, who (with Sherff) described this species notes (Fl. Haw.-1956): "Growing beyond the reach of wild goats on the arid cliffs that extend from Mt. Haleakala southeast along the western side of Kaupo Gap, Maui. It was first discovered by Degener, Ordonez & Salucop in 1939 and named, not for the great rift valley known as Haleakala Crater, but for the mountain on which it grows."

Though quite rare, this species was noted at ca. 6000-7000 ft elevation on western cliffs of Kaupo Gap within the study area and Haleakala National Park. Schiedea haleakalensis grows at this site with Artemisia mauiensis, Bidens micrantha, Dubautia cf. menziesii and Viola trachelifolia. As Degener stated, S. haleakalensis has been eliminated by feral goats

from all but the most inaccessible locations. Direct browsing and erosional damage by goats are the primary threats to the long term survival of this species.

Voucher: ACM #575, #576

Schiedea implexa (Hbd.) Sherff 1943 (E:EMA)

This glabrous undershrub is noted by Hillebrand (1888) as being found on both East and West Maui. Sherff (1945) in his review of the genus, recognizes S. implexa as being endemic to East Maui.

Schiedea implexa sensu Sherff is known from two collections, one by Hillebrand ca. 1869 ("East Maui") and one by Rock in 1910. For Rock's collection of S. implexa (#8643), his number notebook states: "Schiedea sp.? In deep gorges, slopes of Haleakala near Kaupo; elevation 5000 ft. Growing along stream on rock walls. E. Maui. Nov. 1910." His notebook further notes Neraudia sp. (#8648), Dubautia plantaginea (#8652), Artemisia cf. australis (#8667) and Viola tracheliifolia (#8686) as growing in the same locality as Schiedea. Regarding the Neraudia collection, Rock states: "growing in the wet districts near Kaupo." However, according to Sherff (1945), Rock's specimens of S. implexa at Gray and New York herbaria are labeled "#8643 Auahi, Haleakala, Nov. 1910."

This species has not been collected since 1910 and was not seen during this survey. Schiedea implexa, a delicate undershrub, was probably quickly eliminated by herbivores.

CELASTRACEAE

Perrottetia sandwicensis Gray 1854 (E:H.I.)

Olomea, waimea (used on Maui only)

This small tree is locally rather common in both wet and dry forests of all islands, from 1000 to 6000 ft (Rock 1913). It thrives in open-canopy situations-erosion scars, stream gully sides, etc.

Perrottetia is currently locally common in watercourses within the koa-'ohi'a forest of Kahikinui at 4300-5600 ft and occurs in eastern Kaupo Gap (one mature specimen) at 4100 ft. Higashino and Mizuno (1976) report it from 4000 ft in Healani Gulch, east of Kaupo Gap.

Saplings, probably vegetatively produced, are crowded around the single specimen in Kaupo Gap. Young trees were seen in Kahikinui, although browsing was apparent. We have discovered only one site with seedlings (Wailaulau-ACM) on the

south slope. This species reproduces well in wetter forests of East Maui.

Sylva reports that it grows easily from cuttings.

Voucher: ACM #308

CHENOPODIACEAE

Chenopodium oahuense (Meyen) Aellen 1933 'Āheahea, 'Āweoweo
var. oahuense (E:H.I.)
cfr. var. discospermum Fosberg 1962 (E:EMa)

Selling (1947) remarks concerning C. oahuense: "It is a dry district species. On the coast as well as at low elevations in general, it is a much branched shrub about 1m high (sometimes subherbaceous). In high altitudes, it becomes a tree." Though not noted by Selling, the tendency toward increased stature at high elevations seems confined to the island of Hawaii and is not found on Maui. Selling (1947, 1948), in examining pollen in peats from Hawaiian bogs, noted the surprising abundance of Chenopodium pollen throughout the islands, but especially on Maui. Selling (1947) states: "The highest values are all from Maui... This is reflected in the averages; in Maui this is almost 15%..." A satisfactory explanation of this situation has never, to our knowledge, been produced.

This species was scattered but relatively common from just above sea level to ca. 2800 ft throughout the study area, including the Puu o Kali area on the western slope at 700-1000 ft. Hobdy (pers. comm.) notes this species as rare at 7000-8000 ft in the Kula Forest Reserve. Chenopodium oahuense cf. var. discospermum was found growing on sheer cliff walls within Haleakala National Park in western Kaupo Gap at 5600-6800 ft. Reproduction of this species through seedling establishment appeared excellent in many sites. No vegetative reproduction was noted.

Voucher: ACM/LLL #255; ACM #599; RAH/LLL #187, #208

CONVOLVULACEAE

Bonamia menziesii Gray 1862 (E:H.I.)

Degener (1932-Fl.Haw.) considers the Hawaiian representatives of Bonamia to constitute an endemic Hawaiian genus, Perispermum. St. John (1973) accepts the more conservative approach of Asa Gray.

This rare xerophytic woody climber was noted twice and collected once by Forbes (#2067M) at Kamana, near Auwahi in 1920. Forbes noted: "Climbing by several main stems to the top of a Maba [=Diospyros] tree about 20 ft high and then covering the top of the tree."

Eight individuals in six sites were recorded by this survey between the Puu o Kali flows on the west slope and the Lualailua district at elevations of 1100-2400 ft. These plants run prostrate along the ground or lean on low shrubs such as Lantana for support. One individual grows tangled in a low Diospyros bush, while another reaches 20 ft in height supported by a trunk of Pleomele aurea. There is a specimen of Bonamia menziesii at Maui Botanical Garden.

Voucher: ACM/LLL #259; ACM/LLL #261

Cuscuta sandwichiana Choisy 1841 (E:H.I.)
var. sandwichiana

Kauna'oa

Degener (1933-Fl. Haw.) states: "Growing on probably all the larger islands at lower elevations often along coastal dunes and in arid regions. It is commonly found on Convolvulaceae, Heliotropium, Scaevola and Pluchea... This plant is sometimes confused with Cassytha filiformis... The latter because of its greenish-yellow firm stems and its habit of growing mostly on trees and shrubs can be distinguished easily from the dodder even when both plants are devoid of flower and fruit."

This parasitic species is uncommon, and restricted to coastal sites within the study area.

Voucher: ACM #602

Ipomoea brasiliensis (L.) Sweet 1818 (I:Pantropic)

Pohuehue

Hillebrand (1888) notes: "On all sandy beaches...A common sea-coast plant in nearly all tropical countries." Degener (1932- Fl.Haw.) states: "Native to all the Islands. Typical of coastal dunes just beyond reach of waves.. During times of famine, the roots and stems were cooked and used as food although if eaten exclusively for any length of time, they cause dizziness. Stock are similarly affected."

The harsh, coastal lava cliffs of the southern flanks of Haleakala present poor habitat for this species. Ipomoea brasiliensis (formerly widely known as I. pes-caprae) prefers sandy areas on more protected coastlines. This species, though found from La Perouse Bay to the bay of Manawainui drainage, is sporadic in distribution and common in only a few places.

Voucher: ACM #600

Ipomoea congesta R. Br. 1810 (I:H.I., Aust., Pac. Is., Mex., W.I.)
Koali'awania, koali'awa

Degener (1959-Fl.Haw.) states: "Common on all the larger islands scrambling over rocks and climbing over bushes and rarely trees at lower and medium elevations. Along the hot arid coast it is densely hairy while toward the cooler, moister hills it becomes progressively more glabrate." Hillebrand (1888) states: "The root is a powerful cathartic, much used in native medicine, but not without danger, as it irritates the kidneys; is also employed externally in bruises and fractures of bones."

This vine is a characteristic part of the vegetation of the lower part of Haleakala's south slope, from near sea level to 2800 ft.

Voucher: RAH/LLL #171

Ipomoea tuboides Deg. & van Ooststr. 1940 (E:H.I.)

This vine species occurs in hot, dry coastal and lower forest areas throughout the islands. It thrives on the south slope of East Maui up to 2500 ft during the wet season, forming thick mats that envelop trees with branches reaching near the ground. Leaves are variable in shape, from suborbicular with cordate bases to irregularly palmately lobed, often with intermediates on the same plant. The tendency for divided leaves seems strongest in the hottest, driest areas. In sites such as Puu o Kali, however, individuals assigned to this species seemed to be of two, general "types", those with irregular but generally suborbicular leaves and those with extremely divided leaves. The basis of such variation is unknown.

Ipomoea tuboides was collected from the south slope by Rock, Forbes, and others. Our survey found it particularly common on 'a'a in Auwahi and Kanaio at 1700-2000 ft and on the western slope at Puu o Kali on 'a'a lava flows at 700-1500 ft.

Voucher: ACM/LLL #262

Jacquemontia sandwicensis Gray 1862 Pa'u-o-Hi'iaka
var. sandwicensis (E:H.I.)
var. tomentosa (Choisy) Hbd. (Mo, Kah, H, EMa?)

Jacquemontia sandwicensis was called Pa'u-o-H'iika, literally "skirt of Hi'iaka (sister of Pele)", by the Hawaiians. It is today usually thought of as a coastal strand plant, but was apparently widespread in the lowlands at one time (Hillebrand 1888, Degener 1956, St. John 1976b). St. John (1976b) notes: "The Jacquemontia is one of the conspicuous maritime littoral plants on all the main Hawaiian

Islands....Unlike most of the other Hawaiian littoral plants, it is not a strict halophyte. On Niihau, it is common on the shores and is found throughout.. to the top of the mountain at 1281 ft altitude.. On Lanai it grows inland to 1500 ft altitude. On Hawaii near Kawaihae to 1500 ft altitude."

On the south side of Haleakala, Jacquemontia is common only in rocky or compacted soil sites below 100 ft. Some of these populations such as those at the bottom of Manawainui drainage and at the coast in the Kaupo district seem to represent the var. tomentosa, a variety not listed by St. John (1973) for Maui. The species has been recorded (RAH/LLL #156) as high as 1980 ft in the Kanaio District.

Robertson (1974) considers J. sandwicensis a subspecies of J. ovalifolia which in a broad sense he considers distributed in Africa, Madagascar, Mexico, the West Indies, and the Hawaiian Islands. St. John (1976b) disagrees with this treatment and reinstates the Hawaiian populations as a distinct species, including a key for three Hawaiian varieties, one of these (var. laevis) new.

Voucher: RAH/LLL #156; ACM #589

CUCURBITACEAE

Notes on native Hawaiian Cucurbitaceae:

St. John (1974, 1978c, 1978d), in reviewing native cucurbits (formerly all considered species of Sicyos), has divided the Hawaiian representatives into five genera. These genera are Sicyos, Cladocarpa, Sarx, Sicyocarya and Skottsbergiliana, the latter four newly described by St. John and considered endemic. As these works occurred after publication of St. John's (1973) checklist, the names listed below differ from that treatment.

Cladocarpa hispida (Hbd.) St. John 1978 (E:EMa)

Hillebrand (1888) noted of this species (as Sicyos hispidus): "E.Maui, Kula!" St. John (1978c) transferred it into a new endemic genus, Cladocarpa, distinguished by thick, woody exocarp and the branch-like lobes which nearly conceal the fruit body.

This species was not encountered by this survey. Its status is uncertain.

Sicyocarya sp. ined. St. John (E:E/WMa)

This endemic genus is distinguished from other Hawaiian genera of the family by its hard, woody nuts (St. John

1978c,d). This species was observed only once by this survey, at Manawainui gulch at 5200 ft in the Kahikinui Forest Reserve, where a tall climbing individual grew to over 30 ft in height in a tree of Urera glabra (Urticaceae). When this site was visited a year later, only dried up stems remained, indicating a short life cycle. This species can also be found at Ukulele on northwestern East Maui and in gulches of West Maui.

This species appears to be quite rare and vulnerable. Though encountered by this survey, no voucher material was collected.

Sicyos hillebrandii St. John 1934 (E:EMa)

Hillebrand (1888) noted of this species as (Sicyos laciniatus): "E.Maui, Kula!" Because the combination S. laciniatus had already been used by Linnaeus, St. John renamed this species S. hillebrandii.

This species was not encountered by this survey. Its status is uncertain.

Sicyos microcarpus Mann 1867 (E:K,O)

Though listed in St. John's (1973) checklist as endemic to the islands of Kauai and Oahu, this species apparently also occurs on Maui, based on materials collected by Hobdy from the dry lowlands of Wailea-Kihei to Makena. Hobdy has also noted this species from central and southern West Maui.

Apparently, this same species was collected by St. John and Mitchell (#21,198 and #21,199) in 1945 at 6200 ft in eastern Kaupo Gap. Stemmermann et al. (1981) reported a Sicyos (sterile material only) as "Occasional in Kaupo gap." This citation may represent S. microcarpus.

This species has been noted by Hobdy in the Puu o Kali area, but no collection was made by this survey.

Sicyos sp. ined. #1 St. John (E:EMa/?)

This undescribed species was noted by this survey several times on the 'a'a lava flows and Lantana filled gulches of the Auwahi and Kanaio districts at 2400-3200 ft.

Sicyos sp. ined. #2 St. John (E:EMa/?)

This undescribed species seems most common along the western and southwestern arid lowlands of East Maui. At the

Puu o Kali lava flows at 700-1400 ft, it is extremely common in certain wet years. At the advent of the winter rainy season, thousands of uniform sized seedlings of this annual species can be seen growing with roughly equal numbers of seedlings of the introduced annual, Bidens pilosa. As the rainy season advances, Sicyos vines grow into the canopies of trees, often interconnecting them, and sprawl across areas of bare lava. At the end of the winter rains (usually May-June), these vines have matured and are setting seed and dying back. This seasonal growing period is not strictly predictable however. Hobdy has noted that sometimes an area that has a dense growth of Sicyos may produce little or none of that species the following year, even when rainfall appears adequate. Seed dormancy is probably an important mechanism allowing these annual species to survive seasons of unreliable winter soil moisture.

EBENACEAE SJ273

Diospyros ferrea (Willd.) Bakh. 1933 Lama
ssp. sandwicense (A. DC.) Fosberg 1939
var. sandwicense (A. DC.) Bakh. 1937 (E:H.I.)
var. degeneri Fosberg 1939 (E:L,EMA-2forms)

Rock (1913) stated of D. ferrea: "The tree is common on all the islands of the group, but especially so in the dry districts, where it forms almost pure stands. The berries.. are quite palatable and are eaten by the natives and birds." Lamb (1981) wrote: "Hawaiians used the wood for timbers for houses of the gods as well as for very durable tide gates for fish ponds." Most specimens from Haleakala's south slope were identified in Fosberg's (1939) review as the var. degeneri, with oval leaves and "tardily glabrous foliage."

Lama is a very common tree at 1000-4000 ft on the south slope, from Kanaio to Alena districts, with scattered individuals further east, perhaps as far as Kaupo Gap. In the lower part of this zone in Auwahi/Kanaio, it is perhaps the most common tree.

This species had abundant orange-red fruits in November-December 1981. Numerous seedlings have been observed under trees of Diospyros. In some cases, they survived the dry season, but only a few saplings, partially protected by a Lantana shrub, were noted. Several botanical gardens state that this species is easy to establish from seed.

Voucher: RAH/LLL #166; J.Lau #1005

EPACRIDACEAE

Styphelia douglasii (Gray) F. Muell. ex Skotts. 1925
(E:K,Mo,Ma,H)

See Styphelia tameiameiae.

Styphelia tameiameiae (Cham.) F. Muell. 1867
(including Styphelia douglasii Gray) (I:H.I.,Marquesa Is.)
Pukiaawe, kawa'u (on Maui & Lanai)

Common throughout the Crater District of Haleakala National Park and much of the south slope above 4000 ft, Styphelia is one of the more resistant native species to browsing and trampling. Nevertheless, goat browsing has been sufficiently intense to nearly eliminate this shrub from much of western Kaupo Gap, Nuu, Nakula, and the kikuyu zone of Auwahi east to Puu Pane. Styphelia occurs as low as 2000 ft on the south slope on the three rougher aa flows-Kaunauhane, Kanaio/Auwahi and Lualailua.

As stated by Sleumer (1963) in his review of the genus, S. douglasii is an upper elevation species found on Maui and Hawaii above 6300 ft and in montane bogs of Molokai and Kauai. This survey observed no significant consistent morphological discontinuity between upper and lower elevation populations of Styphelia on southern East Maui. Therefore, all Styphelia populations encountered are referred to as S. tameiameiae. The distinctive large-leaved variety, S. tameiameiae var. brownii, was not encountered in the study area.

Observations on a small fenced enclosure erected by the NPS in western Kaupo Gap in 1978 show that recovery of Styphelia from browsing damage occurs, but is very slow. Seed sources have been locally eliminated or severely reduced. Seed dispersal may not be an insurmountable problem, since observations indicate that introduced game birds disperse Styphelia seed in feces (C. F. Crivellone pers. comm.). Nevertheless seedling establishment is very rare below 5000 ft, apparently because of displacement by various introduced grasses. Styphelia also reproduces by vegetative reproduction.

Obata (1973b) noted very poor seed germination.

Voucher: RAH/LLL #192

ERICACEAE

Vaccinium berberifolium (Gray) Skotts. 1927 (E:Ma,H) 'Ōhelo

This species occurs on East Maui above 6000 ft in moist, fog-brushed sites. Where it overlaps with V. reticulatum, a species characteristic of higher, drier areas, intergradation

occurs (e.g., Halemau'u switchbacks area of Haleakala N.P.). This survey noted V. berberifolium in our study area only in extreme upper Kaupo Gap, at 6000 ft, below Paliku (Haleakala N.P.). It may occur elsewhere on the south slope in the 5600-8000 ft zone.

Voucher: ACM/LLL #411

Vaccinium reticulatum Sm. 1819 (E:EMa,H)

'Ōhelo

Vaccinium reticulatum is common in rocky areas at 6700-9700 ft on East Maui, including the south slope. It is not a species preferred by goats, but has been eliminated in areas of highest goat concentrations. It is reproducing by vegetative root suckers in many parts of the study area.

EUPHORBIACEAE

Antidesma pulvinatum Hbd. 1888 (E:K,O,Mo,E/WMa,L,H)

Hame, mehame, ha'a

Rock (1913) writes: "This species... is confined to the dry districts, especially to the aa (rough) lava fields.." Rock in 1910 and Forbes in 1920 (#1748M, #1850M, #1963M) collected A. pulvinatum at Auwahi/Kanaio, the latter noting it as "rather common."

Our survey found A. pulvinatum rare but widely distributed on the south slope of Haleakala, occurring from Puu Mahoe, east to Mahamenui district. It is fairly common on the Puu Mahoe flow at 1900-2600 ft and the flow east and mauka of the Lualailua Hills at 2000-2400 ft. Most trees seen are in decline apparently due to old age, with substantial reduction in foliage due to the feeding of Chinese rose beetles, Adoretus sinicus. No sign of seedling establishment or vegetative reproduction was seen.

This tree species is dioecious, producing male and female individuals. Flowers produced abundantly, and the species is apparently wind pollinated.

Obata (1973a) notes that cultivated plants suffered heavily from rose beetle predation. Obata (1974) presents flowering and fruiting observations of the species in cultivation.

Voucher: ACM #551, #552

Claoxylon sandwicense Muell.-Arg. 1865
var. sandwicense (E:EMa)

Po'ola

Hillebrand (1888) stated concerning the species: "On all islands from Hawaii to Oahu! ..rather common in parts of Maui! and Lanai!"

Rock collected this species at Auwahi (#8675) in 1910, noting it as "common." Rock (1913) states that C. sandwicense at Auwahi "grows to a small tree at an elevation of 2000 to 2500 ft, in company with Alectryon, Xanthoxylon, Xylosma, Pelea, Tetraplasandra, etc." Forbes collected Claoxylon in the same area (#1971M) in 1920, noting first: "..frequent, some very large, 15 feet" and later: "Claoxylon, common in places."

Our survey found only 25-30 individuals of this species in Auwahi at 3200-4000 ft. All were dense, crowded shrubs, with numerous shoots, 2-3m tall. Though these plants appear vigorous, all observed were heavily browsed by cattle. No reproduction was noted, although flowering and fruiting does occur. Wind pollination appears likely.

We could locate no specimens of this variety in cultivation. Cultivated specimens of other varieties of Claoxylon sandwicense are at Wahiawa Botanical Garden and Waimea Arboretum on Oahu and Maui Botanical Garden. These are apparently from seedlings transplanted from the field.

Voucher: RAH #137

Drypetes phyllanthoides (Rock) Sherff 1939 (E:K,O,Mo,E/WMa,H)
Mēhamehame

This is, and apparently has long been, one of the rarest trees of the south slope. Rock (1913), who called it Neowawraea phyllanthoides, did not record it for Maui. Forbes collected it (#2020M) at Auwahi in 1920.

Only two living individuals of Drypetes (a third died recently) are known from the study area, all at 2800 ft in eastern Auwahi on a small finger of relatively open aa flow. In 1981 one of the two living trees was badly infested with scale insects. Since Drypetes closely resembles the more common Antidesma pulvinatum and therefore may be easily overlooked, there is a possibility that unrecorded individuals survive in the dense Lantana scrub.

The black coffee twig borer (Xylosandrus compactus), an introduced insect first reported on Maui in 1931, attacks the young shoots of many native and exotic trees and shrubs, substantially reducing vigor (Hara and Beardsley 1979, Samuelson 1981). Gagne (1976) noted this insect species on Drypetes in the Waianae Mountains of Oahu, where it was

"heavily attacking the sucker like twigs." In many areas of the Hawaiian Islands, X. compactus is considered a major factor limiting the survival of natural and cultivated populations of Drypetes. Drypetes is also attacked by the Chinese rose beetle (Adoretus sinicus).

Propagation by cuttings has been attempted by various workers with little success. Wooliams (pers. comm.) found that seed from South Kona trees germinated well after soaking 6 hours in gibberelic acid, but all seedlings damped off.

Euphorbia celastroides Boiss. in A.D.C. 1862 'Akoko, koko
var. amplectens Sherff 1936 (E:H.I.)
var. mauiensis Sherff 1936 (E:L,Ma)

Hillebrand (1888) treated all tree Euphorbiae in the islands as one species, E. lorifolia, noting: "A tree at elevations of 2000-4000 ft... The native name 'Koko' or 'Akoko' (blood) which is given to all Euphorbia on account of their milksap, applies principally to the present species." Rock (1913) stated: "It (E. lorifolia) reaches a height of 20-25 ft... The species occurs in the gulches back of Makawao, Maui, and also on the slopes of Mauna Kea." Forbes collected a tree Euphorbia in Kaupo Gap in 1919 (#1104), noting: "Small trees 8-12 feet tall, capsules sessile, stiff, erect", and then several times in the Auwahi-Kanaio area (#1811M, #1812M, #2044M, #2048M, #2091M) in 1920. In Auwahi, Forbes noted: "Euphorbia in rocky places, but rare."

The fairly numerous disjunct populations of Euphorbia celastroides within the study area which we tentatively ascribe to var. mauiensis are widely scattered, both geographically and ecologically, from just above sea level to 6400 ft. These populations are morphologically variable in leaf size, plant height, and habit.

There are two morphological forms of coastal E. celastroides, the more common tall erect pyramid-shaped shrubs (e.g., Kanaio beach area) and the prostrate form with shorter, broader leaves with light-colored undersides encountered by this survey only in the coastal area around the Manawainui drainage. Above the coastal zone of the south slope, there are no populations of this species until 1600 ft elevation in the Auwahi and Kanaio districts where it is rare and restricted to collapsed lava tubes. In the Auwahi district, this species becomes more common with increasing elevation to its upper limit at 4800 ft. In the upper part of its Auwahi range at 4000-4500 ft, it forms pure stands of trees up to 9m in height, with a unique drooping growth habit, appearing somewhat like certain Acacia spp. of savannah Africa from a distance. It occurs above Lualailua Hills and as occasional individuals eastward at 2200-2600 ft. Perhaps several dozen trees occur in eastern Kaupo Gap of Haleakala National Park.

On the western slope of Haleakala at 800-1500 ft in the Puu o Kali lava fields, this species occurs as a small tree up to 3m in rough aa lava.

Lennox (pers. comm.) and this survey observed large numbers of small Euphorbia seedlings in the upper Auwahi and Kanaio districts after winter rains. Most of these do not survive beyond the cotyledon stage, however. Older, apparently established seedlings and saplings do exist in low numbers. Good seedling and sapling development of this species does appear to occur at the Puu o Kali lava flows, and in west Kaupo, however. In rocky areas of upper Auwahi, vegetative reproduction from root suckers was observed. This species may be only rarely, if ever, browsed by cattle and goats. A second variety of this species, var. amplectens, has been cited by Stemmermann et al. (1981) from the study area as "common in W. Kaupo Gap with scattered specimens elsewhere in the Gap." This variety is distinguished primarily by its prostrate habit. Whether this represents a genetic or an environmental grouping (or both, as is probably the case) is unknown. In the western part of Kaupo Gap, we observed a substantial amount of intergradation between prostrate and shrub/tree extremes. Here, E. celastroides tends to be prostrate along cliff walls and at higher elevations (up to 6400 ft). Plants growing in deeper soils tend to be taller.

Vouchers: RAH #104; RAH #140; ACM/LLL #419, #422, #430; ACM #571, #597

Euphorbia multiformis H. & A. 1832 'Akoko, koko
var. haleakalana Sherff 1936 (E:EMa)

This variety was described from a single collection by Forbes in 1920 (#2010M) from the south slope of Haleakala, apparently from lower Auwahi (Sherff 1938). Forbes remarked in his notebook: "Low shrubs 2-3 ft, flat topped... Lvs rather thin."

This taxon was not seen by our survey. Its status is uncertain.

FABACEAE

Acacia koa Gray 1854 (E:H.I.) Koa

Lydgate (1883) stated: "Probably the most valuable as well as one of the most abundant forest trees is the koa (Acacia koa) which is found to a greater or less extent throughout the islands, but reaches perfection on the mountain slopes of Hawaii and East Maui....In early times, koa sawing was a regular and flourishing business, largely because of the

difficulty of obtaining any other kind of lumber and many of the older houses and churches - with what seems to us now almost reckless extravagance - were built of the finest furniture koa." Because of its dominance or co-dominance in large areas of native Hawaiian forest and because of its commercial importance, a substantial amount of ecological literature exists on koa (e.g., Judd 1920; Whitesell 1964; Lamoureux 1971, Scowcroft and Wood 1976, Mueller-Dombois *et al.* 1981). [For simplicity, varietal names (St. John 1979c) are not used here. Only those lower-elevation, narrow-phyllode populations resembling Acacia koaia have been set apart from the main group of A. koa.]

Holmes (1981) notes regarding the use of Acacia koa for canoe making: "The greatest incidence of straight and tall koa trees was found on the slopes of Haleakala on Maui and the high mountains of Hawaii.. Of old, certain areas such as the mountains above Hilo and Kona and the slopes of Haleakala produced such an abundance of high quality canoe logs that a very disproportionate amount of the total number of canoes throughout the islands came from these sites."

Within the study area, Acacia koa occurs between elevations of 3200 and 6400 ft from Lualailua eastward beyond the margin of the study area, with a gap in eastern Nuu and western Kaupo Gap. In small gulches between 3500 and 5400 ft from Lualailua east to Puu Pane, A. koa is scattered but not uncommon. From Puu Pane east to Pukai Gulch in Nakula, koa is frequently the dominant tree in relatively intact forest with Metrosideros polymorpha in large gulches at 4400-6200 ft. No native trees are numerous below about 4400 ft in Manawainui, Nakula, and Nuu districts, but scattered koa occurs in gulches down to about 3200 ft. In eastern Kaupo Gap, A. koa is once again a common species, especially in the gulch along the eastern wall of the gap. This forest extends eastward to the Manawainui planeze where koa-dominated forest extends as far as Kipahulu Valley. The elevational range of koa in Kaupo Gap is 3800-5820 ft; on the planeze, it occurs at 3500-6800 ft (Higashino and Mizuno 1976).

While vigorous trees are common throughout the range described above, nearly all are older individuals. Seedlings, saplings, and young mature trees are either rare or absent through nearly all the south slope koa range. Abundant reproduction is known to us in three sites: 1) the Healani enclosure at an elevation of 4000 ft in Kipahulu Forest Reserve where a small area has been fenced to exclude goats and pigs since 1976 (Scowcroft and Hobdy 1986), 2) two small enclosures at ca. 4800-5100 ft on the east wall of Kaupo Gap, and 3) a small landslide area at 4100 ft on the east wall of Kaupo Gap just above the Haleakala National Park boundary which has been thickly colonized by koa since the slide occurred in 1978. The slide cleared the area of kikuyu grass long enough for koa reproduction to get established. Koa in general reproduces

well from seeds and root suckers, especially after disturbance. However, current pressure on the south slope from continual browsing and trampling appears too severe for perpetuation of koa forests.

Koa has been grown in nurseries by Territorial and State foresters with good results, although seedlings are sensitive to root disturbance during transplanting. Obata (1973a) has experienced poor germination rates, but rapid growth once seedlings are established. Many botanical gardens and numerous individuals have grown koa from seed or from transplanted root suckers.

Voucher: ACM/LLL #405; J. Lau #1001, #1008, #1009

Acacia koaia Hbd. 1888 (E:Mo,E/WMa,H)

Koai'e, koai'a

Lydgate (1883) stated: "The natives distinguished a second species which they call koaea, which is found ...in dry and stony districts...a scrawny, gnarled tree of small size, all knots and twists and kinks, but none the less valuable...for they were accustomed...to tie a knot in a young shoot, which grew and hardened in that form until it became fit for manufacture of large and strong fishhooks. The wood is hard and durable..." Rock (1913) noted that "the koaia inhabits the very dry districts on the leeward sides...On Maui, it can be found on the Kula slopes of Haleakala at an elevation of 2000 ft or more, together with Halapepe." According to Fosberg and Herbst (1975) and Kimura and Nagata (1980), Acacia koaia has become extremely scarce throughout its range.

St. John (1979c) cites the following collections of Acacia koaia from East Maui: a 1920 Forbes collection from "Kealia forest" (south slope); a 1948 Degener collection from Kamole (south slope); and a 1952 Degener collection from Olinda.

Our survey encountered what is probably Acacia koaia at five sites (Kepuni Gulch, Mahemenui, at 1800 ft; Lualailua at 1900 ft and 2500 ft; along the Auwahi-Kanaio boundary at 2450 ft; in Kanaio at 2200 ft; and at Puu o Kali at ca. 800 ft). However, we have encountered fruiting material essential for identification of this species only at Puu o Kali. Therefore, some degree of uncertainty exists for the remaining four populations. Rock (1913) stated that "flowers and fruits usually can be observed on the same tree during July and August." The total known population (excluding Puu o Kali) is several hundred trees, all of which are old and many of which are senescent, with partial crown death. At Puu o Kali, about 100 individuals of Acacia koaia have thus far been recorded. Though naturally occurring seedlings of this species have not been seen in the field, vegetative reproduction by "root suckers" occurs at several sites, especially Puu o Kali.

At the Puu o Kali site, some of the limited Acacia koaia seed produced were destroyed by insect larvae. One of these raised to maturity was identified by S. Montgomery as Cryptophlebia illepada (Family Tortricidae), an introduced moth that feeds on the seeds of a number of native and exotic species (Zimmerman 1978).

Hobby describes propagation of A. koaia as being similar to koa propagation. Lennox planted five small trees raised from seed in the Nature Conservancy enclosure at Auwahi, which have survived in spite of dense kikuyu grass and cattle. Variable germination success has been reported, even after scarification and heat treatment. Germination can occur as early as two weeks after planting (Bornhorst pers. comm.).

Voucher: ACM #352, #545; ACM/LLL #253, #260

Notes on native Hawaiian Canavalia:

Hillebrand (1888) considered this genus to have a single Hawaiian species with two varieties. St. John (1970) revised the genus in Hawaii recognizing 18 endemic species, including many new ones. St. John (1970) notes of general ecology of the group: "The native Hawaiian species are all semixerophytic, occurring in the lower, drier forests, or in the even drier scrub lands at lower elevations."

This survey has noted a number of populations of this genus from ca. 50 to 2800 ft elevation. Unfortunately, many of these individuals were sterile and thus need to be revisited to collect fertile material. Two species, below, were noted by St. John (1970) for the study area.

Canavalia forbesii St. John 1970 (E:EMA)

'Awikiwiki

Canavalia forbesii is known only from the type collection by Forbes (#1884, 3/7/20) from Manawainui gulch on the south slope. Hobby and this survey have noted a sterile individual in a relict native ecosystem growing on a steep slope with Melinis minutiflora at 2750 ft on the central gulch of the Wailaulau/Pahihi planeze. Because of the close proximity of this site to the type locality of C. forbesii, fertile material of this or other surviving individuals should be collected for comparison. The relatively high elevation of this site in comparison to other collections of Canavalia in the study area also warrants attention. Rene Sylva (pers. comm.) has noted a native Canavalia at 2800 ft in the Kanaio district, possibly of this species. Sylva has collected seeds from this individual which he is growing at the Maui Botanical Garden in Wailuku.

This taxon was not positively verified by this survey. If extant, it is certainly threatened by the nearly complete conversion of former habitat into grazing lands.

Canavalia haleakalensis St. John 1970 (E:EMa)

'Awikiwiki

Forbes, the first collector of this scrambling vine species endemic to the south slope of Haleakala, noted of his 1920 specimen from Kamana (#2122M): "Climbing over Dodonaea bushes. Thick, intertwining." Kimura and Nagata (1980) state that this species has since been collected less than six times. Recent collections (BISH) and observations (Hobdy, Sylva, and this survey) indicate that, although rare, this species can be found today from Puu o Kali aa flow on the western slope eastward to Nakaaha district from less than 50 ft above sea level to at least 1200 ft. Our survey encountered sterile Canavalia plants just east of Lualailua Hills at 1650 ft that judged on leaf size and shape are best interpreted as C. haleakalensis.

This species germinates (with scarification) and grows easily from seed (Hobdy, Sylva, Miranda, J. Tavares). Hobdy notes that native Canavalia are biennial in cultivation, dying after the second year.

Voucher: ACM #547

Cassia gaudichaudi H. & A. 1832 (I:H.I., Tahiti) Kolomona, kea

Once common at low elevations on all the islands (Hillebrand 1888; Mann 1868), C. gaudichaudi has been greatly depleted (Fosberg and Herbst 1975; Lamb 1981). The Bishop Museum has eight Maui collections of this species, four of which are from East Maui. Three of these are 1920 Forbes collections from the Auwahi area. Degener collected it at "Ulupalakua" in 1927.

This survey found C. gaudichaudi to be localized and somewhat rare, mainly on the Auwahi and Kanaio flows at 1750-2200 ft and the Puu o Kali aa flow at 900-1400 ft, as well as down to near sea level in the Kaunauhane and Kanaio districts. At a rocky site at 1900 ft in Kanaio, a small grove of vigorous mature shrubs were seen with seedlings up to 12cm in height. At another Kanaio site, an isolated juvenile Cassia gaudichaudi (45cm tall) was seen growing in full sun, in low Lantana cover.

In Tahiti, this species is rare and localized (F.R. Fosberg pers. comm.).

This species is fairly easy to grow from seed (ACM, J. Obata).

Voucher: ACM #360; RAH #134

Erythrina sandwicensis Deg. 1932 (E:H.I.)
var. sandwicensis
f. sandwicensis (E:H.I.)
f. lutea St. John 1959 (E:Mo,L,Ma)

Wiliwili

Hillebrand (1888) remarks for this tree (as Erythrina monosperma): "On dry rocky hills and plains of all islands..., much more common formerly than now." It has a very light wood, reportedly used by the Hawaiians for outriggers on their fishing canoes (Rock 1913). egener (1932-Fl.Haw.) states "Its branches, because of their readiness to root when inserted in the ground, were much used in erecting fences. Prized surf boards were made from this wood..." Hatheway (1952) found it to be one of the few native trees which are successional on sites disturbed by fire and/or grazing at Mokuleia, Oahu, although the exotic grass Melinis was locally inhibiting seedling production.

Erythrina was widespread on the south slope from near sea level to 2700 ft. It is quite common at 1000-2000 ft. Although, like most native trees, it does best on the roughest aa where cattle and exotic plants have relatively little impact, it is also common in dense Lantana thickets and in dry gulches. Erythrina sandwicensis is summer deciduous, with flushing of leaves in late fall and flowering when leafless during the summer. Most E. sandwicensis in the study area had dark orange flowers (f. sandwicensis), but some had pale yellow-green flowers (f. lutea). Single stands often contained trees of each flower color. Trees with intermediate or mixed flower color also occurred occasionally. Hard red seeds drop in late fall or early winter, normally just as winter rains are beginning. Rodents and insects do not appear to consume or damage the seeds.

Abundant robust seedlings were noted under mature trees (no apparent dispersal other than gravity) in March-May, 1982-84, almost always in competition with the introduced weed Bidens pilosa. By early September, most seedlings had disappeared. Nevertheless, the presence of Erythrina saplings of various size classes, with much browsing damage, indicates that occasional recruitment of seedlings occurs on the south slope.

Seedlings are easily grown in nurseries, with germination in 2-4 weeks (Bornhorst, K.Nagata; Obata, 1973a). Survival of transplanted seedlings is dependent on handling and site conditions. Specimen plants are growing at Maui Botanical Garden and at several of the Honolulu Botanical Gardens.

Voucher: RAH/LLL #206; ACM/LLL #253

Mezoneuron kavaiense (Mann) Hbd. 1888 (E:K,O,Ma,H)
Uhiuhi, kea (Maui only- Rock, 1913), k̄awa'u (Maui)

Mezoneuron kavaiense, found on Kauai, Oahu, Maui, and Hawaii, is one of the rarest dry forest trees in the Hawaiian Islands. Mann described this species as a Caesalpinia from a specimen brought to him by a "native" from Kauai. Mann (1868-71) noted: "A small tree with dark colored and almost indestructible wood...." Wawra (1872, cited in Selling 1948) reported this species at 2000 ft in Waihee, West Maui. Hillebrand (1888) cited its distribution as "Kauai! Oahu! Waianae mountains and Wailupe; E. Maui, Ulupalakua! and West Maui! on dry forehills." Rock (1911a), in a report on the North Kona area, wrote: "The Uhiuhi is quite plentiful, one tree being of especially large size. The wood is highly prized by the natives, it being the hardest and heaviest of all native woods. Its color is almost black.." Rock (1913) stated that "the tree.. inhabits the leeward sides of the islands, especially the aa lava fields. It is not uncommon on the island of Hawaii...The tree is known by the natives as Uhiuhi on Kauai and Hawaii, while on Maui, along Kaupo.. it is known as Kea." Rock also related how the wood was carved into lures that, "besmeared with a sweet, sticky substance," were used to catch fish. Other sources say the wood was used to make a lure for catching he'e, or octopus. Rock (1913) added, "The wood, being very heavy, will sink in the water even if one hundred years old, and is on that account selected by the natives for the above described purpose." Degener (1934-Fl.Haw.) noted: "Beautiful tree whose former range...had practically dwindled by 1930 to a small area on Hawaii." Nine years after calling this species "quite plentiful" in North Kona (Rock 1911a), Rock (1919a) wrote that he considered there to be hardly two dozen trees in existence. Kimura and Nagata (1980) report "less than 50 trees" on the Big Island between Huehue and Puu Waawaa. John Obata (pers. comm.) knows of about eight trees in two locations in the Waianae Range of Oahu. Lamb (1981) reported four trees in the Pacific Tropical Botanical Garden Kaupulehu tract on Hawaii. Lamb (1981) notes regarding Mezoneuron at Kaupulehu on Hawaii: "It appears to have been driven nearly to extinction by grazing and repeated fires that burn through the area..." Kimura and Nagata (1980) add: "Rats are known to eat the seeds while the pods are still on the trees."

Mezoneuron is fairly easy to grow by seed, though apparently susceptible to apical damage by the black coffee twig borer (Xylosandrus compactus) (J. Obata, pers. comm.). Seedlings have been seen in the Waianae, Oahu populations (3-4 seedlings about 15cm tall) by Obata, but he finds that long term survival is rare. Obata (1973a) reported that this species germinated and grew to pot stage easily.

This species was not seen during this survey and may be extinct on Maui. However, a retired cowboy named Ventura still living in Makawao recalls an old Hawaiian man taking him up a

valley apparently at or near Manawainui to a grove of "mamane trees with pink flowers." The Hawaiian man would take pieces of wood from these trees. When they returned to the coast, the Hawaiian man demonstrated the weight of the wood by dropping the pieces into a tidepool, where the wood sank to the bottom (John Tavares, pers. comm.) The general description and high specific gravity of the wood suggests these trees may have been Mezoneuron kawaiense.

Allen and Allen (1981) have reported nitrogen-fixation by Rhizobium bacteria in the following native legumes: Acacia koa, A. koaia, Erythrina sandwicensis, Sesbania tomentosa, Sophora chrysophylla, Strongylodon ruber, Vigna marina, V. owahuensis, and V. sandwicensis. Allen and Allen (1981) note however that though Mezoneuron kawaiense and another species of the genus from the Philippines were examined, there was no evidence of nodulation.

Sophora chrysophylla (Salisb.) Seem. 1865 (E:K,O, Mo,L,E/WMa,H)
Māmane

Sophora chrysophylla, a species of wide ecological amplitude and much morphological variability, has been subdivided by Chock (1956) into a complex array of infraspecific taxa, at least four of which are said to occur on the south slope of Haleakala as follows:

- S. chrysophylla subsp. glabrata var. mauiensis
 - f. mauiensis- the common taxon of the subalpine zone
 - f. lualailuaensis- described from type collection by Forbes near the Lualailua Hills
- S. chrysophylla subsp. unifoliata var. elliptica- described from type collection by Degener from 1463 ft in Auwahi var. kanaioensis- described from a 1920 Forbes collection and a 1952 Degener collection from Kanaio

Chock (1956) seems to make no mention of a taxon which fits the large tree Sophora found at middle to low elevations in and west of Auwahi.

A preferred browse species, Sophora is highlined by goats in most locations. In some high elevation locations where goat browsing is not heavy (e.g., Kula Forest Reserve), vegetative reproduction seems to make gradual progress. Small seedlings of Sophora can normally be found in protected locations under shrubs throughout most of the upper elevational range of the species, but they seldom attain heights of over 10cm before being browsed. No sign of successful reproduction, either vegetative or by seed, has been seen by us below 5000 ft.

Sophora chrysophylla is common over much of Haleakala Crater as well as over much of the subalpine shrubland of the

south and west slopes. In Kahikinui, it is a subcanopy tree within the koa-ohia forest. Large solitary trees are scattered in the 2800-4500 ft zone of Auwahi. Scattered trees are also common on parts of the Kanaio-Auwahi and Kaunauhane flows at 1500-2500 ft. In the eastern portion of the Kahikinui Forest Reserve, goats have reduced the population to a few battered survivors.

The occurrence of Sophora seedlings at high elevations in locations where no Sophora occurs today is apparently not uncommon on the south slope (observations by T. Rodrigues, D. Miranda, and R. Hobdy in addition to ours). The most likely explanation for this phenomenon is the persistence of slow-germinating seeds in the soil long after mature trees have been eliminated from an area (similar to the appearance of the legume, Canavalia kauensis, under protection from goats in Hawaii Volcanoes National Park, reported by St. John, 1972).

Voucher: ACM #344, #354, #355; RAH/LLL #182

Tephrosia purpurea (L.) Pers. 1807 (P.I:trop.s.Asia & Pacific)
'Ahuhu

Not a native species, T. purpurea was brought to the Hawaiian Islands by the colonizing Polynesians. Called "ahuhu" or "auhola" by the Hawaiians, this plant was gathered, beaten and tied in bundles, and immersed in tidepools to stupefy fish that could then be easily gathered. An excellent documentation of this technique was recorded in photographs by E. H. Bryan of the Bishop Museum with natives from the Kona coast of Hawaii.

Hillebrand (1888) noted: "Occurs on all islands, on rocky ground near the sea coast and further inland." Neal (1965) notes the active agent in the fish poison as tephrosin, harmful to fish but not to mammals. Degener (1932-Fl. Haw.) states that a variety of plants were used in this type of fish poisoning, but that Tephrosia was by far the most effective.

Tephrosia purpurea was noted by this survey at numerous, but highly scattered, rocky sites from Kanaio to Lualailua at 1000-2000 ft. This species was also seen occasionally in rocky areas just above the coast at 20-50 ft elevation from Cape Kinau to Kanaio beach. It may also occur between these two elevational ranges, but was not encountered. These populations may be regarded as relicts of plantings by ancient Hawaiians.

Voucher: ACM/LLL #264

Vigna marina (Burm.) Merr. 1917 (I:H.I.,Tropics)

Nanea, Pohilihili

Hillebrand (1888) notes of this species: "On all islands at short distances from the shore, but not common." This species was encountered within the study area only in the Kaupo district where it is occasional in the strand zone.

Vigna sandwicensis Gray 1854 (E:L,Ma,H)

var. sandwicensis

var. heterophylla Rock 1920

On East Maui, the species has been collected on the western slopes near Makawao by Hillebrand and by Rock. Hillebrand (1888) notes that the strict species occurs at higher elevations, i.e. above 3000ft, while the var. heterophylla with dimorphic leaves occurs lower at 1500-3000ft in the same localities. He notes this species and its variety on East Maui as occurring near Makawao and in the Kau district of Hawaii. Rock (1920) who botanized in the area some 40 years later did not observe the variety heterophylla possibly due to disturbance of its lower elevation habitat. He notes the species as "a prostrate twining herb, or suffrutescent herb, as the branches and stem become woody at the base."

This species was not seen by this survey. It has been extirpated on East Maui, or reduced to very low population numbers.

FLACOURTIACEAE

Xylosma hawaiiense Seem. 1865

Maua

var. hillebrandii (Wawra) Sleumer 1938 (E:Mo,Ma,L,H)

Rock (1913), who called this tree X. hillebrandii, reported it on Maui "above Makawao" and "on the lava fields of Auahi. at. 2600ft." Forbes (1920) collected it in the Lualailua area (#1951M) with the note: "only one seen." Forbes noted Xylosma as being "quite common" in Auwahi and noted the presence of "two species," probably referring to the variability of the leaf margins (entire vs. crenate or sinuate) and leaf size in the population.

Xylosma hawaiiense is presently restricted to the rough aa flows of Kaunauhane and Kanaio/Auwahi at 2200-3000 ft and to the kikuyu grass-dominated zone of Auwahi at 3000-4200 ft. On the rough, dry aa below 3000 ft, it is typically a small tree up to about 6m tall with leaves 6-10cm long and about 5-8 cm wide. In contrast, trees in the kikuyu grass-dominated zone of Auwahi are taller (9-15m) and have broader crowns with typically much larger leaves. It is often one of the largest trees in upper Auwahi stands.

Except for seedlings found in 1970 by Lennox (pers. comm.) only a few juvenile plants have been seen in Kanaio at ca. 2400 ft. Most individuals are fairly vigorous, and abundant fruit production has been observed at nearly all times of year (Rock 1913; Lennox pers. comm.). Rodents may eat Xylosma fruits.

Hobby failed to obtain germination from Auwahi seed. Wooliams was able to germinate seed from other islands after warm-water treatment in about 1 month.

Voucher: RAH #112; ACM #554

GERANIACEAE

Geranium arboreum Gray 1854 (E:EMA)

Noho-anu

Hillebrand (1888) notes of this species: "southern slope of Haleakala! Maui at an elevation of 6000 ft (near the path which leads from Ulupalakua to the crater)." Degener (Fl.Haw.-1937) states: "..near the upper border of the forest, at about the elevation of 6000 ft..A rare plant growing on the sides of sunny gulches..on the outer slopes of Haleakala."

Forbes collected this species twice on the south slope in 1920, first above Lualailua Hills (#1994M) with the note: "Rare. Only one seen.", and then again above Puu Ouli in upper Auwahi (#2153M), noting, "Small single-stemmed upright undershrub 2-2.5 feet, or loose and hanging over edge of gulch, 3-4 feet long and branched. Flowers dark red."

We found G. arboreum on the south slope only on the margin of the study area in the Kula Forest Reserve at 5600-6800 ft where it is restricted but locally common in gulches and at the edge of replanted forest.

Geranium cuneatum Hook. 1837 var. tridens (Hdb.) Fosb. 1936

(E:EMA)

Hinahina, noho-anu

This attractive species, locally common on the northwestern slopes of East Maui above 7000 ft, is quite rare on the southern slopes. It is found in our study area only in extreme upper Kaupo Gap at 6000-6500 ft, in Kula Forest Reserve above 6000 ft, and as a small apparently relict population growing on a ledge inaccessible to goats below Puu Alii at 7800 ft in roughly the center of the study area.

Though still relatively common in certain rocky areas of the central Crater area and the outer western slope, this species faces extirpation from the study area due to feral goats.

Geranium multiflorum Gray 1854 (E:EMa,H)
var. canum Hbd. 1888 (E:EMa)

Noho-anu

Though still fairly common in restricted habitat on the northern outer slopes as well as within Haleakala crater, this taxon, endemic to East Maui, is known from the south slope by a single 1920 Forbes collection (#1901M) from above Puu Pane with the note - "sterile, only one seen." Though the specimen is sterile, there seems little doubt as to the validity of the determination made in 1936 by Fosberg, monographer of the genus in Hawaii. It was not seen during this survey and may be locally extirpated from the study area.

GESNERIACEAE

Cyrtandra begoniaefolia Hbd. 1888 (E:EMa) 'Ilihia, ha'iwale
Cyrtandra cordifolia Gaud. 1829
var. gynoglabra Rock 1918 (E:EMa)
Cyrtandra lysiosepala (Gray) C.B. Clarke 1883 (E:Mo, Ma, H)
Cyrtandra sp. #1
Cyrtandra sp. #2 (allied to C. begoniaefolia and C. cordifolia)

The genus Cyrtandra is broadly distributed in moist forests of the Hawaiian Islands with many species endemic to very restricted areas. St. John's (1966) monograph of Cyrtandra for the island of Oahu included 118 species. St. John's (1973) checklist recognizes 167 species for the Hawaiian Islands, and more have been published since. The systematics of this group, especially on islands other than Oahu, is not well understood. Specimens encountered were collected when possible and turned over to Dr. St. John, the most knowledgeable individual for this genus.

This survey has encountered at least two taxa, both restricted to the last remnants of cloud forest between Manawainui and Wailaulau at 4400-5600 ft. Several other taxa, not encountered by our survey, have been reported for the south slope by others.

The most common Cyrtandra ("sp. #1") noted by our survey occurred along steep, moist gulch sides at 4400-5450 ft in Manawainui and Wailaulau drainages. St. John examined a collection of this species from 5350 ft in Wailaulau drainage and considers it a new species. The second Cyrtandra taxon ("sp. #2") was found to be restricted to a single site where several plants grow at about 5300 ft in the Manawainui drainage in a protected gulch. This taxon belongs to the distinctive section Crotonocalyces of Cyrtandra.

Forbes in 1920 collected a Cyrtandra sp. (#1885) also referable to the section Crotonocalyces, near Manawainui, remarking in his number notebook: "Seen in several places about a dozen plants in all."

Hillebrand (1888) in describing the distribution of C. begoniaefolia (also Section Crotonocalyces) notes: "E. Maui! woods of Ulupalakua". Rock (1918) states that the Berlin holotype collection of this species is labeled: "East Maui, southern slopes of Mt. Haleakala, Ulupalakua, flowering Sept. 1870." Rock (1918) further notes: "The place known as Ulupalakua on East Maui must have been more or less covered with forest in Dr. Hillebrand's days. Today there is nothing but meadow land and planted Eucalypti. Many plants which were peculiar to that region, as for example Cyanea comata, Cyanea arborea and others have vanished forever and among them also is Cyrtandra begoniaefolia. This species could only have thrived in dense shady forests, which are no more and their place is taken by a cattle ranch, covered with obnoxious weeds."

Rock (1918) published a variety of C. cordifolia (Sect. Crotonocalyces), var. gynoglabra, endemic to the southern slope of Haleakala. This variety is based on the holotype (Rock #8687) from "...southern slopes of Haleakala in gulch near Kaupo, 5000 ft, flowering Nov. 1910..." and a Hillebrand collection from 1870 from the southern slopes of Haleakala. Rock (1919c) cited, in distributional notes for C. lysiosepala and C. lysiosepala var. pilosa, collections made by Hillebrand in 1870 (Kew, Berlin) from the southern slopes of Haleakala and Ulupalakua. Forbes in 1920 made a collection of Cyrtandra from the cloud forest near Manawainui drainage (#1828M) which remains without positive identification.

Voucher: Cyrtandra sp. #1- ACM #234
Cyrtandra sp. #2- R. Hobdy #1690

GOODENIACEAE

Scaevola chamissoniana Gaud. 1833 (E:K,Mo,L,E/WMa,H)
Naupaka-kuahiwi

Found on the major islands (except Oahu, where it is replaced by S. gaudichaudiana), this polymorphic species occurs in a variety of cool, middle to upper elevation habitats. It is found in rain forests over much of the north and east slopes of East Maui.

Scaevola chamissoniana was collected by Hillebrand in the 1860's from "Haleakala south" (specimen at Kew). Forbes collected a sterile specimen (#2001M) of a "Scaevola sp." (probably this one) above Lualailua with the note: "only one seen." This survey located it at only one location-eastern Kaupo Gap at 5900-6000 ft, where only a few specimens were seen.

Voucher: ACM/LLL #399

Scaevola coriacea Nutt. 1843 (E:H.I.)

Naupaka

Degener (1950-Fl.Haw.) states: "Probably native at one time to the arid lowlands of all the larger islands.. but now on the verge of extinction... Mann and Brigham discovered it on the 'Isthmus of Maui,' while Hillebrand and Lydgate reported it from Kalepolepo [a land division and beach near Kihei, Maui]. Degener in 1948-49 discovered it scattered here and there on the sun-scorched consolidated sand dunes extending from Wailuku to Waihee point."

A recent status report (Carr, 1981) states that four known populations of this species remain: one on West Maui, one on an island off West Maui, one on East Maui and one on Molokai. The East Maui population, discovered by Rene Sylva in 1978, is located in the eastern part of the study area in the Kaupo district. The species grows in a single restricted site forming thick mats on steep sea cliffs. The population consists of approximately 20 individuals scattered over 50 meters of coastline and covering approximately 40 square meters. Associated native species include Fimbristylis pycnocephala, Vigna marina, and Scaevola taccada sericea.

Voucher: Davis/Sylva #28 (BISH #422412)

Scaevola gaudichaudi H. & A. 1832 (E:H.I.)

Naupaka

This distinctive yellow-flowered Scaevola of lower leeward forest areas was once known from all major Hawaiian islands, but has been greatly depleted. Scaevola gaudichaudi can still be found in small numbers on Oahu and somewhat more abundantly on northwestern Kauai. Hobdy reports it to be locally common on West Maui. Forbes collected this species on the south slope of Haleakala, previously the only collection from East Maui, at "Kealii forest" (#2121M-3/28/20) with this note: "Small herb, 3 feet. Flowers yellow, fruits purple. Leaves thick with an ivory felt. Only one seen." S. gaudichaudi was seen and collected during this survey in November 1982. Nineteen individuals, many flowering and fruiting, were found at 750 ft below the road at Kepuni Gulch. This is the only known population of this species on East Maui.

Voucher: ACM #318

Scaevola taccada (Gaertn.) Roxb.

var. sericea (Vahl) St. John 1960

Naupaka-kahakai

(I:H.I., trop. Pac. & Indian Ocean Isl.)

Neal (1965) states: "A smooth, spreading succulent shrub about 3 to 10 feet high, found on coasts of tropical Asia and

some islands of the Pacific, is represented commonly in Hawaii and elsewhere by a more or less downy variety. The species is rare here. The variety grows wild on Hawaiian beaches..."

This species is common in the coastal strand zone of southern East Maui, growing wherever sand and colluvial material accumulate in flats. It does not grow in rough aa lava locations.

Voucher: ACM #586

LAMIACEAE

Haplostachys haplostachya (Gray) St. John 1973
var. haplostachya (E:Ma)

St. John (1973) lists three varieties for H. haplostachya, restricted to Maui, Hawaii and Kauai respectively. This species was referred to by Hillebrand (1888) and Sherff (1935a) as H. grayana, with the same three varieties. All five species of this endemic genus were thought to be extinct until recently when H. haplostachya var. angustifolia was rediscovered in a kipuka in the saddle area of Hawaii and placed on the Federal endangered species list (Kimura and Nagata, 1980). Of the Maui populations, Hillebrand (1888) notes: "E. Maui! Kula and Honuaula; ..." Honuaula is a major land district on East Maui straddling the SW rift of Haleakala. Sherff (1935a) cites collections from the U.S. Exploring Expedition ("on the sands of the isthmus of Maui."), Hillebrand ("erect, 1-2 feet tall, in open ground altitude 2000 ft, Kula, East Maui.. common name Honohono") and Heinrich Wawra 1868-1871 ("island of Maui"). This taxon, not seen during this survey, is probably extinct.

Lepechinia hastata (Gray) Epling 1940
(I:EMa, Socorro Is., Baja Calif.)

Pakaha

Lepechinia hastata is considered indigenous to Maui, Socorro Is. and Baja, California by St. John (1973). Hillebrand (1888) notes: "E. Maui! where the gregarious plant forms an interrupted belt round Haleakala at an elevation of 2000-3000 ft above the sea; most plentiful at Ulupalakua. It emits a heavy odor.." Rock (1913) adds: "On the open grassland between 3000 and 5000 feet, is a belt of the endemic Labiate, Sphacele [= Lepechinia] hastata, peculiar to Haleakala...it owes its survival to its peculiar mint odor, apparently offensive to the taste of the cattle."

Forbes in 1920 collected this species at or above Puu Pane (#1843M). Other collections were made by Forbes, Rock and others but usually on the western slopes often near Olinda.

Lepechinia hastata was seen during this survey in the former Nature Conservancy exclosure (planted by C. Lennox - Lennox, pers. comm.). It was also seen in western Kaupo Gap at 4000 ft, growing in goat impacted Styphelia shrubland (same population reported by Stemmermann et al. 1981), and at 2650 ft on the Wailaulau/Pahihi planeze. It is reported by Hobdy east of this latter population on adjacent ridges at 2000 ft.

Voucher: ACM/LLL #423

Phyllostegia brevidens Gray 1862 (E:E/WMa,H)
var. pubescens Sherff 1934 (E:EMa)

Sherff (1935a) and St. John (1973) both list eight varieties for this species on East and West Maui and Hawaii. One of these is endemic to leeward Haleakala, based on a single collection by Lydgate in the late 1800's from upper Kula. It was not seen during this survey and has apparently been extirpated from the study area. It is likely therefore that the variety is extinct.

Phyllostegia hillebrandii Mann ex Hbd. 1888 (E:EMa)

Phyllostegia hillebrandii, recognized by Sherff (1935) as an East Maui endemic, is known only from several collections by Hillebrand and Lydgate in the 1858-1870 period. Hillebrand's herbarium labels read "in woods of Kula, East Maui" and "Haleakala south." Hillebrand (1888) gives the range as "Maui! woods of Kula and Ulupalakua." This species was not encountered in this survey and may be extinct.

Phyllostegia mollis Benth. 1831 (E:H.I.except H)

Phyllostegia mollis is found on all major Hawaiian Islands except Hawaii where the closely related P. stachyoides occurs. Prior to 1912, it was frequently collected from Haleakala's west and southwest slopes. Collections by Mann and Brigham (#404) in the 19th century and Rock in 1912 (Auwahi) were definitely from the south slope. It was not seen in this survey and is probably extirpated from the study area.

Phyllostegia sp.

A sterile individual of the genus Phyllostegia was observed in upper Manawainui at 5300 ft in October, 1981. A flowering collection was later obtained from a plant grown (near Haleakala National Park headquarters at 7000 ft) from a small cutting from this same individual. It does not closely

resemble any of the three Phyllostegia spp. previously recorded from the study area.

Voucher: ACM #312 (sterile)

Stenogyne angustifolia Gray 1862 (E:Mo,EMa,H)
var. mauiensis Sherff 1934 (E:EMa)

Sherff's (1935a) treatment of Stenogyne recognized six varieties of S. angustifolia from Molokai, East Maui and Hawaii. All were considered by Fosberg and Herbst (1975) to be "probably extinct" or "probably endangered." One (var. angustifolia) was recently rediscovered on Hawaii and placed on the Federal list of endangered species (Kimura and Nagata, 1980).

Sherff (1935a) cites only one specimen for var. mauiensis - the type, Hillebrand 77, collected "at Makie's, eastern Maui." Hillebrand (1888) gave the range of var. mauiensis as "Maui! Kula and Honuaula." Honuaula refers to a broad area on both sides of Ulupalakua. Stenogyne angustifolia var. mauiensis was not seen during this survey and is probably extinct.

Stenogyne cinerea Hbd. 1888 (E:EMa)

Hillebrand (1888) described this species with the note: "E. Maui! Kula; only a few fragments collected by Lydgate, which have the appearance of Phyllostegia mollis." Sherff (1935a) commented: "The type consists of four fragments, which, however reveal a species quite distinct." The type of S. cinerea is apparently the only specimen ever collected. It was not seen during this survey and is probably extinct.

Stenogyne crenata Gray 1862 (E:EMa)

Hillebrand (1888) notes of this species, "Maui! forests of Haleakala, northern and eastern slopes." Stemmermann et al. (1981) note for the Crater District of Haleakala National Park: "Vine occasionally associated with mamane groves and occasionally also with Santalum."

This is a subalpine shrubland species rarely found below 7000 ft. Within the study area, it is restricted to the southwest rift and environs.

Stenogyne glabrata (Hbd.) Sherff 1934 (E:EMa)

Hillebrand (1888) viewed this taxon as one of 3 geographically separate varieties of S. rotundifolia endemic to

East Maui. He gave its range as "W. slope of Haleakala, in the woods of Kula (Lydg.)." Sherff (1935a) recognized it at the specific level, from a fragmentary type collection by Lydgate from Kula ca. 1860. It was not seen by this survey and is presumed extinct.

Stenogyne haliakalae Wawra 1872 (E:EMa)

Stenogyne haliakalae is known from fewer than a dozen collections between 1868 and 1937. All collections for which reasonably precise information was recorded were collected on the south slope of Haleakala - above Puu Pane and above Lualailua by Forbes in 1920; in the 3000-4000 ft zone of southern Haleakala by Hillebrand; from 4000 ft near Ulupalakua by Mann and Brigham. The last collection of this species was made by Olson (#74) in 1937 from near the Kaupo Trail at 5600 ft in Haleakala National Park. Regarding the Puu Pane collection (#1833M), Forbes notes: "Plant growing in Dodonaea viscosa tree...high elevation edge of forest." Regarding the collection from above Lualailua (#1996M) Forbes remarks: "Vine very high up in a lehua tree. Flowers pale pink, pubescent." This species is presumably extinct.

Stenogyne rotundifolia Gray 1862 (E:Ma)

Pua'a-i-naka

var. rotundifolia (E:EMa)

var. oblonga Sherff (E:Ma)

The type variety of this species is known from numerous collections from montane cloud-belt forest of Haleakala's north and northeast slopes and is still fairly common there today. Hillebrand (1888) noted: "Maui! in the forests of Haleakala between 3000 and 5000 ft, both on the southern and northern slope. This taxon was not encountered by this survey, however, except in upper Kaupo Gap near Paliku in Haleakala Crater just outside the limits of the south slope study area.

The type specimen of Sherff's S. rotundifolia var. oblonga was collected by Forbes in eastern Kaupo Gap of Haleakala National Park in 1919. We are aware of no collection made since then.

See also Stenogyne glabrata.

Stenogyne vagans Hbd. 1888 (E:EMa)

Hillebrand states for S. vagans: "Maui! southern and western slopes of Haleakala, in forests." Sherff (1935a) notes the type as being collected by Hillebrand at "altitude 4000 feet, in forests on southern slope of Haleakala, Ulupalakua." Sherff includes this species in the section Microphyllae (which also includes S. crenata).

Stenogyne vagans seems to be the mesic forest counterpart of Stenogyne crenata, a plant of Haleakala is subalpine shrubland zone, from which it differs in having usually 4-6 (vs. 2) flowers, usually growing larger than crenata, and having a smaller calyx and longer petioles. It was not seen during this survey and is probably extinct.

LAURACEAE (CASSYTHACEAE)

Cassytha filiformis L. 1753 (I:"tropics")
Kauna'oa, kauna'oa-pehu, kauna'oa-uka

This parasitic, nearly leafless, orange-yellow vine, is considered native to the Hawaiian Islands but is also widely distributed throughout the tropics. It was originally found on all islands in the lower dry forest zone (Rock 1913; Degener 1932-Fl.Haw.), but may have been most common on Kauai (Hillebrand 1888). Degener (1932-Fl.Haw.) states that it is parasitic on grasses, Osteomeles, guava, Scaevola, Prosopis, Lantana, Sapindus, Osmanthus, etc. and forms dense matted masses over trees. Rock's (1913) Plate VIII shows this species entangling a specimen of Canthium. He states that trees "in due time succumb to this pest." Forbes collected Cassytha (#1911M) in 1920 between Nu'u and Kaupo with the note: "in a Rauvolfia tree."

Our survey found this species to be somewhat sporadic though widespread. It was noted at a few clustered roadside sites in Kaunahane district near Ulupalakua at ca. 1900 ft sprawling over Melinis minutiflora, Lantana camara, Cocculus, Sophora, and Kalanchoe. Cassytha was also noted in the Lualailua, Alena and Kipapa districts at ca. 600-800 ft. In this latter area, as Rock (1913) noted, Cassytha covers native trees (especially Rauvolfia mauiensis) in thick mats including abundant dead material. Though there was no direct evidence of mortality, trees showed an obvious lack of vigor.

Voucher: ACM/LLL #249

LOBELIACEAE (CAMPANULACEAE)

Clermontia kakeana Walp. 1835 (O,Mo,E/WMa) 'Ōhā-wai, naha

This is the most common lobeliad on the islands of Oahu, Molokai and Maui, growing from 1000 to over 4000ft. Hillebrand (1888) notes: "...on the lower edge of the woods up to 2500ft. The insipid fruit, which on E. Maui grows to the size of a crab-apple, is eaten by the natives."

Clermontia kakeana is scattered but not uncommon at 4300-4800ft in the Kahikinui district at the lower edge of

remnant Metrosideros/Acacia forests. It grows only in sites inaccessible to browsing animals, such as sides of deep stream gulches. This species is also found in relict populations in the Keauhou district near Ulupalakua at ca. 3400 ft.

Obata (1973b) reports poor germination and poor survival of seedlings.

Cyanea arborea (Mann) Hbd. 1888 (E:EMa)

Hāhā-nui

Cyanea arborea, now extinct, was one of the tallest and most impressive members of this endemic genus in the Hawaiian Islands. Rock (1919b) notes: "One of the finest and most interesting species...is Cyanea arborea. Unfortunately the plant is practically extinct. It occurred on the slopes of Haleakala between Kula and Ulupalakua. Anyone familiar with the forest region, or rather region, as the forest has gone, can see why C. arborea one of the finest Lobelioideae of the Hawaiian Islands had to succumb. Where there was once fine forest stalked with beautiful arborescent Lobelias there we find Hilo grass (Paspalum conjugatum) and herds of cattle the arch enemy of Hawaiian forests. The illustration here shown [Plates 32,37,83,84] represents the last of this Lobelioid."

Rock (1919b) places C. arborea in the section Palmaeformes, noting: "The most interesting species of that section appear to be C. leptostegia, C. superba, C. arborea and C. Giffardii. These four species are decidedly distinct and probably extremely old, while the others are closely connected and range more or less into each other.. They form as it were a common group by themselves, pointing back to a common ancestor."

Forbes in 1920 collected this species twice in the cloud-belt forest above Puu Pane near Manawainui drainage (#1826M and #1944M). Regarding the first collection, Forbes notes, "Flowers white with a greenish tinge nearly straight or slightly curved. Slit to the base on the upper side, lower petals slit less than halfway down, glabrous. Calyx green, truncate & minutely toothed...Single stout stem over 20 feet high & erect. Only one seen in a gulch. Not seen by boy before. Leaves rather thick, dark green and polished above..the mid rib stout, fleshy." For the latter collection (#1944), Forbes notes: "...35 feet high, single stem, 5 inch at the base with stout roots. Lvs. finely pubescent below. Flowers white. Lvs. dark green polished above. A faint line of purple at the point of attachment of calyx and corolla on the corolla. Calyx minutely toothed. 1 plant seen."

Hillebrand (1888) described this species and noted its range as "E. Maui! Ulupalakua, 3000-4000ft...Kula!.." Cyanea arborea was collected by Mann & Brigham, Hillebrand, Munro, Rock, Forbes, Degener and others, most often from the

Kula/Ulupalakua area. The Degener and Munro collections are both from the Olinda area and the Forbes collections come from the southern slopes of Haleakala. These collections indicate that in pre-contact times C. arborea was found from the western to the southern slopes of Haleakala in cool mesic forests. The last collection of this species was made by Munro in 1928.

Cyanea comata Hbd. 1888 (E:EMa)

Cyanea comata was a branched shrub 1.5-2.5m tall with drooping racemes of grayish pale lilac flowers, according to Hillebrand (1888) who noted: "Maui! southern slope of Haleakala, 3000-4000ft, in shape of calyx and corolla, very different from all other species which constitute this group." Apparently the type collection of Hillebrand (BISH, GRAY) in the 1860's is the only collection ever made. Rock, who searched in vain for this species, noted (1913): "Cyanea comata, another beautiful lobeliaceous plant once common in this district, has vanished forever." Rock (1919b) further stated: "It probably occurs in the forests of Kaupo, Maui or did occur back of Ulupalakua, which is strictly speaking on the southern slope of Haleakala; however all native vegetation has disappeared from that region, which is now covered with Paspalum conjugatum and replanted Eucalypti."

Cyanea comata was not seen during this survey, and is undoubtedly extinct.

Cyanea obtusa (Gray) Hbd. 1888 (E:E/WMa)

Rock (1919b) considered C. obtusa endemic to Maui and Hawaii, whereas St. John (1973) gives the range as Maui only. It was collected by U.S. Exploring Expedition botanists from "Maui"; by Mann and Brigham from the Makawao area; by Rock and Forbes from the Makawao area in 1910; and by Hillebrand from "Haleakala south" in 1870. Hillebrand (1888) noted its presence at Honuaula [vicinity of Ulupalakua], Waikapu, and Lahaina of West Maui.

This species was not seen by this survey. See Cyanea sp. nov.

Cyanea quercifolia (Hbd.) Wimmer 1956 (E:Mo,EMa,H)
var. quercifolia (EMo,EMa)

Hillebrand (1888) noted of this taxon: "E. Maui! Ulupalakua and Hamakua, at elevations of 3000-4000ft. Attains the size of a small tree, 15ft." It was first described as a variety of C. solanacea (a species now considered endemic to Molokai). Wimmer raised it to the species level and included a variety from Hawaii within the species.

Rock (1919b) noted: "At Ulupalakua the plant has become extinct; there is not a vestige of forest left in that

district. The only remaining sign of a forest is here and there a tree of Pterotropia dipyrena [=Tetraplasandra kavaiense]; the rest is grazing land and planted Eucalypti." No collections have been made since and we presume that Cyanea quercifolia has been extirpated from leeward East Maui.

Cyanea sp. nov. St. John ined.

Forbes in 1920 collected a Cyanea sp. (#1840M) from near Manawainui drainage, noting: "Tree 10ft. The flowers are blue and longer than C. angustifolia. On a cliff and could not even rope. Lvs. pubescent below." This survey encountered two individuals of Cyanea at 4900 and 5300ft in Manawainui drainage. These specimens superficially resemble C. obtusa. However, upon examining the specimens, St. John (pers. comm.) feels that these plants and Forbes' #1840M collection from the same area belong to a distinct species, as yet undescribed.

Vouchers: A.K. Kepler #46, #47, #48, #49; ACM #306

Lobelia grayana E. Wimmer 1948 (E:K,EMa)

Rock (1919b) expressed some doubt regarding inclusion of Kauai and Haleakala specimens within a single species. He stated of the range of L. grayana on Haleakala: "...rather abundant at an elevation of 5000-7000 feet on the northwestern slope of the crater, as well as in both the Koolau and Kaupo gaps in the crater." There have been numerous collections made of this species on East Maui, mostly from the north slope, although it may have once occurred in a band around East Maui. It was noted by Rock on the south slope and in Kaupo Gap and was collected by Forbes in 1920 east of Puu Pane (#1825M) in the Manawainui drainage. Our survey noted L. grayana between Manawainui and Pahihi drainages at 4500-5600ft, on cliff walls in both east and west Kaupo Gap, and in lava fissures near Paliku.

LOGANIACEAE

Labordia sp.

Kāmakahala

This taxon is represented by two individuals found in Manawainui and in a nearby drainage to the east at 5000-5300ft. So far as we can determine, this is the first Labordia collected on the southern slope of East Maui. Both specimens were collected in gulches within moist Metrosideros/Acacia koa forest. This taxon and associated native species are threatened by feral goats and pigs and by cattle.

St. John, working with the specimens at the Bishop Museum Herbarium, could not match it to other Maui or Hawaiian collections and considers it an undescribed species.

Vouchers: ACM #307; Hobdy #1688

LORANTHACEAE (VISCACEAE)

Korthalsella complanata (v. Tiegh.) Engler 1897 (E:H.I.)
Hulu-moa, kaumahana

Degener (1939-Fl. Haw.) states: "This is the least rare of our native mistletoes, and also considered the least polymorphic. It grows from about sea level to... at least 5000 or 6000 ft." Forbes [1920] and Degener [1927] have collected K. complanata several times on the south slope from hosts Osmanthus and Styphelia.

This species, widespread in native forests on East Maui on a variety of hosts, is found on the south slope at 3000-8000 ft. It parasitizes Acacia and Metrosideros in the upper forest zone, Osmanthus in lower dry forest.

Korthalsella remyana v. Tiegh. 1896 (E:O,Mo,L,Ma)
Hulu-moa, kaumahana

Degener (1938-Fl. Haw.) remarks regarding this species: "A rather rare species parasitizing the native lama. It has been collected on Oahu in Niu, Makua, Hauula and Kipapa; on Molokai in Wailau; on Maui at Auwahi; on Lanai near Koele....not known elsewhere".

Korthalsella remyana is known on the south slope from an area of about one hectare, just above 2000ft in Kanaio. It occurs exclusively on lama (Diospyros ferrea) at this site, though a number of other tree species also occur in the area. At this site a single lama tree may be "infested" by as many as a hundred individuals of K. remyana, causing stunting of the foliage of the host tree and giving the normally green leaves a yellowish color.

MALVACEAE

Abutilon menziesii Seem. 1865 (E:L,H, Ma) Ko'oloa-'ula

This attractive shrub species is restricted on East Maui to two known locations. Four small, widely separated groups of plants have been found on lava fields near Puu o Kali at 1150ft and 1500ft. In addition, a relict population of an estimated 25 individuals of A. menziesii in five sites at 600-750ft was discovered recently below Pukalani, growing with Lipochaeta rockii and Dodonaea (R. Hobdy, John Tavares, pers.comm.).

Hibiscadelphus wilderianus Rock 1911 (E:EMa) Hau-kuahiwi

This species of the endemic genus Hibiscadelphus was known from only a single individual discovered by Rock in November, 1910. The tree, erect and 5m tall, grew in Auwahi on

Haleakala's south slope between 2500 and 2600 ft. Rock (1913) states: "...when last visited (1912) by Mr. Gerrett Wilder....the tree was found to be in a dying condition; the branches were completely covered by a species of Usnea, probably australis....As the tree is situated on a cattle ranch, it will be only a very short time until it will have disappeared from its natural habitat."

This species was not seen by our survey and is generally considered extinct.

Hibiscus brackenridgei Gray 1838 (E:K,O,Mo,L,Kahoolawe, E/WMa) Ma'o-hau-hele

The type specimen of H. brackenridgei was collected in the 1840's by botanists of the U.S. Exploring Expedition at an unstated location on West Maui. Degener and Wiebke collected it in 1927 at Pokahea gulch in West Maui. It has recently been "rediscovered" on West Maui by Rene Sylva at the head of Kaonohua gulch.

This survey and R. Hobdy found H. brackenridgei on the western slope of East Maui near Puu o Kali at ca. 1400ft. Hibiscus brackenridgei had previously been collected only once on East Maui, by Hillebrand and Lydgate before 1880 at "Brown Hill, Kula." Since the local name for Puu o Kali is Red Hill, it is possible that the collections made by Hillebrand and this survey are from the same area.

This species was noted from only the single restricted site below Puu o Kali, with approximately 40 individual stems found there. Flowering, fruiting and apparent vegetative root suckering were observed. The substrate was rough aa lava. Native species found nearby include Erythrina, Euphorbia celastroides var. mauiensis, Nototrichium, and Sicyos.

Seeds collected from this site have germinated without scarification after six weeks.

Hibiscus tiliaceus L. 1753 Hau
(I:trop. Pac. & Old World)

Hillebrand (1888) remarks: "Very common along the coast, extending up to elevations of 1500 feet and more.. This useful plant is generally planted near native habitations..."

Stemmermann (1981) notes: "This Hibiscus grows in dense thickets in the lowlands where it can be found along streams, at mangrove margins, in lowland swampy areas and on slopes as well....Hawaiians at one time used the wood for outriggers on their canoes and parts of the plant have been used medicinally in many cultures."

Hibiscus tiliaceus is not common in the study area. It grows in several scattered groves from Cape Hanamanioa eastward

to Kanaio beach. At these sites, it forms thick groves in sandy, swampy areas.

Sida fallax Walp. 1843 (I:H.I., Pac.Is., China) 'Ilima

Hillebrand (1888) notes: "Common on all islands, particularly on ancient lava beds on the leeward side of the islands of Maui and Hawaii! up to 2000ft or more." Neal (1965) states: "In many parts of Hawaii, from near sea level to an altitude of more than 2000ft, are found various forms of 'ilima plants, from about 4ft high to nearly prostrate... Some forms were used medicinally."

A low shrubby form of this polymorphic species grows abundantly in certain areas on the lower flanks of the study area up to nearly 3000ft. It thrives in rocky lowland sites and in some disturbed areas where other native species have been eliminated.

Voucher: ACM/LLL#251; ACM#365

MENISPERMACEAE

Cocculus lonchophyllus Hbd. 1888 (E:EMa) Huehue, hue'ie

Hillebrand (1888) states: "Maui! Kula and Honuaua." Although some workers have considered all Hawaiian Cocculus to belong to a single polymorphic species (C. ferrandianus), St. John (1973) retained Hillebrand's treatment (4 species), which we use here.

In our study area, C. lonchophyllus is found from just above sea level to 4900ft. It is especially common in arid, rocky sites at 1500-2500ft between Ulupalakua and Auwahi. The upper elevation limit (4900ft) was observed along the eastern Kaupo Gap trail in Haleakala National Park.

Voucher: ACM/LLL #248; ACM #345

MORACEAE

Broussonetia papyrifera (L.) Vent. 1799 Wauke
(Polynesian introduction, cult.E.Asia)

This species, a Polynesian introduction, still persists in some lowland Hawaiian forest areas as relicts of ancient Hawaiian plantations. Hillebrand (1888) states: "At present it is found in isolated clumps along the lower wood-zone, mostly in Kona, Hawaii, and in various parts of Maui." Forbes collected B. papyrifera on the south slope in 1920 at Waiopai (#1850M). Degener collected it in 1927 near Ulupalakua "among

lava in arid region." Though not encountered during this survey, Hobdy reports several patches of this species growing in a rocky area in lower Kaupo Gap, near Pohakuloa at about 900ft.

Streblus sandwicensis (Deg.) St. John 1973 (E:K,O,L,Ma,H) A'ia'i
(=Pseudomorus sandwicensis Deg.)

Rock (1913) stated: "It is common on the island of Maui, especially in dry gulches above Makawao, where the writer met with some very large trees, about 40 feet high... At Auahi...in the dry forest, it is again not uncommon in company with Ochrosia sandwicensis, Sideroxylon (=Planchonella) auahiense, Pelea multiflora, etc. as well as at Ulupalakua at an elevation of 3000ft." Forbes record Streblus as being "not uncommon" at Auwahi in 1920.

Streblus sandwicensis was encountered within the study area from Kanaio district east to the Wailaulau-Pahihi planeze in the Nakula district at elevations of 2100-4500ft zone of Auwahi, and roughly the same number in the Lualailua district at 2200-4000ft. Lesser numbers of this species were recorded in Kanaio (2100ft) and in Kepuni (3200ft) and Wailaulau (4060ft) gulches. A few individuals still survive in the Waihou Spring area above Makawao on the wester slope. Fruit production is often fairly abundant, with dark purplish-red fruits present in October-November. Flowers are apparently wind-pollinated. A few saplings (possibly vegetative reproduction) were seen in central Auwahi district amidst kikuyu grass. Obata (1972) reports good germination and successful pot culture of this species and notes that it seems to prefer a dry environment.

Voucher: ACM #369, #561

MYOPORACEAE

Myoporum sandwicense Gray 1862 (E:Nihau,K,O,Mo,L,Ma) Naio
var. sandwicense

Rock (1913) considered M. sandwicense as "one of our most common forest trees." Of the situation on Maui, Rock stated: "In the dry forest back of Makawao (elevation 2500 feet) as well as at Auahi... trees of 50-60 feet with trunks of more than 3 feet in diameter are not uncommon. It prefers the leeward sides of the islands especially the aa lava fields." Like Metrosideros and Sophora, it has a remarkably wide ecological amplitude over its range. Hillebrand (1888) pointed out that on Hawaii it reaches 10,000ft elevation and that "on Hawaii as well as Maui it extends downward to near the sea, gradually dwarfing to a low decumbent shrub." In marked contrast to its range on the island of Hawaii, Myoporum does not occur in the subalpine zone of Maui.

The abundance of naio at one time on the south slope may be indicated by the district place name "Kanaio", translating to "the Myoporum tree." Myoporum is still present, but has apparently undergone a severe decline and is not common in the study area. In the Auwahi/Kanaio area at 2000-3000ft, for example, where living Myoporum trees are present but uncommon, dead Myoporum snags are frequent. Its continuing decline seems in marked contrast to the situation reported by van Riper (1980) on Mauna Kea on Hawaii where Myoporum is increasing at the expense of Sophora due in part to browsing pressure.

The variety sandwicense is still found across the study area, though more common in the western sections, at elevations from just above sea level up to at least 4000ft. In eastern Kaupo Gap within Haleakala National Park, four large individuals (up to 10m) occur at 4000-5000ft, at the top of this variety's elevational range.

Flowering and seed production occur consistently for south slope populations of Myoporum. A few small seedlings were seen at 1200-1600ft in the Auwahi-Kanaio area in March of 1981, but these were dead when checked two months later. Reproducing populations of Myoporum were found only along the coast (e.g., abundant seedlings and saplings in La Perouse Bay-Kanaio beach area). Young saplings of this species are quite distinctive due to strong leaf serration not present in adult trees.

Obata (1973b) notes fair germination and good growth of seedlings and saplings with mortality rare.

Vouchers: RAH/LLL #174, 189, 195; ACM #228; ACM/LLL #417, #418

Myoporum sandwicense var. degeneri Webster 1951 (E:EMa)

Degener and Greenwell (1952-Fl Haw.) wrote of var. degeneri: "Growing on the dry leeward slopes of Haleakala, Maui from near Ulupalakua to Kaupo Gap, but being reduced alarmingly in numbers and areas by fires and the ravages of feral goats." The variety degeneri is easily distinguished from the variety sandwicense by its larger, pubescent leaves.

Forbes collected this variety twice. He notes of #1940M from Nakaaha: "Tree very large 40ft high.. shaped like a koa, much branched." His collection #1875M was from Waiopai drainage where this taxon was "not common." The type for the described variety was collected by Degener in 1927 with the note: "N. mauka of Ulupalakua in dryish grassy open forest. Trees 15-30 feet high, large trunked, spreading."

This survey found var. degeneri only in upper Auwahi and Lualailua districts at 3800-5400ft. In this area, there are still large trees with dbh as great as 80 cm. Hobdy reports two trees at 4300ft in the Waiopai drainage to the east. This

distinctive variety has been collected few times, and though many large individuals are still extant, it must be considered threatened due to lack of reproduction and habitat reduction. The scattered disjunct distribution suggests that this taxon may have been more widespread in the past.

Voucher: RAH #125

MYRSINACEAE

Myrsine lanaiensis Hbd. 1888 (E:H.I.)

Kōlea

Hillebrand (1888), who described this species, knew it only from Lanai, noting: "Lanai! in the scrub of the forehills." Rock (1913) stated: "This handsome species, which has hitherto been thought to be peculiar to the Island of Lanai, has also been collected on the eastern part of Maui in open dry gulches back of Makawao at an elevation of 2500ft, where it reaches a height of 30ft... It is exceedingly common on...Lanai in the open dry gulches...where it is a small tree, and quite conspicuous on account of its pale graceful foliage, which always has a pinkish tint." Hosaka's (1940) revision of the genus in Hawaii gives distribution of M. lanaiensis as "...in the lower forests on...Kauai, Lanai, Oahu, Maui and Hawaii."

Myrsine is one of the most common trees in eastern Kaupo Gap at 4500-5200ft and occurs several hundred ft above and below this level. Stemmermann et al. (1981) have regarded this population as M. lanaiensis var. lanaiensis. Myrsine lanaiensis is also found in Auwahi, Kanaio and Lualailua districts, usually below 3000ft. Reproduction by seed is abundant in Kaupo Gap, especially along the margin of the forest or of individual tree canopies.

Although not preferred by browsing feral goats, reproduction is prevented in areas where goat concentrations are high.

Voucher: RAH/LLL #161

Myrsine lessertiana A. DC. 1841 (E:H.I.)

Kōlea

Rock (1913) stated: "This species is one of the most variable ones in the genus...hardly two trees are alike. The leaves are the most variable part of the plant; also shape and branching habit vary greatly... Should one undertake to describe all the various forms as new species...one would certainly be naming individuals and swell the synonyms of Suttonia [=Myrsine] lessertiana, into which most of H. Leville's species have wandered to remain there forever... It favors an elevation of ..3000-4000 ft... It grows in rain

forests, though its best development is attained in the more open park-like forests..."

Hosaka (1940) wrote: "Plants belonging to the Lessertiana group, collected on different lava flows, show great variation. Plants belonging to one species and growing side by side in lava flows of varying ages in the same climatic zone seem to vary. The most variable forms of Lessertiana are found on the new lava flows of Maui and Hawaii. It appears that the variation of the plants is caused by an edaphic factor."

Within certain parts of the study area, this taxon may be confused with M. lanaiensis. In general, M. lessertiana is found on the south slope of East Maui at 3000-6400ft, with M. lanaiensis usually below 3000ft. Myrsine lessertiana is currently largely restricted to the lava flows of Kaunauhane, Auwahi, and Lualailua, and to the cloud forests of Kahikinui, eastern Kaupo Gap, and Manawainui planeze. Scattered individuals occur in Nakula and Nuu. Scattered individuals also occur at about 6000ft below Oili Puu in upper Kaupo Gap as well as in the vicinity of Paliku.

As with M. lanaiensis, seedlings are produced abundantly and saplings are not unusual in areas protected somewhat from browsing. Saplings are even present in the kikuyu grass zone of Auwahi.

Lyon Arboretum reports good germination of Myrsine in about two months. Obata (1973b) reports poor germination of both M. lanaiensis and M. lessertiana.

Voucher: RAH #127

MYRTACEAE

Metrosideros polymorpha Gaud. 1830 (E:H.I.) 'Ōhi'a, Ōhi'a-lehua

In pre-contact times, this species, the most common Hawaiian tree, probably formed an uninterrupted belt of forest around Haleakala. Metrosideros-dominated rain forest is currently found on the northern, eastern, and southern flanks of east Maui, usually at 2000-6500ft. In the dry and mesic forests of the south slope, the distribution of Metrosideros is more sporadic at 1400-6900ft.

The lowest elevation populations of Metrosideros encountered in our survey were at Lualailua Hills at 1400ft, where dense isolated groves occur on rough aa lava. At 4500-6200ft, it (with Acacia koa and Cheirodendron) forms a band of cloud forest in the Kahikinui, Nakula and Nuu districts, in eastern Kaupo Gap of Haleakala National Park, and on the adjacent Manawainui planeze. In western Kaupo Gap, Metrosideros occurs as large isolated individuals on rough aa

flows otherwise largely devoid of woody vegetation. In both western and eastern Kaupo Gap, both red- and yellow-flowered forms occur, often otherwise morphologically similar.

From Ulupalakua to Lualailua, in the western portion of the south slope, Metrosideros is found at 1400-4000ft, usually with small monospecific stands scattered within a diverse mixture of overstory trees. In this same area, Metrosideros grows in gulches from 4000ft up to 6900ft.

Metrosideros polymorpha is a robust, adaptable, slow-growing species. On the south slope, trampling and other ground disturbance by goats, cattle and pigs is probably as important as browsing in reducing seedling establishment to a minimum and threatening survival of these forests. Alteration of microclimate by destruction of the fern understory may be another factor involved.

Voucher: RAH/LLL#193

NYCTAGINACEAE

Boerhavia diffusa L. 1753 (I:tropics)

Alena

Hillebrand (1888) states: "Common on the lower plains and slopes. Like other species of this genus, the plant possesses some drastic property in the root and forms part of the native materia medica."

Our survey found Boerhavia confined to the coastal strand and the seasonal dryland forest, not occurring above an elevation of 1100ft. It may be locally common, but is absent from many areas of coastline.

Voucher: ACM #587, #590

Pisonia brunoniana Endl. 1833 (E:O,L,Ma,H)

Pāpala-kēpau

The sticky fruits of this tree were used in bird-catching by the ancient Hawaiians. The fruits were tied to the branch of a flowering lobeliaceous plant, which was then raised into the surrounding cover. Birds of the families Meliphagidae and Drepanididae visiting the flowers were unable to disentangle themselves from the fruits of Papala-kepau (Rock, 1913).

Pisonia brunoniana may be difficult to distinguish from P. umbellifera or even P. sandwicensis unless flowers are present (St. John, pers. comm.). The shape of the inflorescence and size of the perianth, anthers and style are critical in distinguishing members of this group in Hawaii (Skottsberg, 1936). Skottsberg considered the three Hawaiian representatives to represent distinct genera. This report follows St. John (1973) in considering them distinct at only the species level.

Based on numerous collections, P. brunoniana once occurred all around leeward East Maui in the 2000-4500ft zone. Forbes collected it in eastern Kaupo Gap (#1118M) in 1919 and near Lualailua Hills (#1933M) and in Manawainui drainage in 1920.

Though not currently abundant, P. brunoniana still occurs in Auwahi district at 2800-4400ft. It is rare but present further east in Mehamenui district below Puu Pane at 3200ft. It occurs, surrounded by kikuyu grass, in eastern Kaupo Gap of Haleakala National Park at 3850-4200ft.

This species appears to reproduce well vegetatively at a few sites (e.g., eastern Kaupo Gap). Germination and seedling growth and survival in cultivation are reported as good to excellent (Obata, 1973a; Hobdy; ACM).

Voucher: RAH/LLL #122

Pisonia sandwicensis Hbd.1888 (E:H.I.)

Pāpala-kēpau

This species is recorded from only two collections from leeward Haleakala. Wilder collected it from Ulupalakua in 1913. C.N. Forbes collected it on the west slope in 1920 with the note: (#2174M) "Kula, near Sanitorium in a patch of native forest. One tree seen, 30ft. high..." The only additional collection from Haleakala in the Bishop Museum is a Rock specimen (#8672) labeled only "East Maui."

Although still locally common on Lanai and Kauai, this species is quite scarce on both East and West Maui and was not seen by our survey.

OLEACEAE

Osmanthus sandwicensis (Gray) Knobl. 1895 (E:H.I.)

Olopuia

Osmanthus is frequently a co-dominant with Pleomele aurea in the scattered stands of native forest of the Kanaio, Auwahi and Lualailua districts at 2200-3300ft. It is a common tree at 2000-4800ft from Puu Mahoe east to Alena district. Scattered populations still survive in steep gulches eastward at least to Nakula. Only six trees of this species occur in eastern Kaupo Gap at 4500-5000ft.

Despite abundant fruit production in the late fall, we saw few seedlings in the course of field work - only in rocky areas without kikuyu grass. Although the species is currently common, only old trees survive. This tree species does not seem to reproduce vegetatively.

Obata (1973b) reports good germination and rapid seedling growth, whereas others (Hobdy, Wooliams, pers. comm.) report only fair success. Specimens of O. sandwicensis are in

cultivation at Maui Botanical Garden, Wahiawa Botanical Garden and Waimea Arboretum.

Voucher: ACM #556; RAH #139; J. Lau #1004

PAPAVERACEAE SJ164

Argemone glauca Pope 1929 (E:"Kauai to Maui")

Pua-kala

Hillebrand (1888) notes of A. glauca: "Common in rocky dry situations on the leeward sides of various islands, particularly Oahu. The natives employ the acrid juice as a local application to chronic ulcers." Degener (1958-Fl.Haw.) adds: "Oliu Pohina of Kona, Hawaii, stated that the juice of stalks is put on warts to drive them away.. Though undoubtedly poisonous, its bitter taste and sharp prickles warn stock against eating it.. Like Gossypium tomentosum, the puakala is an Hawaiian endemic of early American origin. It has been in the islands long enough to differ cytologically and morphologically from all other species, and to begin to segregate into different kinds, particularly in regard to prickliness."

Argemone glauca is scattered (locally common) throughout the lower dry sections of the south slope up to 2800ft, with a few individuals found higher. It is uncommon but present in mid-Kaupo Gap of Haleakala National Park at ca. 4000ft on aa (R. Nagata, pers. comm.).

Voucher: ACM/LLL #266.

PHYTOLACCACEAE

Phytolacca sandwicensis Endl. 1936

Pōpolo-ku-mai

var. puberulenta (Deg.) St. John 1940 (E:Ma)

Hillebrand (1888) states that P. sandwicensis is "common in the lower forests.." Degener (1933-Fl Haw.) states: "Found on all the larger islands in open rain forests usually at higher elevations. Not common excepting in certain localities.." Regarding var. puberulenta, Degener (1933-Fl.Haw.) states: "Differing from the species in being puberulent, especially on the veins on the underside of the leaves."

This taxon is known from the study area from a single collection from eastern Kaupo Gap at 6000ft made by Tachikawa in 1937 within Haleakala National Park. It has not been seen in this survey and is presumed locally extirpated. It was, however, reported as occasional at 2500-3500ft in Kipahulu Valley by Lamoureux (1968) and can still be found on the north slope of East Maui.

PIPERACEAE

Peperomia cookiana C.DC. 1869 (E:K,Mo,L,E/WMa,H)
'Ala'ala-wai-nui

This quite variable species is fairly common in middle and upper elevation rainforest in the Maui Nui group. On Haleakala's south slope, it was collected three times by Forbes: at Puu Ouli (#2140M), at Puu Pane (#1832M), and "far above Puu Pane" (#1891M), all in 1920. Degener and Wiebke collected it in 1927 (#2620) northeast of Ulupalakua.

This survey noted P. cookiana as uncommon in upper east Kaupo Gap and at several sites in Manawainui drainage at 4000-5300ft, often growing epiphytically on Acacia koa.

Voucher: ACM #315

Peperomia erythroclada C.DC. 1913 (E:L,E/WMa)
'Ala'ala-wai-nui

Only locally common throughout most of its range, this rainforest species was noted by this survey at a single site, at 5100ft in upper Manawainui drainage. At this site, P. erythroclada grew adjacent to P. cookiana and P. tetraphylla in several epiphytic colonies in Acacia koa-dominated forest.

Voucher: ACM #315b

Peperomia leptostachya H. & A. 1832 (I:H.I.,Polynesia,Austr.)
'Ala'ala-wai-nui

Yuncker (1933) wrote in his review of Hawaiian Peperomia: "This species grows at lower elevations and under more arid conditions than any other Hawaiian species. The plants occur singly or more commonly in clumps on dry rocks or on the ground under Lantana and other shrubs or rarely epiphytically, from sea level to an altitude of 1000 feet or rarely higher. It is found throughout the Hawaiian Islands and other parts of Polynesia."

Peperomia leptostachya is common on the south slope, especially on aa, from just above sea level to about 2800ft. For the Crater District of Haleakala National Park, Stemmermann et al. (1981) listed it as "Occasional, gulches, E. Kaupo Gap." These Kaupo Gap populations were observed by this survey to reach at least 6400ft.

Voucher: RAH/LLL #150; ACM #203; ACM/LLL #401, #416, #426

Peperomia tetraphylla (Forst. f.) H. & A. 1832
(I:trop.Pac., E. Indies, Asia)

'Ala'ala-wai-nui

Although this species is common in many low to middle elevation sites of the Hawaiian Islands, it is relatively rare on the south slope. Peperomia tetraphylla was reported by Mitchell (1945) as found in the Paliku and Kaupo Gap areas of Haleakala National Park, but Stemmermann et al. (1981) did not encounter this species. Our survey found P. tetraphylla growing as an epiphyte in upper eastern Kaupo Gap on Acacia, Myrsine, and Metrosideros, and in western Kaupo Gap at 3900ft on Metrosideros. We also found it on Acacia koa in the 4000-5200ft zone between Manawainui and Wailaulau drainages.

Voucher: ACM #313; ACM/LLL #425

PITTOSPORACEAE

Note on the genus Pittosporum:

Ho'awa (name for genus)

Pittosporum in Hawaii is a difficult genus in terms of both nomenclature and taxonomy. Hillebrand (1888) included 10 species of Pittosporum. Sherff (1942) revised the genus, recognizing 23 species. Haas (1977), in reviewing Pittosporum of the Pacific, recognized 11 Hawaiian species. St. John (1977b), stimulated by the work of Haas, recognized 21 species in a treatment he considers intermediate, but closer to Sherff's. For purposes of this report, St. John's (1977b) treatment will be used, giving Haas' names as synonyms when appropriate.

Pittosporum argentifolium Sherff 1941 (E:E/WMa)

=P. insigne Hbd. var. fosbergii Sherff f. pertinax Deg. & Sherff (Haas, 1977)

This is a distinctive tree species endemic to Maui (Sherff, 1942; St. John, 1973; 1977b). The leaves have a characteristic appressed tomentum, especially on the undersides. Rock collected P. argentifolium in 1910 at 5500ft at Ukulele above Makawao (#8656) with the note: "A tall tree with rather ascending branches which are stiff, leaves silvery or golden-brown underneath..." Forbes collected this species 6 times in 1920 in Auwahi and Kanaio (#1786M, #1964M, #1981M, #2052M, #2062M, #2064M), where it was a tree 18-30ft tall, with cream-colored and very fragrant flowers, apparently not common.

Our survey did not encounter this species. It is presumed to be extinct.

Pittosporum confertiflorum Gray 1854 (E:O,L,E/WMa,H)
var. confertiflorum (E:E/WMa,H)

Rock (1913) states: "The writer collected.. this species from the type locality southern slopes of Haleakala, Maui, where the tree is not at all common. It also grows near Kaupo at an elevation of about 5000ft." Four south slope collections of this species are known to us: Hillebrand's type from 4000-5000ft, south Haleakala; Rock's 1910 collection, with the note: "a small tree found on the edge of gulch near Kaupo"; Forbes' collection (#2005M) in forest above Lualailua Hills, with the note: "tree 20ft tall, middle forest, flowers fragrant, cream white"; and a G.E. Olson specimen collected in 1937 from 5600ft along the Kaupo Trail in Haleakala National Park.

Pittosporum confertiflorum is very rare currently in subalpine shrubland of East Maui, but is not uncommon in upper elevation rainforest of Haleakala's north slope. Our survey found only one individual at 5700ft in upper Manawainui drainage. An individual also occurs in central Kaupo Gap at about 6000 ft (R. Nagata, pers. comm.).

Pittosporum insigne Hbd. 1888 (E:Mo,E/WMa)
var. insigne
var. micranthum Sherff 1941 (E:EMa)

This taxon has apparently been extremely rare on the south slope of Haleakala for some time. Forbes collected the type material (#1800M) for Sherff's var. micranthum on aa at 2200ft at Kanaio, with the note: "1800M growing beside 1786M [=P. argentifolium (ACM)] but the inflorescence is pedunculate and lvs. more glabrous. Appears as a seedling of 1786M but apparently a different species." Degener also collected this species on the south slope at Ulupalakua (#10963) in an "arid lava region."

A single individual assigned to this taxon was found by this survey at 3300ft in Auwahi. It is 6m tall, somewhat scandant, and nearly hidden in a grove of Planchonella auahiense. In November 1981, this tree carried old fruiting capsules.

Voucher: ACM #18

Pittosporum terminaloides Planch. ex Gray 1854 (O,L,Ma,H)
var. mauiense Sherff 1941 (E:E/WMa)

Haas (1977) states that this species has been collected in a variety of sites on Maui, ranging from Iao Valley (WMa) to the Puu Alaea area of northern East Maui. Sherff regarded collections from the Auwahi and Kanaio districts as representing a distinct variety, var. mauiense.

We are aware of only two south slope collections. Rock collected the type (#8669) for Sherff's var. mauiense at Auwahi in 1910 with the note: "Not uncommon on aa lava, Kahikinui E. Maui, along government road; a small tree, 15ft with rather rambling branches, not ascending ones as the other species common in the same region which is a much stouter tree." The "other species" to which Rock refers is probably Pittosporum argentifolium. Degener also collected P. terminaloides mauiensis in 1948 at Hokukano in lower Auwahi, with the note: "Arid aa lava flow. Straggly, spreading 8ft tree."

We did not encounter this species during our survey. It may be at least locally extirpated.

PLANTAGINACEAE

Plantago princeps C. & S. 1826 'Ale
var. laxifolia Gray 1862-6 (E:K, Ma, H)

Stemmermann et al. (1981) state for this taxon: "Rare woody herb on cliffs of West Kaupo Gap." This report was based upon a single individual in a dry stream gully in upper western Kaupo gap (L. Stemmermann, pers. comm.) at ca. 6100ft. Part of a taxonomically difficult species complex, this taxon, the only variety of the species recorded on Maui, has been only rarely collected and appears on the verge of extinction.

PLUMBAGINACEAE

Plumbago zeylanica L. 1753 (I:"tropics of E.Hemisphere")
Ilie'e

Hillebrand (1888) states of this species: "Common in the lower plains and lava fields....The acrid juice of this plant is considered poisonous, and used to be employed like that of Sisyrinchium acre for black tattooing." It was collected by Forbes in 1920 (#1854M) in the lower Waiopai drainage of south Haleakala.

Plumbago zeylandica is fairly common on the south slope at 40-3000ft elevation on open lava fields and other open sites or in understory situations. It is apparently not grazed by livestock. Its fruits, enveloped by a persistent calyx with viscid structures, are well-adapted for dispersal by mammals or birds.

POLYGONACEAE

Notes on native Hawaiian Rumex:

Hillebrand (1888) recognized two species of endemic Rumex, R. giganteus and R. albescens. Degener (1971), working

primarily with Hawaii island material, identified a third species R. skottsbergii growing mainly on lava. He recognized this shrubby red-flowered species as distinct from the green-flowered rain forest liana, generally called R. giganteus.

The morphological variability between populations and apparent continuity within populations of Rumex presents some problems in identifying some material. Some Maui populations need further investigation.

Rumex giganteus Ait. 1811 (E:H,perhaps also Ma,Mo) Pawale

This trailing shrub is currently rare on northern East Maui in moist, protected, upper elevation montane forest. It is likely that this is the species collected by C. N. Forbes in 1920 in mesic forest above Puu Pane (#1841).

This species was not encountered in the study area by this survey. We tentatively consider it extirpated.

Rumex skottsbergii Deg. & Deg. 1971 (E:Nihoa,Mo[?],EMa,H)

Degener and Degener (1971), who authored this species, note: "At present we know this species complex is native to Hawaii (island), where it is common on the ash and aa flows from about Kilauea...through the Ka'u desert...into Kona, until stopped by forests. It grows from about 2000 to 7000 feet elevation. It is strictly a pioneer, springing up like a weed in bulldozed aa lava. The roots of the seedling apparently rush during the rainy season to reach moist depths for the plant's establishment before advent of the dry season.. The species extends in imperfectly known varieties and forms to Maui, where it thrives in and about Haleakala's cinders and ledges...It does not reappear until dry, eroded Nihoa, where it was collected at 600 feet elevation.." (Degener and Degener, 1971-Fl.Haw.).

St. John (1973) includes Molokai as part of the above distributional range, perhaps erroneously.

The Degeners' evaluation of the status of native Rumex on East Maui as "thriving" may be misleading. Native Rumex is today quite rare within Haleakala Crater and on the upper dry slopes.

Forbes in 1920 collected Rumex in the Auwahi district (#2110M) with the field note: "on a rocky ridge." Fosberg (1972) has also noted this species at Auwahi. These collections may best be interpreted as R. skottsbergii.

This survey has not encountered native Rumex in Auwahi or neighboring districts. However, it has been recorded from Kula Forest Reserve on the SW rift above 6000ft, where Hobdy (pers.comm.) considers it quite rare.

PORTULACACEAE

Portulaca cyanosperma Egler 1937 (E:Lehua,K,O,H,EMa?) 'Ihi

Egler (1937) noted: "A segregate from Portulaca villosa Chamisso to which it is similar... P. cyanosperma is presumably endemic to Kauai and to the nearby islet of Lehua; P. villosa Chamisso is not known to occur on these islands."

Degener (1938-Fl. Haw.) stated: "A typical xerophyte collected by the writer June 13, 1926 on the arid plain given over to cattle just back of the Barking Sands of Mana, Kauai. The plants were quite common locally among the sparsely growing grass exposed to full sunlight or partly shaded by scattered algoroba trees...Known only from Kauai and Lehua."

An examination of BISH collections of P. cyanosperma reveals an interesting pattern of apparent spread of this species from Kauai/Lehua to the islands of Niihau, Oahu, Maui, Hawaii, Molokini and Kaula rock. A note on the Niihau collection (BISH) states that local residents said that this species had been introduced with horses five years previously. Portulaca cyanosperma may be identified in the field by its shiny, metallic blue seeds.

This species is common in many locations on the south slope of Haleakala from near sea level to 2800ft. It thrives in areas of disturbance - even in areas heavily impacted by cattle and in cracks in the main road.

Voucher: ACM/LLL #257; ACM #367, #555

Portulaca lutea Soland. ex Forst. f. 1786 'Ihi
(I:H.I.Pacific Is.)

Degener (1933 - Fl.Haw.) states: "A rare native strand plant growing among bare rocks or in sunbaked clay usually within reach of the ocean spray during storms. Common in many low Pacific islands...The Hawaiian Archipelago is apparently a little too north for this species to thrive."

Whatever the reason, this species is apparently quite rare in the study area. Portulaca lutea was observed but not collected on a steep slope above the sea in the Kaupo district.

Portulaca sclerocarpa Gray 1854 (Kah,L,Ma,H) Ihi-mākole, po'e

Hillebrand (1888) states: "Hawaii! and Maui! on dry lava fields 2000-5000ft above the sea; Lanai (M & B); Kahoolawe (Lydg.)."

This species is distinguished from all other Hawaiian species by its extremely thick capsules which Hillebrand (1888)

notes "generally do not open until some time after they have fallen from the plant."

Collections have been made of Portulaca growing in the upland regions of the study area by Hillebrand/Lydgate ca. 1869, Forbes at Nu'u district in 1920, Degener in the Nakaohu district in 1948, and Stemmermann/Sylva in Lualailua district in 1977. This latter collection was made from a colony of about 200 plants at 1600ft near Lualailua Hills (L. Stemmermann, pers.comm.). Due to the confusion between this species and P. villosa, and the lack of fruiting materials in many collections, positive identifications as P. sclerocarpa are lacking.

This species may still be extant in the study area but if so has low population numbers.

Portulaca villosa Cham. 1831 (E:Nihoa, Kaula, O, Molokini)

For many local botanists, there is some confusion between this species and P. sclerocarpa. Hillebrand (1888) noted: "In dry rocky places...(Cham. & U.S.E.E.). Unknown to me if really distinct from the following [= P. sclerocarpa]."

Collections that key to this species have been collected by Hobdy, Sylva and this survey, mostly along the coast or in the rocky lowland foothills. This species is found occasionally in isolated locations from Kanaio beach eastward to Kaupo (R. Hobdy, pers. comm.). It is quite rare but apparently not threatened at this time.

Voucher: ACM #594, cultivated specimens of Portulaca spp. at Kahului Forestry baseyard, Maui (Hobdy).

PRIMULACEAE

Lysimachia kipahuluensis St. John 1971 (E:EMa)
Pua-hekili, kolokolo-kuahiwi

St. John (1971) described this variable species, citing collections from eastern Koolau gap across the north rim of Haleakala Crater to the Paliku area and in upper eastern Kaupo Gap. He noted: "The characters of these specimens all fall within the limits recorded for the holotypic collection."

Stemmermann et al. (1981) state, "Lysimachia sp. cf. remyi Hbd. Occasional, vertical cliffs of Paliku, E. and W. Kaupo, and Koolau."

This report will refer to those specimens of this genus found within the study area as L. kipahuluensis. In western Kaupo gap, the plant is occasional in tufts of surrounding vegetation at 4700-6800ft on the sheer pali walls. In eastern

Kaupo, this same species (often with broader leaves) grows on cliffs as well as in mesic shrubland in the vicinity of the large fenced enclosure.

Voucher: ACM/LLL #406, #407; ACM #573

RANUNCULACEAE

Ranunculus mauiensis Gray 1854 var. mauiensis (E:K,O,Ma) Makou

Ranunculus mauiensis may once have been fairly common, but is now extremely rare above 4000ft on East Maui (Medeiros and Loope, unpublished). Forbes collected it (#1834M) in 1920 at "Waihualele" in the forest above Puu Pane on the south slope of Haleakala. We encountered a small population (no collection due to scarcity) at 5650ft in a gulch of upper Manawainui drainage in October, 1981.

RHAMNACEAE

Alphitonia ponderosa Hbd. 1888 (E:K,O,Ma,L,Mo)
var. auwahiensis St. John 1977 (E:EMa)
Kauila, 'o'a (Maui only)

Rock (1913) noted that Alphitonia "inhabits the dry regions on the leeward slopes of all the islands, but is nowhere common except on Kauai and at Auahi, district of Kahikinui, on Maui, where it is gregarious on the aa lava fields. It is in this latter place that the writer met with trees whose trunks were more than 2 feet in diameter." Rock (1910) noted of this species that "tall trees were found at Auahi, E. Maui, near Ulupalakua, also at Kahikinui, but most of them had died." Forbes in 1920 noted seeing "about 8 trees" of Alphitonia in a day's hike from "Kaluali'i to Middle Auahi." St. John (1977a) distinguished the Maui population as a separate variety.

This species was found by us only in eastern Kanaio and western Auahi, between elevations of 2000 and 4000 ft. About 200 trees occur as scattered individuals, most commonly in the more kikuyu grass-free areas. The presence of numerous "skeletons" of dead trees provide concrete evidence that Alphitonia was at least somewhat more common in the recent past. No young trees or seedlings are known, although flower and fruit production is abundant in late summer and fall. The hard dry fruits showed no rodent damage when left on the ground in our experiments. An unidentified insect infested the pulp of many fruits, but seeds appeared intact.

Very poor germination is reported from several nurseries. Seedling survival rate is even worse. No known specimen plant survives in cultivation.

Voucher: ACM #362, RAH/LLL #161a, #163

Gouania lydgatei St. John 1969 (E:EMa)

Hillebrand (1888) included two varieties of Gouania hillebrandii and noted: "Maui! gulches of Kula and Lahaina." Hillebrand attributed the beta variety solely to Kula, E. Maui. St. John (1969b) reviewed the genus and considered the collections from lower Kula by Lydgate and Hillebrand a new species, G. lydgatei. This taxon was not encountered by this survey and is probably extinct, whereas several populations of G. hillebrandii still survive on West Maui.

Gouania pilata St. John 1969 (E:EMa)

This shrub species was described by St. John (1969b) as a segregate taxon of Gouania hillebrandii. The type collection of the new species has no collector name nor precise locality, only the location "Maui." However, Hillebrand's (1888) description of G. hillebrandii (sensu latu) would imply that the collection now considered G. pilata probably came from Kula, E. Maui. Gouania pilata, like G. lydgatei, has not been recorded since the type collection in the late 1870's and is undoubtedly extinct.

ROSACEAE

Fragaria chiloensis (L.) Duch. 1766 'Ōhelo-papa
var. sandwicensis Deg. & Deg. 1961 (E:Ma,H)

This taxon is endemic to the 4000-7000 ft zone on Maui and Hawaii. Forbes noted but did not collect it in high-elevation shrubland above Lualailua in 1920. This survey found it fairly common in upper east Kaupo Gap and along the subalpine shrubland-forest ecotone from Wailaulau west to the Kula Forest Reserve. It is found with native Dryopteris spp. in the understory of plantings of introduced conifers in Kula Forest Reserve.

Osteomeles anthyllidifolia Lidl. 1822 (E:H.I.) 'U'u lei, u lei

The growth habit of this shrub varies tremendously on Haleakala's south slope and elsewhere, from prostrate and rambling to erect. In the Auwahi and Kanaio districts at 2500-4000 ft, it forms large, rounded shrubs to 2m tall. During the summer months, Osteomeles flowers attract large numbers of honeybees (Apis mellifera, introduced).

Though probably reduced somewhat, Osteomeles is still fairly common over much of the south slope from 1500 to 7500 ft. It is abundant in low Sophora shrubland at ca. 6000 ft in Kula Forest Reserve as well as in certain areas of western Kaupo Gap at ca. 4000 ft. A light-demanding species, it is not found in areas occupied by closed forest. Like other native

shrub species which are surviving in spite of heavy browsing, its reproduction is primarily vegetative - from new shoots produced at the base of existing plants as old shoots die.

Voucher: ACM/LLL #421

Rubus hawaiiensis Gray 1854 (E:K,Mo,Ma,H)

'Ākala

Rubus hawaiiensis is common in open, moist areas at high elevations on Maui and Hawaii, and less common on Molokai and Kauai. Hillebrand (1888) notes: "..Maui! southern slope of Haleakala! near the path from Ulupalakua to the crater, where it grows at an elevation of 6000-7000 ft in company with Geranium arboreum." Forbes collected it (#1827M) above Puu Pane in the Lualailua district and in Kula. Our survey encountered it at 4900 ft and above in Kula Forest Reserve, Kaupo Gap, and the cloud-belt Acacia/Metrosideros forests from Manawainui to Wailaulau.

RUBIACEAE

Bobea sandwicensis (Gray) Hbd.1888 (E:Mo,L,Ma)

'Ahakea

Hillebrand (1888) and Rock (1913) provide nearly identical keys to the species of this endemic genus. The characters emphasized are those of calyx shape, number of flowers per cluster and number of pyrenae (seeds) in the drupe. The Hawaiian genus is divided into two separate groups of species (Rock 1913): 1) the "wet forest" group, including B. elatior and B. manni, which Rock notes are "perhaps a single species"; and 2) the "dry forest" group including B. sandwicensis, B. hookeri and B. timonioides, of which Rock (1913) notes (p.439) "...only differing from each other mainly in the number of pyrenae", and concedes that (p.445), "These last three species may form in reality only a very variable species."

Forbes, who was aware of these characters, made successive collections of Bobea (#1957M, 1958M, 1959M, 1960M) on the south slope in 1920. He noted: "#1957M Bobea sandwicensis 2-6 flowers, large tree 30ft. #1958M Bobea hookeri? flowers mostly single, a few inflorescences with three flowers, otherwise as #1957M. #1959M Bobea timonioides? calyx toothed, not broadly lobed. Flowers single or in threes, otherwise as in #1957, #1958. #1960M Bobea sandwicensis calyx lobes broad. I think these Bobea all the same species or varieties of the same species." In this area, Forbes in 1920 noted Bobea as being "very common".

Our observations and collections of this genus on the south slope confirm the variability cited by Rock and Forbes. Shape of the calyx, leaf shape, and size and numbers of

flowers, all of which are supposedly diagnostic characters, seemed variable from individual to individual even at the same site.

Bobea specimens from the study area generally had a short cup-like calyx with four broad lobes. Numbers of flowers varied from single to three and up to seven. The number of pyrenae per drupe was variable between four and six, with most having five. Most of these characters generally match those of B. hookeri, except that that species is described as having single flowers and is not listed as being present on Maui by St. John (1973).

Regarding B. hookeri, Rock (1913) notes: "This species differs very little from Bobea sandwicensis Hbd. Its outward appearance, color of leaves and branching habit are exactly the same in both species. When neither in flower or fruit, it would be absolutely impossible to separate the two species...It also grows on the lava fields of Auahi.. there the writer met with a single tree ...associated with Alectryon macrococcus, Tetraplasandra meiantra var., Pittosporum, Dracaena aurea, and others. It is one of the rarest trees in the territory."

The genus Bobea is still fairly common within a restricted area on the Puu Mahoe flow at 1900-2400 ft and above Lualailua hills at 2160-2400 ft, comprising over a hundred trees in the latter site. A few trees were also seen in Kanaio at 2600 ft, and a single tree, almost dead, was seen in Auwahi at 2800 ft.

In general, the surviving trees are old, but still vigorous, with slight crown loss and with moderate to robust fruit production. Although Bobea occurs outside the kikuyu grass zone, no reproduction was noted.

Canthium odoratum (Forst. f.) Seem 1866
(I:H.I., Fiji, Polynesia)

Alahe'e, walahe'e

Hillebrand (1888) states of C. odoratum: "All islands, on dry open slopes of mean elevation, rather common in the southern parts of Hawaii and on E. Maui..." Rock (1913) remarks: "...a shrub or small tree reaching a maximum height of 20 ft. It has a round crown, bright green, very glossy leaves; the white fragrant flowers add to the beauty of the little tree during the summer months. It inhabits the dry regions of the low lands or lower forest zone up to 2000 ft, and is a rather common tree on all islands... The wood...is very handsome, exceedingly hard and durable. It was used by the natives for their implements with which they tilled the soil. The leaves were used in coloring articles black."

This survey found Canthium common from Kaunauhane near the western edge of the study area east through Mehamenui district at 1000-2000 ft, occasionally up to 2400 ft. Flowering occurs

intensely during the summer months. The strong daytime fragrance of the flowers attracts large numbers of introduced honeybees (Apis mellifera). Though abundant fruit production was noted in late-November and December, only a few ephemeral seedlings were observed. In contrast, fairly good seedling establishment is reported by Williams (1980) for the lowlands of Hawaii Volcanoes National Park on Hawaii.

Good seed germination is reported in the greenhouse (Hobby; Obata, 1973b).

Voucher: RAH/LLL #188

Coprosma ernodioides Gray 1858 Kukae-nene, 'ai-a-ke-nene
var. mauiensis St. John 1935 (E:Ma)

Hillebrand (1888) states regarding C. ernodioides: "high mountains of Hawaii, E. and W. Maui! from 5000-7000 ft, where it covers the ground in abundance on the bare lava. The wild mountain geese...feed on the berries, which are called by the natives 'Kukai neenee', droppings of geese." Coprosma ernodioides is distinct from other Hawaiian Coprosma species and is presumably the result of a separate introduction (Oliver 1935).

We found this species scattered and locally common in open areas at 1850-9750 ft, especially in the 5000-8000 ft zone. Within Haleakala National Park, it is fairly common in Kaupo Gap above 4600 ft.

Coprosma montana Hbd. 1888 (E:Ma,H)

Pilo

This shrub is an abundant component of the open forests and subalpine shrublands above 5500 ft on the south slope and in adjacent Haleakala National Park. Coprosma montana reproduction (usually vegetative) has been observed in much of this range. Goat browsing and pig rooting restrict reproduction (both vegetative and by seedlings) in some areas, as in upper Nakula and Nu'u, and have eliminated the species itself in some localities (e.g., Crystal Cave area of Haleakala Crater).

Coprosma stephanocarpa Hbd. 1888 (E:Ma)

Pilo

This shrub/tree is common in upper Auwahi, throughout the Acacia koa forests of the Manawainui planeze and Kahikinui, and in the koa/Myrsine forests of eastern Kaupo gap. Its elevational range is from 3600 to over 6000 ft. Fruiting occurs in the August- November period. Caches of empty seed cases of both C. stephanocarpa and C. montana provide evidence of predation by rodents. Nevertheless, C. stephanocarpa is

currently reproducing by seed in eastern Kaupo Gap and in some areas of koa forest outside the Gap, where browsing pressure is light to moderate. Heavy browsing pressure has resulted in suppression of seedlings and saplings in many areas.

Voucher: RAH #107; ACM/LLL #400

Gouldia hillebrandii Fosberg 1937 (E:Mo,E/WMa,H) Manono
var. hillebrandii

Fosberg (1937) states: "Gouldia hillebrandii presents a series of three varieties, one on each island of its range. From Molokai to Hawaii they become progressively more hairy and the inflorescences become progressively more reduced. On Molokai and Maui the varieties are divided into several closely related forms." Fosberg notes the distribution of var. hillebrandii as "eastern Maui and eastern slope of West Maui.."

Stemmermann et al. (1981) give the status of Gouldia hillebrandii in Haleakala Crater as "uncommon above Paliku." This survey found this taxon to be relatively common in Acacia/Metrosideros forest at 4500-5650 ft between Manawainui and Pahihi drainages. We located a single tree in the upper part of the large E. Kaupo enclosure (4900 ft).

Gouldia terminalis (H. & A.) Hbd. 1888 (E:H.I.) Manono

Rock (1913) stated: "The genus Gouldia is strictly Hawaiian, and consists of a goodly number of ill-defined species, most of which are shrubs, only very few becoming trees. As they are at present in a mixup, and difficult to determine without type material, it is thought wise to mention only these few..."

Fosberg (1937) undertook the formidable task of straightening out this "mixup." His work illustrates one approach to the treatment of the great morphological variation which occurs in many Hawaiian groups, sometimes correlated with geographic separation, and sometimes not. St. John (1973) lists 39 varieties and 54 forms of Gouldia terminalis, most described by Fosberg.

Gouldia terminalis var. pubescens of Fosberg (1937) is based on two specimens, both collected on the south slope of East Maui. Forbes in 1920 collected the type material (#1898M) near Puu Pane in the Mahamenui district. Degener also collected this taxon in 1927 "north of Ulupalakua" (#9472).

Gouldia terminalis var. parvifolia of Fosberg (1937) has two forms, f. euparvifolia and f. subpilosa, both apparently restricted to the area around Kaupo Gap. Forbes collected the former form in E. Kaupo Gap in 1919 (#1121M). Degener

collected the latter form in 1927 in the "rainy region of Kaupo Gap" (#2570).

This survey found this twining shrub or low tree relatively common in the lower section of the Metrosideros/Acacia forest ca. 4000-5000 ft between Manawainui and Pahihi drainage. It is rare in eastern Kaupo Gap at 4750 ft. Hobdy (pers. comm.) noted this species as very rare in upper Auwahi ca. 4000 ft.

Obata (1973b) reports that G. terminalis is easily germinated from seed and grows well in pot culture. Transplanted seedlings grew well, flowered and then eventually died at Wahiawa Botanical Garden.

Voucher: ACM #241

Hedyotis centranthoides (H. & A.) Steud. 1840 (E:O,Mo,L,Ma,H)

Fosberg (1943) states: "This species is widespread, but only very locally common, and is highly variable."

This survey noted and collected this species within the study area only once, at 4900 ft, west of Manawainui drainage in Acacia/Metrosideros forest in a gulch with Myrsine, Pelea grandifolia, Lobelia grayana, Rubus hawaiiensis, and numerous ferns. The specimen keys most closely to H. centranthoides f. vestita Fosberg, restricted to Molokai, Lanai, Maui, and Hawaii.

This species is still widespread in rainforest on East Maui. Within the study area, it has been previously collected by Forbes in 1920 at "Kaopilopilo gulch" (#1943M- apparently near our collection site), by Degener (#2357) in 1927, and by Degener and Salucop (#12519) in 1939 on the east side of Kaupo Gap. Although the species occurs near Paliku at present, we did not observe it in Kaupo Gap.

Obata (1973b) notes seed germination of unspecified Hedyotis as good, and that growth both in the ground and in pots is rapid.

Voucher: RAH/LLL #121

Hedyotis foliosa (Hbd.) Fosb. 1943 (E:EMa)

Fosberg (1943) states concerning H. foliosa: "Found.. on East Maui, on the slopes of Haleakala, according to Hillebrand, at altitudes of about 4000 ft." Fosberg lists six collections made by Hillebrand and/or Lydgate ca. 1860-1870 on the southwest slopes of Haleakala. Locality descriptions on these specimens include "Kula, Isthmus of Maui," "upper Kula,"

"Haleakala," "Haleakala south," and "southern slopes of Haleakala". Fosberg (1943) further states: "Not found since Hillebrand's time, possibly extinct."

Hedyotis foliosa was not found by our survey and is presumed extinct.

Psychotria mauiensis Fosberg 1964 (E:EMa,L)

Kopiko

This variable taxon was described by Hillebrand from material collected at Ulupalakua ca. 1870. Rock (1913) noted it as a 25 ft tree in dry gulches back of Makawao. Forbes collected it three times (#1977M, 2049M, 2094M) on the south slope, twice noting a single tree seen.

Although this species is currently more common in some mesic forest areas of Maui, our survey found only 5 trees on the south slope. Three were on the Auwahi-Kanaio aa flow, one at 3300 ft, the others at 2400 ft. Within the Haleakala National Park section of the study area, two individuals of P. mauiensis are known, both in a fenced (1981) enclosure on a west-facing slope ca. 4900 in east Kaupo Gap. No reproduction is known from these sites, although fruits are produced. Psychotria mauiensis flowers at east Kaupo Gap in June-July and fruits in July-August.

Voucher: ACM #212

RUTACEAE

Hawaiian name for genus Pelea = 'Alani)

Pelea adscendens St. John & Hume in St. John 1944 (E:EMa)

This species was described in St. John (1944) based on two specimens collected by Forbes in Auwahi on March 24, 1920 (#2100M-Holotype, #2088M). Forbes notes regarding the holotype, "...the same as 2088M but another plant a long distance away. Capsule deeply parted nearly to the base." Regarding the habitat, he notes: "Open forest type with Osmanthus dominant, Dracaena second at least in the lower part." From this description, the collection seems to be made in the 3000-4000 ft level in middle or west Auwahi. No further collections were made until 1982.

We encountered only a single individual of P. adscendens at 4000 ft near Puu Ouli in Auwahi. The habit of this endemic south slope species is distinct from other species of the genus. Whereas most Pelea are trees, P. adscendens more resembles a sprawling vine. The plant is barely a meter tall, yet two meters broad with at least a hundred branch tips. The leaves are opposite with revolute margins and resemble a large leaved maile (Alyxia olivaeformis).

The identification of this species was confirmed by Stone, monographer of the genus, who identified the Pelea specimens collected during this survey.

Voucher ACM #230

Pelea clusiaefolia Gray 1854 (E:H.I.)
ssp. clusiaefolia var. crassiloba Stone (E:O,EMa)
f. degeneri Stone 1966 (E:EMa)

Pelea clusiaefolia was collected by this survey in Acacia/Metrosideros forest at 5100-5400 ft between Manawainui and Pahihi gulches. About a dozen individuals were observed, in an area where P. grandifolia also occurs. Pelea clusiaefolia ranges throughout moist forests of the Hawaiian Islands and is extremely polymorphic. Stone tentatively assigned our specimens to var. crassiloba f. degeneri. Previously, this form was known only from a 1927 Degener specimen (#8553) from "north and inland of Ulupalakua, in small ash-cinder crater." The type form of var. crassiloba (the only other form) is found only on Oahu. Stone (in litt., 1983) noted of ACM #309: "This specimen lacks fruit, so the thick-walled character of var. crassiloba cannot be determined; but the leaf form and locality and other vegetative features strongly suggest f. degeneri. It is possible that this forma should be placed under ssp. cookeana. Fruiting collection needed."

Voucher: ACM #236, #309

Pelea grandifolia (Hbd.) St. John & Hume in St. John 1944
var. grandifolia (E:Ma,H)
var. ovalifolia (Hbd.) St. John 1944 (E:Ma,H)
var. terminalis (Rock) Stone 1969 (E:EMa)

This is a species of high elevation mesic to rain forests on East Maui and throughout its range. Stone (1969) notes: "Pelea grandifolia is a highly variable species, and it is a matter of doubt whether the varieties described above will prove, in a consideration of numerous collections, to have much value." The type specimens for var. ovalifolia and var. terminalis were both collected from the south slope. Hillebrand collected the var. ovalifolia material at an unspecified south slope site ca. 1870. Rock collected the type material for var. terminalis at Auwahi in 1910, noting: "A shrub with long rambling vinelike branches. . ."

Pelea grandifolia var. grandifolia and var. ovalifolia are both known from numerous East Maui collections. Many south slope collections have been assigned to var. ovalifolia. Forbes collected this species above Puu Pane (#1896M) and near

Puu Ouli above 4000 ft. Degener collected this species in 1927 "north mauka (inland) of Ulupalakua" (#8552) and in the Paliku area.

This species was noted on the south slope by this survey in two areas. Several hundred individuals were found in the cloud forest belt between Manawainui and Pahihi drainages at 4000-5500 ft, mostly on stream banks in gulches. Only three individuals were found at 4700-5100 ft in eastern Kaupo Gap - two on a west-facing ridge and one in a stream gulley below in Myrsine/Acacia/Sophora forest. In June, 1983, one of the two trees situated at the upper end of the fenced enclosure on the ridge appeared dead. Trees were found to flower and fruit, but no seedlings were seen. Many individuals in the study area are in a decadent condition.

Voucher: ACM #238- var. uncertain
ACM #317- var. terminalis
ACM #216, #217- cf. grandifolia

Pelea haleakalae Stone 1966 (E:EMa)

Stone (1969) notes regarding P. haleakalae: "This interesting new species is...closely related to Pelea clusiaefolia...it differs markedly however in the much larger flowers with...thickened sepals which persist on the mature capsule, and also in spatulate and decurrent leaf blades."

An East Maui endemic collected mainly in middle elevation rain forest on the northwest outer slopes, this species was collected by P.J. Scheur and F. Werny (#3219) in 1959 with the note: "south slope of Haleakala, ca. 2000 ft." Our survey has not encountered this species, nor any Pelea of the distinctive P. clusiaefolia type at an elevation below 5000 ft. Its status within the study area remains uncertain.

Pelea hawaiiensis Wawra 1873 Manena
var. hawaiiensis (E:Ma,H)
var. pilosa St. John 1944 (E:L,Ma)
var. racemiflora (Rock) St. John 1944 (E:EMa)

This attractive and variable (9 varieties, according to Stone, 1969) species with distinctive tomentose reddish to green capsules is known from dry to mesic forest sites on most islands. Although south slope specimens have been assigned to three varieties, we collected only one, var. hawaiiensis.

Pelea hawaiiensis var. hawaiiensis is restricted to East Maui and the western part of Hawaii (Stone, 1969). It has been collected by Degener on "ridge north of Pohakea gulch" in lower Kanaio. Four mature, relatively vigorous trees (but with browse lines) were located by this survey in western Auwahi at 3000-4000 ft. Two trees were found in East Kaupo Gap

(Haleakala National Park) at 4850 ft. Fruits with plump seeds were found at both sites, but there are no seedlings. For the genus Pelea in general, seedlings are very slow growing and intolerant of any browsing.

Pelea hawaiiensis var. pilosa was described from Hillebrand's ca. 1870 collection from Lanai. According to Stone (1969), this taxon has since been known only from a series of 1920 Forbes collections from Haleakala's south slope [Forbes #2097M, 2098M, 2099M, 2115M, s.n.]. These were all from the Auwahi district and noted by Forbes as trees 12-15 ft tall.

Pelea hawaiiensis var. racemiflora was described from material collected by Rock in 1910 [#8676] "on the rough aa flows on the southern slopes of Mt. Haleakala... between the huge blocks of lava, at an elevation of 1500 ft, where it is in company with Reynoldsia sandwicensis and Alphitonia excelsa (=A. ponderosa var. auahiensis), one of the most predominant trees in the district." Forbes collected this variety from the south slope at "Pakiloi forest" (location unknown to us - #2082M).

Voucher: RAH #101, #128, #131; ACM #229, ACM #211.

Pelea mucronulata St. John 1944 (E:EMA)

Stone (1969) states of P. mucronulata: "This species appears to be very rare. It differs from P. barbiger in the much shorter and sparser pubescence, the more ovate leaf blades, the shorter petioles, and the larger mucronulate follicles... Rediscovery of this species is an important desideratum."

The type collection (#2078M) of P. mucronulata was made by Forbes in 1920. Forbes' description of the area covered while collecting that day reads: "Palikoi mauka and Kamana below this, both below the trail. Forest west of camp. A rich varied forest with perhaps Dracaena [=Pleomele] dominant, not much Osmanthus." This description suggests a collecting locality in lower Auwahi/Kanaio at ca. 2200 ft (Pleomele abundant, Osmanthus mostly above this level). Forbes noted of the type collection: "Tree 12 ft high. Capsules with very thin walls and very narrow, 1-2 seeded, bluish-green in color, cocci separate to the base."

Pelea specimens collected by this survey were sent to Stone at Kuala Lumpur, Malaysia, where he kindly made determinations. Dr. Stone identified specimens RAH #110 and #129 as "low altitude, less puberulent forms of Pelea multiflora." He noted regarding RAH #110, "this specimen like RAH #129 approaches P. mucronulata St.J. in its less puberulent leaves, but it has puberulent sepals. It seems to be merely a low-elevation form of P. multiflora." In comparing these

specimens to type material of P. mucronulata at the Bishop Museum, it is apparent that the collections are quite similar.

This survey has noted three widely scattered trees in Kanaio at 2200-2700 ft that are close to P. mucronulata. Though subject to browsing primarily by goats, all three were still vigorous. All were fruiting heavily in October-December 1981. One individual had many of its leaves badly deformed by galls of an unidentified insect. No seedlings or saplings were noted.

Voucher: RAH #110, #129

Pelea multiflora Rock 1911 (E:EMa)

This species is endemic to Auwahi, where Rock discovered it in 1910. Rock (1913) notes it as a tree, 30-40 ft tall, growing with Tetraplasandra, Alectryon, Bobea, Alphitonia, Planchonella, and Antidesma. Forbes noted of this species at Auwahi in 1920: "very common, some trees 40 feet tall, one foot diameter... The tree has the aspect of a Xanthoxylon."

Stone (1969) noted of Pelea multiflora: "It is close to Pelea tomentosa St. John and Hume of Maui but differs in the denser pubescence and the larger fruits." Dr. Stone (in litt.) assigned five of our specimens to P. multiflora. He noted that two of the collections (RAH #110 and #129) represented lower elevation, less puberulent forms (see Pelea mucronulata).

This survey found about a dozen trees of P. multiflora at Auwahi and Kanaio in the 2500-4000 ft zone. None of the trees seen produced large inflorescences comparable to those illustrated in Rock (1913, Plate 89). Hobdy (pers. comm.) has suggested that this may be attributed to the low vigor of the surviving trees. Hobdy notes that several trees that seemed vigorous in the early 1970's were dead by 1982. No seedlings or saplings were seen.

A healthy 6m tree of P. multiflora is growing (1983) in the arboretum at Puu Mahoe above Ulupalakua. It was planted in the 1930's by Dr. David Fleming as a seedling obtained from the Auwahi area (J. Vockrodt, pers. comm.).

Voucher: RAH #110, #129, #135, #138; LLL #1101; ACM #560

Pelea tomentosa St. John & Hume in St. John 1944 (E:EMa)

Described in St. John (1944) based on a specimen collected by Munro at "Auhi, Ulupalakua" in 1915, P. tomentosa has apparently otherwise been collected only twice. Stone (1969) cites a specimen collected by Forbes in 1920 above Puu Ouli in

upper Auwahi district [#2137]. St. John has also identified a collection made by Colin Lennox in Auwahi at 3300 ft in 1971 as this species.

Stone (1969) states: "This species manifestly differs from P. multiflora and P. knudsenii, which appear to be close relatives.. It is an imperfectly known species, and new collections and field data would be very worthwhile."

No specimens collected by this survey have been identified as P. tomentosa. Lennox's 1971 collection of this species in Auwahi at 3300 ft places it at least partly in sympatry with P. multiflora. The 1920 Forbes collection #2137M appears to have been collected in more mesic upper elevation forests than is typical of P. multiflora, however. The relationship between the three species of section Apocarpa of the genus Pelea (P. multiflora, P. mucronulata and P. tomentosa) endemic to the study area deserves further exploration.

Pelea volcanica Gray 1854 (E:L,E/WMa,H)

Stone (1969) notes that this species belongs to a "cluster of species" in the Megacarpa group that includes P. grandifolia. He further states: "Though P. volcanica is here distinguished by its very large, thick-walled capsules from P. grandifolia, it may be as Hillebrand felt, that the two species intergrade and... one species with several varieties is involved. However, I have not found intermediates with regard to capsule size and wall thickness; there seems to be real discontinuity here."

None of the specimens collected by this survey were identified by B.C. Stone as belonging to this species. It was previously collected on the south slope by Munro at Auwahi/Ulupalakua in 1915 (Stone 1969) and by Forbes in 1920 at Auwahi (#2116M) and in Kaupo Gap (#1110M- with the note: "Stiff tree 10 ft high. Leaves curled toward the underside. New growth pubescent."). Forbes and others have also collected this species a number of times in the rain forest of the northern and eastern slopes of Haleakala.

Zanthoxylum hawaiiense Hbd. 1888 (E:H,L,EMa)

A'e, hea'e

Hillebrand (1888) did not include Maui in the distribution of this species, giving its range as 5000-6000 on the island of Hawaii. Rock (1913) first recorded Z. hawaiiense on Maui, stating: "The true species, answering Hillebrand's description in nearly every detail, was found by the writer on the southern slope of Haleakala, Maui, where the tree is however not abundant. There, the trees have not the slightest odor of lemon, but the ordinary, somewhat soapy smell, as have the rest of our Zanthoxyla."

Zanthoxylum hawaiiense was collected in Auwahi by Rock (#8657) in 1910, and by Forbes in 1920 at the following sites: Laumau forest above Lualailua (#1926M and #1929M); forest east of Lualailua (#1952); Auwahi (#1956M and #1962M); and "Pakiloi forest" (#2068M).

Regarding #1929M, Forbes noted: "leaflets the color and shape of Eucalyptus, even the petioles the same reddish tinge. Tree with straight trunk 35 feet high, few branched above. Sterile." Regarding Auwahi, Forbes' notes state: "Zanthoxylon two species, not uncommon," apparently referring to Z. hawaiiense and Z. kauaense. Degener collected Z. hawaiiense (#26868) with Ward Fleming in 1960 with the note: "Single erect 25 ft high tree. Skyline drive, mauka of Kahikinui cabin, Maui. Probably last Fagara in entire decadent forest." In 1967, Herbst, Lamoureux and Bishop collected this species at Auwahi at 3400 ft.

This survey located nine trees of Z. hawaiiense at 2400-4900 ft in Kanaio, Auwahi, and Lualailua. One of these, in western Auwahi at 3400 ft, was a 3m sapling. This species is very near extirpation on Maui.

Voucher: RAH/LLL #175

Zanthoxylum kauaense Gray 1854 (E:K, Ma)

A'e, hea'e

Rock (1913) wrote concerning this species on Maui: "At Auwahi... the trees reach a handsome size and trunks of a foot and a half or even more in diameter are not uncommon, though growing never taller than 40 feet. The trees are quite numerous, especially on the southern border of Auahi, where the district of Kahikinui meets Kaupo; there the writer saw the finest specimens, which formed practically the sole tree growth... They differ... from the Kauai specimens in that the leaves are always three-foliate and never five-foliate, in being chartaceous instead of coriaceous... On the northwestern slope of Haleakala the writer met trees of this species in the forests above Makawao, but there the leaves were all five-foliate, membranous and quite glabrous..."

Rock collected this species in 1910 and 1912 in the Auwahi and Makawao areas. Forbes collected it in 1920 near Haiku (NW slope) and on the south slope at Manawainui drainage (#1881M), noting "...3-foliate, sterile. One seen."

In contrast to Rock's comments regarding the relative abundance of this species in 1910-12, we found it to be extremely rare. A few trees of this species were found (sterile) in October, 1981, in Auwahi at 4600-5000 ft. Within Haleakala National Park, a single specimen occurs on a steep slope at 4850 ft in eastern Kaupo Gap, protected since mid-1981 by an exclosure. A sterile collection was made from this small tree in 1982. On the west slope of Haleakala, in relictual

native forest above Makawao (Waihou Spring Reserve), three senescent trees (3-5 leaflets) apparently of this species were seen in 1983 (see Z. maviense, last paragraph).

Voucher: ACM #214; ACM/R.Hobdy #374; RAH #124

Zanthoxylum maviense Mann 1866 (E:Mo,L,E/WMa,H) A'e, hea'e

Hillebrand (1888) noted the distribution of Z. maviense as "W. Maui! (Remy and Lydg.)," recognizing distinct varieties from Molokai, Lanai and Oahu. Rock (1913) stated: "This species seems to be indeed a very variable one; the writer has collected material of this species on Maui, Hawaii and Lanai... The specimens from the above mentioned islands vary considerably, especially those from Lanai and Maui proper... It is the writer's opinion that the tree must be a dry district species.."

This survey encountered no specimens that matched Z. maviense in the study area or on the adjacent western slopes. Some of the unidentified Zanthoxylum collections from the study area housed at BISH (e.g., Degener #28095-Ulupalakua-1920) may be Z. maviense, however. This species has apparently been much less common in the study area than Z. kauaense or Z. hawaiiense within historical times.

Rock (1913) also described the variety rigidum, noting: "Collected on the Island of Maui on the northwestern slopes of Haleakala in Waihou gulch, back of Makawao, elevation 3000 ft, March, 1912, in company with Pseudomorus brunoniana and Sideroxylon Ceresolii... It is a small tree 15 feet high and is peculiar to Mt. Haleakala, where it grows in the drier districts on the steep slopes of Waihou gulch."

In company with R. Hobdy, who knew the location of Zanthoxylum in Waihou gulch, the type locality for Z. maviense var. rigidum Rock, we visited this western slope site above Makawao. We observed three trees of Zanthoxylum that appeared closer to Z. kauaense (ACM/R.Hobdy #374). These trees have leaves mostly five-foliolate (versus three) with leaflets much smaller than described. The trees were sterile, and there was no sign of reproduction.

SANTALACEAE

Exocarpus gaudichaudii A. DC. 1856 (E:H.I.) Heau

Exocarpus gaudichaudii is the commonest of the three endemic species of the strange genus Exocarpus in Hawaii. Though once found on leeward slopes throughout the Hawaiian islands, E. gaudichaudii is now very rare and scattered in distribution, especially on Maui. Exocarpus in Hawaii

generally grows in hot, dry areas exposed to high levels of solar radiation - especially open lava flows and exposed ridges.

On West Maui, it has been collected three times, twice by Forbes at Lahainaluna (1910-s.n.) and in Olowalu valley (1920-#2362M), and by St.#John and S.B. Jones (#17688) in 1936, north of Lahainaluna. Rene Sylva (pers. comm.) has also found Exocarpus at Hanaula and Iao valley on West Maui. It was first collected on East Maui by Rock in 1910 (#8653) who noted: "A single tree observed at Auahi on a-a lava, E. Maui. Elevation 2600 ft." Forbes in 1920 (#2085M) collected E. gaudichaudii at "Pakiloi forest, south slope of Haleakala" with the following observation, "...pericarp fleshy dark red with very fine fleshy dots. Nut light green with yellowish green dots. Shrub 6-8 ft. high, two seen..."

No records for the south slope since 1920 are known to us. Exocarpus may be locally extirpated.

Obata (1972) reports no success with seed germination for this species.

Santalum ellipticum Gaud. 1829 (E:H.I.)

'Ili-ahi

This green-flowered Santalum is a shrub or small tree up to 4-5m tall, though usually 2m tall, is abundant on the rough 'a'a flows of Kanaio Auwahi (1500-3500 ft) and Lualailua districts (1000-2600 ft). Scattered trees also occur east of Lualailua. Several groups occur in western Kaupo Gap at about 4200 ft. Stemmermann et al. (1981) note of this latter locality: "Locally occasional, in a few areas of lower central Kaupo Gap."

Flowering and fruiting have been observed during September- November. Although most trees are mature or senescent, root suckers, saplings and a few seedlings have been seen in Kanaio/Auwahi and Lualailua.

Flowering often occurred prolifically, flowers being sweet scented and attracting large numbers of introduced honeybees (Apis mellifera). Fruits of Santalum species are heavily preyed upon by rodents (e.g. Loope and Crivellone unpublished). Cattle break branches and trample seedlings, and goats browse this tree heavily. Lennox (1967) observed a number of sickly or dead trees in Kanaio and Auwahi which were infested with homopterous insects. Kikuyu grass inhibits regeneration in the upper part of the elevation range.

Although several botanical gardens have grown this tree from transplanted root suckers, germination rates are reported as poor to sporadic (Hobdy, Sylva, Wooliams). Specimen plants

may be seen at Maui Botanical Garden and at the Puu Mahoe Arboretum near Ulupalakua.

Voucher: RAH/LLL #162; J. Lau #1006

Santalum freycinetianum Gaud. 1829 'Ili-ahi
var. auwahiense Stemmermann 1980 (E:E/WMa)

Rock was the first botanist to note a distinctive red-flowered population of Santalum at Auwahi. He considered it a form of Santalum haleakalae. Rock (1913) wrote: "...it was observed by the writer...on the lava fields of Auahi, Kahikinui, at an elevation of 2600 feet. At this latter locality, which is one of the richest botanical districts in the Territory, it is a fine looking tree and does not show any sign of stiff branches and short gnarled trunk, as, of course, must be expected at high altitudes.. one could easily mistake it for [Santalum freycinetianum] of Oahu, which it, in reality, resembles greatly."

Stemmermann (1980) described these Auwahi trees as a new variety, S. freycinetianum var. auwahiense. Holotype material as well as other collections examined indicate distribution on the leeward side of East and West Maui. Collections from East Maui including type material for the variety are all from Auwahi district, centered around 4000 ft.

Stemmermann (1980) states: "Above approximately 5000 ft on East Maui there is a gradation to typical S. haleakalae, but affinities of the lower elevation plants with typical S. freycinetianum are apparent. Differences in leaf and petiole length separate S. haleakalae from the low elevation plants."

St. John (1984) considers S. freycinetianum var. auwahiense a taxonomic synonym of S. lanaiense. He states of the distribution of S. lanaiense in his revision: "Lanai on the slopes from 300 to 1000 feet, and on the mountain to 3,000 feet altitude; lower middle slopes of East Maui, especially at Auahi." This report provisionally retains the name Santalum freycinetianum auwahiense Stemmermann.

This survey found S. freycinetianum var. auwahiense generally restricted to Auwahi district at 3000-4000 ft. A single small tree is known from Kanaio district at 2700 ft. One of the surviving individuals growing at 4000 ft in Auwahi stands about 12m tall with a diameter of 50cm and is one of the largest living Hawaiian sandalwood trees (Figure 14).

At 5500-6400 ft, on the upper fringe of the Metrosideros/Acacia koa forest, there is also a red flowered Santalum. The populations encountered at the upper elevations of this range were typical S. haleakalae. Those at the lower

elevation sites, on the drier ridgetops growing with Acacia koa, correspond most closely to the characters S. haleakalae than to those of any other Santalum species. In specimens from these latter populations, however, there is some tendency for the lengthening of leaf and petiole, characteristics associated with S. freycinetianum var. auwahiense.

In all populations, flowering has been observed frequently, fruiting occasionally, usually in late summer or fall. No seedlings or saplings were noted. Vegetative reproduction by root suckers was noted infrequently at Auwahi. All trees at Auwahi are surrounded by a thick kikuyu grass mat that may inhibit reproduction (either vegetatively or by seed). Also, domestic cattle browse these trees.

At Kahikinui in the upper drainages of Manawainui and Poopoo, Santalum is under severe pressure from ungulates. Cattle, goats and pigs seem to seek out these trees as resting places. The ridges where the trees grow are used by these animals as accessways to lands above and below. As a result, erosion here is most severe. The ground beneath tree crowns is typically nearly devoid of vegetation and covered with droppings and hoofprints. The root system of nearly every sandalwood tree in Kahikinui is exposed by erosion to a depth of 50 cm or more. The roots of several Kahikinui trees had been gnawed, presumably by goats.

Santalum haleakalae Hbd. 1888 (E:EMA)

'Iliahi

This small tree is endemic to the slopes and crater of Haleakala between about 6000 and 8700 ft. As stated under the previous species, individuals perhaps best referable to this species were found in the study area down to 5500 ft.

We estimate that fewer than 200 individuals of S. haleakalae survive on the south slope of Haleakala. Goats browse all foliage within reach, and we observed no sign of successful reproduction either from seed or by vegetative sprouting from the root system.

Voucher: RAH/LLL #115, #116, #117, #118

SAPINDACEAE

Alectryon macrococcum Radlk. 1890 (E:K,Mo,E/WMa)

Māhoe, 'Ala'ala hua

This rare and beautiful tree with large fruits and compound leaves is found on Kauai, Molokai, and East and West Maui. A closely related species, A. mahoe, grows on Oahu (St. John and Frederick, 1949). Rock (1913) noted of A. macrococcum on Maui: "About seven miles from Ulupalakua.. is a small area

of forest on the lava fields of Auahi. Unpromising as it looks from the road, this forest is botanically, nevertheless, one of the richest in the Territory. It is there that Mahoe is not uncommon, and still thrives in company with many other rare trees peculiar to that small area, such as Pelea, Xanthoxylon, Bobea, Pittosporum, Pterotropia, Tetraplasandra, etc. Owing to its scarcity, it is unknown to most of the old natives, who have heard of it in rare instances from their ancestors." Rock states that he knew of about 40 trees of A. macrococcum in the Auwahi area in 1910 (Rock, 1910). Forbes in 1920 noted seeing "about 15 trees" of Alectryon in a day's hike "from Kalualii to middle Auahi." When Rock returned to the Hawaiian Islands in the middle 1950's and toured the Auwahi area with Ulupalakua ranch hand Bill Kaiakamelie, Jr., he was quite disappointed with the degradation of the area. He noted on a specimen label (#68569) of this species from Auwahi in 1954, apparently in reference to a stand of Alectryon he remembered from 1910: "Only one tree left."

Nine living individuals of Alectryon are known to us on the south slope, all in or very near Auwahi between elevations of 3170 and 3800 ft. All individuals are multiple-stemmed, and most are of moderate to low vigor, fruiting infrequently, and have substantial foliage reduction. The one fruiting tree monitored over several years annually produces approximately 100 fruits, however. No seedlings or young trees have been seen for many years, and several older trees have died since 1970 (Lennox, Hobdy pers. comm.). Most fruits found in 1981 were either destroyed by fungi and boring insect larvae while on the trees or by rodents probably after falling to the ground. However, most of the actual seeds remained intact for at least one season.

A heavy growth of fruticose lichens, especially Usnea spp. and Teleoschistes sp., occurs on the branches of Alectryon at Auwahi. Rock (1913) stated that abundant lichens on Pelea multiflora and several other species "seem to check the growth of the trees." Hobdy (pers. comm.) removed lichens from an Alectryon in Auwahi and found an apparent increase in vigor and fruit production the following year. It is possible that heavy lichen growth may significantly interfere with photosynthesis of trees declining due to old age and hasten their demise. If so, the only "unnatural" part of the phenomenon is that most, rather than a few, trees are in a declining stage.

It is doubtful that the few remaining trees of Alectryon in the Auwahi area will live for more than a few more decades. The odds against survival of seedlings in nature are seemingly insurmountable - given the low production of viable fruit, competition from kikuyu grass, and browsing of cattle and goats. This is a species for which only extreme measures (probably artificial propagation and fencing) would help.

Hobby has grown Alectryon from seed of Auwahi trees. Seedlings did not survive well after transplanting. Lennox tried and failed at nursery germination. Wooliams has attempted rooting of cuttings of A. macrococcum from Auwahi (dipped in 2,4-D solution for six seconds) without success.

Voucher: RAH/LLL #203; ACM #562

Dodonea eriocarpa Sm. 1809 (I:H.I. & Galapagos)

A'ali'i

Tentatively, Dodonaea of the study area will be referred to as D. eriocarpa. The genus is found from just above sea level to at least 7200 ft. on the south slope and as high as 8400 ft on the west slope. It is common and locally abundant in the study area from low elevations up to ca. 5000 ft. In general, this species becomes taller with increasing elevation-ranging from low shrubs near the coast to trees up to 4m at the higher elevations-the tallest individuals found in gulches at 6000-7000 ft. Above this level, Dodonaea again becomes smaller in stature. At the lower elevations, it is found on rough aa flows and the sides of steep gulches. Dodonaea occurs abundantly in a narrow ecotonal band just upslope from the upper limit of mesic cloud forest as well as on ridges within this Acacia or Metrosideros/Acacia forest. Dodonaea may have invaded some of these sites as Acacia has declined due to herbivore pressure.

Dodonaea is one the few native genera on the south slope that are maintaining vigorously reproducing populations. Degener (1960- Fl. Haw.) states regarding Dodonaea on a worldwide basis: "Some species are said to possess medicinal properties; others to contain some HCN and saponins, making them unpalatable or mildly poisonous to stock." Some reproduction is occurring in all areas but those with the heaviest browsing pressure (e.g., western Kaupo Gap, upper Nu'u). In areas with fairly heavy browsing pressure, there is typically a gap in population structure with large shrubs/trees and small seedlings. Reproduction is lacking in areas with thick mats of kikuyu grass. We saw no evidence of vegetative reproduction by Dodonaea.

Obata (1973a) reported excellent germination and growth of Dodonaea.

Voucher: RAH/LLL #151, #155, #181; ACM/LLL #402

SAPOTACEAE

Nesoluma polynesianum (Hbd.) Baill. 1892 (I:Austral.Isl. & Rapa)
f. polynesianum (E:O,Mo,L,Ma,H) Keahi

Rock (1913) notes of N. polynesianum: "Together with Sideroxylon [=Planchonella], Nothocestrum, Suttonia [=Myrsine],

Osmanthus, Reynoldsia, Gardenia [apparently an error on Rock's part, since no other record of its occurrence within the study area exists], Antidesma, Bobea hookeri and Rauwolfia, it forms the typical dry forest at the lower elevation on Mt. Haleakala, on the lava fields of Auahi."

This species is still a moderately common tree at 1400-2200 ft. in the study area, especially on rough aa lava flows in Kaunauhane, Kanaio, Auwahi, and Lualailua districts. Widely scattered individuals still occur further east, noted as far as Kepuni Gulch.

At a distance, N. polynesianum superficially resembles Planchonella spathulatum. Both species form small, dense groves at lower elevations on the south slope, favored as resting places by cattle, pigs and goats. Nesoluma trees are usually smaller with less well-formed canopies than P. spathulata. When flowering or fruiting, the genera are easily distinguished.

This species fruits abundantly in summer and early fall. Large caches of Nesoluma fruits, cleaned of embryo and pulp by rodents, have been found in several instances. In contrast to these seemingly reliable field observations, preliminary experimental evaluation of rodent predation suggested minimal impact by rodents. The pulp of the 2-3cm long dark purple fruit when damaged emits a white latex that becomes sticky when exposed to air-perhaps an adaption for avian dispersal.

Seedlings of Nesoluma were observed in Kanaio, sometimes in large numbers, in the shade of Nesoluma trees in June, 1982. Though some seedlings survived the summer, most had wilted or dried up by September.

Living specimen plants of Nesoluma can be seen at Maui and Wahiawa Botanical Gardens. Germination and seedling survival rates are good in cultivation (Hobdy pers. comm.). Propagation by cuttings attempted from Molokai plants failed (Wooliams pers. comm.).

Voucher: ACM #351; RAH/LLL #184

Planchonella auahiensis (Rock) Skottsb. 1926 'Āla'a
var. auahiensis (E:Ma) var. aurantia (Rock) Skottsb.
1926 (E:Ma)

Rock (1913), who discovered this apparent East Maui endemic in 1910 in the Auwahi district, noted: "...a tree 25 to 30 feet high, has a rather broad round crown, and.. pale yellow sessile fruit..and very pale glabrous foliage. It grows.. with Alectryon macrococcus, Pelea multiflora, Pterotropia dipyrena [= Tetraplasandra kawaiensis], and Sideroxylon [= Planchonella sandwicensis]."

Rock (1913) also described a variety aurantia of this species found in the North and South Kona districts of Hawaii and at Auwahi district, East Maui. Rock (1913) noted that though the variety aurantia may be distinguished primarily by its smaller deep orange-colored fruits, it "...can be distinguished at a glance from the species, even at a distance."

Forbes in 1920 noted the genus Planchonella as being quite common within the study area, "yellow-fruited especially." Though "yellow-fruited" may also be applied to P. spathulata, it is a more apt description of P. auahiensis.

Planchonella auahiensis is locally common at 2500-4000 ft, primarily in the Auwahi district but also in eastern Kanaio district. This species is also present but not common at ca. 3000 ft above Lualailua Hills, in the Lualailua district.

Although Rock (1913) notes that the var. aurantia is easily distinguished, our survey did not find this the case. Though some individuals varied and did not precisely match Rock's description of the species, the variability in fruit and foliage is not as clear cut as Rock implies. One hypothesis raised during this survey is that hybridization between this species and P. spathulata may provide the basis for the observed variation. Further inquiry is needed to reach more definite conclusions.

Planchonella auahiensis fruits abundantly, peaking in late fall or winter. During fruiting season, hundreds of ripe and rotting fruits often litter the ground under the canopies of these trees. Despite the apparent abundance of fruit and seeds, this survey noted no reproduction either vegetatively or by seedling. A cat or dog scat seen in the Auwahi district contained a number of intact Planchonella seeds apparently of this species. Rodents also may affect this species by consuming seeds.

Germination and seedling survival of this species varied from poor (Wooliams pers. comm.) to good with fully ripened fruits (Hobdy pers. comm.).

Voucher: RAH #136; RAH/LLL #200, #204 (var. aurantia?)

Planchonella sandwicensis (Gray) Pierre 1890 (E:H.I.) 'Āla'a

Rock (1913) notes of P. sandwicensis: "On Maui, big trees can be found above Makawao in the gulches...as well as at Auahi..." Forbes regarded this species as rare at Auwahi in 1920, noting and collecting from only a single tree.

Planchonella sandwicensis was found by our survey to be uncommon, but by no means rare, at 3000-4500 ft in Auwahi and

Lualailua districts. On a steep west-facing slope in east Kaupo Gap of Haleakala National Park, a small but healthy population of about a dozen trees occurs at 4700-5100 ft. This and other populations produce abundant purple fruits, the seeds of which persist on the ground below the trees. Soon after this site was fenced to exclude goats by NPS personnel in 8/81, Planchonella seedlings began to germinate. Five seedlings survived as of 6/83. Lennox (1967) noted saplings of this species on the upper Auwahi road. We found several large saplings, perhaps in the same area as Lennox, below Puu Ouli ca. 4000 ft.

Hobdy reports good germination and seedling survival at the State Forestry baseyard nursery on Maui. Obata (1973b) reports fair germination.

Voucher: ACM #213.

Planchonella spathulata (Hbd.) Pierre 1890 (E:O,Mo,L,Ma,H)
'Āla'a

Rock (1913) wrote: "This species is quite common on the island of Lanai... The writer met with this same species on the southern slopes of Mt. Haleakala, on the lava fields of Auwahi, at an elevation of 2000 [ft], near the government road, in company with Reynoldsia sandwicensis, Antidesma pulvinatum, etc."

Planchonella spathulata has attractive foliage, gold-pubescent in young leaves, grey-green in mature ones. Trees often form immense globose canopies which thrive in gulches and channels of 'a'a lava flows. The distinctive fruits of this species are pointed, yellowish with rusty pubescence (especially prominent in young fruits). These fruits never seem to turn yellow-ripe, though seeds appear to be fully formed.

Our survey found P. spathulata to still be fairly common in the Kanaio and Auwahi districts at 1500-2600 ft, generally lower than the other two Planchonella taxa found in the study area. Forbes collected it in 1920 several times (#1979M, #2066M, #2073M, #2114M) in the Auwahi and Kamana areas. It has been collected many times since in Auwahi and Kanaio.

No reproduction of this species was noted. We were unable to obtain specific information on this species in cultivation. In general, the genus Planchonella apparently does not reproduce vegetatively, but germinates fairly well from scarified seed. As in the field, survival and establishment of seedlings are often more difficult than germination.

Voucher: RAH/LLL #158, #159, #164, #194

SAXIFRAGACEAE

Broussaisia arguta Gaud. 1830 (E:H.I.)

Kanawao,

Although this shrub is abundant in the understory of Metrosideros-dominated rainforests of East Maui and elsewhere, it is usually uncommon on leeward slopes. Within our study area, Broussaisia is confined to gulches in the mesic cloud-belt forest at 4500-5700 ft, mostly between Manawainui and Wailaulau. Broussaisia arguta also occurs just outside the study area at Paliku in Haleakala National Park.

SOLANACEAE

Lycium sandwicense Gray 1862 (I:H.I., Polynesia)

'Ohelo-kai, 'ae'ae

Degener (1932- Fl. Haw.) notes of this species: "...a typical halophyte found on limestone or lava rock in arid regions always near the sea or within occasional reach of the ocean spray. Often eaten by livestock, especially during times of drought, but the plant is not common enough to be of any real importance."

Lycium is scattered and common only locally in the coastal strand zone of the south slope.

Voucher: ACM#598

Nothocestrum latifolium Gray 1862 (E:H.I.)

'Aiea

Hillebrand (1888) distinguished Haleakala specimens of N. latifolium as a variety, noting of distribution: "E. Maui! Ulupalakua and Hamakua." Rock (1913- see Plates 172, 173) wrote of this species: "During the winter months, especially in the month of November, the trees are adorned with large dark green foliage...while in the month of May they are either bare or with only very scanty foliage." There is much variation, particularly in shape and pubescence, of foliage of this species on the south slope. In the field, it is easily mistaken for several associated tree species when seen at a distance.

This survey found N. latifolium fairly common on the aa lava flows of Kaunauhane, Kanaio, Auwahi, and Lualailua districts at 1200-3000 ft. Scattered individuals occur in the Lantana-dominated areas between these flows. Nothocestrum latifolium is also found in central Auwahi in an area dominated by kikuyu grass at 3000-4000 ft. Within Haleakala National Park, a single tree, tentatively assigned to this species, can be found in an enclosure on the steep west-facing ridge in eastern Kaupo Gap at 4850 ft.

Numerous seedlings of this species were seen by this survey in the 1200-2000 ft zone in the wet spring (March-May) of 1982, but all died, apparently due to the effects of summer drought and displacement by Bidens pilosa. As with many tree species on the south slope, the N. latifolium population appears composed entirely of mature and/or senescent individuals.

These trees flower in early summer and fruit abundantly in late summer and fall. Fruits are eaten by rodents and insects, but whether the actual seed is destroyed is not clear. Besides direct browsing by cattle and feral goats, the shade of these trees is often sought out by these animals. During the heat of the day, herbivores will rest under Nothocestrum and other trees. Constant disturbance beneath the canopies of these trees seems to preclude the establishment of slow-growing tree seedlings.

Most reports on artificial propagation of this species from seed report good germination rates and fair seedling survival in the nursery. Seedlings planted in Auwahi by Colin Lennox died after 1-2 years. Seedlings planted at Lyon Arboretum died after two years in the ground (K. Nagata pers. comm.). Maui Botanical Garden has a young sapling of this species in cultivation.

Voucher: RAH #109

Nothocestrum longifolium Gray 1862 (E:O,Mo,L, Ma) 'Aiea

Hillebrand (1888) noted this species at the western margin of our study area, giving its Maui range as "...Makawao, Ulupalakua, Lahaina..." It has not been recorded in the Ulupalakua area since and was not encountered by this survey.

Solanum haleakalaense St. John 1969 (E:EMa) Pōpolo-ku-mai

This species is known only from a single collection by Hillebrand in the 1860's (#113) on the "south side of Haleakala" (only specimen at Kew, London). It was described by St. John (1969a), who noted: "It seems most closely related to S. incompletum Dunal of the island of Hawaii..." We did not see S. haleakalaense during this survey and consider it extinct.

Solanum sp. nov. St. John (E:EMa) Pōpolo-ku-mai

St. John, in an unpublished review of Solanum in Hawaii, will elevate part of the collections of S. incompletum var. mauiense to specific level. The new species is known only from a series of Hillebrand collections made ca. 1870 from southwestern East Maui, exact locations unknown. Specimens exist at Kew, Smithsonian, and Melbourne herbaria.

Hillebrand (1888) notes of S. incompletum var. mauiense: "E. and W. Maui! Ulupalakua. There is great variability as to prickliness; while some specimens fairly bristle with spines it requires careful search to discover them in others, and such may be confounded with S. sandwicense."

We did not see this species during our survey and consider it extinct.

STERCULIACEAE

Waltheria americana L. 1753 (I:Trop.Amer., H.I.) 'Uha-loa

Hillebrand (1888) considered this species to be introduced, noting: "A common weed, occurring also in most tropical countries and in many Polynesian island groups." Degener (1932-Fl.Haw.) states: "One of the commonest weeds found throughout the Islands in arid regions chiefly at low elevations... The plant's wide distribution in the Islands even in the early days and its many uses by Hawaiians, tend to substantiate its existence here before the coming of Captain Cook." St. John (1978b) has suggested, based on occurrence of Waltheria and other pantropical weed species among David Nelson's 1779 collections, that Waltheria and others may be inadvertant Polynesian introductions, associated with taro or other cultivars. The origin of W. americana in Hawaii remains uncertain.

Waltheria is common on the south slope from sea level to about 2200 ft, especially in disturbed areas, or rough rocky areas with little soil. It persists in many areas where most other species have been excluded by disturbance by domestic cattle.

Voucher: ACM/LLL #254; RAH/LLL #197

THYMELIACEAE

Wikstroemia elongata Gray 1865 (E:Mo, Ma) 'Ākia

Hillebrand (1888) states of this species, "In the lower woods of Kauai, Lanai! Maui!."

Skottsberg (1972) cites two collections from the study area made by Forbes in 1920 from the Lualailua (#1984M) and Mehamenui districts (#1890M).

This species was not noted by this survey. Its status is uncertain.

Wikstroemia monticola Skotts. 1972 (E:E/WMa)

'Ākia

This is the most common species of Wikstroemia in the study area, known from numerous collections since the 1920's. It is particularly common on the arid lower slopes that have been greatly altered by grazing animals. Gupta and Gillett (1969) note: "Wikstroemia is one of the few indigenous Hawaiian genera that is unpalatable to grazing animals. Therefore populations often occur on very seriously overgrazed pastures."

Wikstroemia monticola is found from Ulupalakua on the southwest rift eastward to the Nuu district at 500-4000 ft, and is common at 1000-3000 ft. It is especially common in the Kanaio and Auwahi districts. In Auwahi district, the leaves of this species became increasingly larger as elevation increased until its upper limit near 4000 ft.

Wikstroemia uva-ursi Gray 1865 (E:O,Mo,Ma)

'Ākia

Hillebrand (1888) states of this species: "On dry forehills of the leeward sides." Skottsberg (1972) cites two collections of this species from the study area both made by Degener, first at Nakula in 1952 (#22039) and then in 1961 in the Kaupo district (#27516).

This species was not noted by this survey. Its status is uncertain.

URTICACEAE

Neraudia sericea Gaud. 1844 (E:Mo,L,Ma)

Ma'aloa, 'oloa

According to a revision of this group by Cowan (1949), this endemic Hawaiian genus consists of five species, with at least one on each major island. St. John (1973) largely accepts Cowan's treatment, but adds a sixth species, Neraudia kahoolawensis (considered by Cowan a segregate of N. sericea).

Cowan (1949) notes of the genus: "It is found from about 1600 to 4000 feet altitude but is seldom represented by more than a few plants in any locality.. its rarity.. and some nomenclatural confusion has contributed to the lack of understanding of the group."

Rock collected this species twice on the south slope in 1910: at 2200 ft in Auwahi (#8647) with the note "small shrub found on aa lava"; and Rock #8648, for which he noted: "A larger shrub than the foregoing, growing in the wet districts near Kaupo." This latter collection was made, according to Rock's notes, in the same locality as Schiedea implexa (#8643). Forbes collected this species twice in 1920 within the study

area: in Acacia koa forest above Puu Pane at ca. 4500 ft (#1824M); and in the Nuu district (#1915M), apparently on a low elevation aa flow, noting: "Shrub 4 1/2 ft high, slightly milky. Berries small, red, pubescent. Leaves rather dark green above."

Our survey did not encounter this species. It may be locally extirpated.

Pilea peploides (Gaud.) H. & A. 1832
(I:H.I., Pac.Is., trop.Asia)

Much like Cardamine konaensis in terms of habitat and habit, P. peploides is often found in or near watercourses. Hillebrand (1888) states: "Rather common in the lower regions on all islands, on wet rocks." From this description the abundance of this species appears to have diminished markedly, although it is still locally common. Pilea peploides ranges in the study area from 1450 to 6400 ft. It is most often found on steep rock stream banks and in stream gravel beds. It was also noted at 1400 ft on the naturally eroded slope of a cinder hill (Puu o Kali).

Pipturus spp. including Pipturus hawaiiensis Levl. 1911 Mamaki
(E:Mo, Ma, H) var. eriocarpus (Skottsberg) Skottsberg.
(E:EMa)

Regarding ethnobotanical use of Pipturus, Degener (1968-Fl.Haw.) stated: "The mamaki.. was the most abundant source of tapa or papercloth for the Hawaiians. Some earlier writers considered it to produce a finer, softer material than wauke (Broussonetia papyrifera), others maintained it was 'second only to wauke.' It was also used for cord or rope."

Hillebrand (1888) recognized one species of Pipturus, P. albidus, with two varieties, stating: "On all islands, at the outskirts or in clearings of the lower forests.. The 'Mamake' of the natives, one of the two principal 'kapa' plants." Rock (1913) noted that to describe the variation within P. albidus, one would have to name individual trees. In various publications, Skottsberg recognized thirteen endemic species in the Hawaiian Islands. Nicharat and Gillett (1970), using leaf anatomy and chromosomal examination, concluded that the Hawaiian representatives can be divided into two groups. They stated: "The evidence indicates that the differences between species are very small ... Indeed, most of Skottsberg's 13 species might better be considered to be of infraspecific rank."

Forbes' 1920 collection of Pipturus (#1932M) from the study area above Lualailua Hills was the type collection for P. eriocarpus Skottsberg 1932, reduced by the author in 1944 to

a variety of P. hawaiiensis. Forbes' field notes stated of the collection: "Common all over but not collected before. Leaves coarse veined, stiff."

This survey noted Pipturus occasionally in the Auwahi district at 3200-4000 ft and more commonly at 3500-5600 ft in the mesophytic cloud-belt forest between Manawainui and Pahih.

Stemmermann et al. (1981) recorded Pipturus sp. as "Uncommon in lower east Kaupo gap in gullies." We observed this species at 4400-4800 in eastern Kaupo Gap and in western Kaupo Gap at 6400 ft.

Voucher: ACM/LLL #415

Urera glabra (H. & A.) Wedd. 1856 (E:H.I.)

'Ōpuhe

Rock (1913) states concerning U. glabra: "It is not a ... dry district plant, but favors regions with more frequent and heavier precipitation." Hillebrand (1888) recorded it from the south slope at Ulupalakua.

Our survey found this species to be rare but present in the Auwahi, Lualailua, and Manawainui districts at 4000-5200 ft. A relict population persists near Ulupalakua in the Keauhou district (G. Le Bouvier, pers. comm.). Higashino and Mizuno (1976) reported this species as occasional in Healani gulch at 4000 ft on the Manawainui planeze. Most individuals seen by us were mature and vigorous. Flowering was observed in June 1981. This species is dioecious (Rock, 1913), possibly wind-pollinated, and is known to reproduce vigorously by root suckers.

VIOLACEAE

Viola tracheliiifolia Gingins 1826 (E:K,O,Mo,Ma)

Pā-makani

This species is a characteristic undershrub of leeward forests of the Hawaiian Islands-especially the older islands of O'ahu and Kaua'i. On East Maui today, it is quite rare, perhaps a remnant of former dry forest understory on the south slope. The tendency of East Maui specimens to have more tomentose leaves than specimens from other islands led Rock, based on a specimen collected in a gulch in Makawao, to describe it as a new taxon, V. robusta var. mauiensis. Skottsberg (1940) considered this taxon a synonym of Viola tracheliiifolia. Rock also collected this species in 1910 within the study area (#8686), growing with Schiedea implexa (#8643) and Neraudia sericea (#8648), with this note: "In deep gorges, slopes of Haleakala near Kaupo; elevation 5000 ft. Collections from Kaupo gap, now within Haleakala National Park, include one by Carpenter in 1930 from an unspecified location

and one by Forbes in 1919 (#1127M) with the note, "Viola, scandent, leaning on Styphelia, Dodonaea, 3 ft tall." In 1939, Degener collected it at west Kaupo Gap on "arid cliffs near Haleakala Springs" (#17466).

In the western portion of the study area, several other collections have been made. Forbes collected this species in 1920 (#1995M) above Lualailua Hills. Greenwell and Hatheway in 1950 made a collection with the note: "South slope of Haleakala, in gulch between Kahua crater and Nawini. Elev. 5500-6000 ft....Viola miniature tree, 5 ft. tall...Several seedlings in vicinity, which are now in cultivation by Miss Greenwell. Shade in remnant of rich montane rain forest but near upper limit of this, grading into Sophora-Myoporum association."

Stemmermann et al. (1981) gave the range within Haleakala National Park as "uncommon, W. Kaupo cliffs." We noted 14 individuals on the western Kaupo palis at 5000-5200 ft (10/83). Another small population occurs at about 4500 ft under a Myrsine forest in eastern Kaupo Gap (R. Nagata). We found no other south slope populations.

Obata (1973a) reports limited success in germination and greenhouse cultivation of this species.

ZYGOPHYLLACEAE

Tribulus cistoides L. 1753 (I:trop. cosmop.) Nohu, nohunohu

Degener (Fl.Haw.-1932) states: "Here and there on all the Islands, especially on the leeward side, on dry sandy coastal dunes or not far from them."

Two beetle species from California were introduced as control agents in 1962, primarily for control of the introduced puncture vine (Tribulus terrestris), considered a problem because of its spiny fruits (Hawaii Dept. of Agriculture, 1964). Microlarinus lareynii, a seed feeder, and M. lypriformis, a stem borer (Coleoptera: Curculionidae), have subsequently decimated certain populations of both T. terrestris and T. cistoides (N. Miyahira, pers. comm.).

Whether or not these control agents are the direct cause, T. cistoides is quite rare in sandy areas near sea level on the south slope, with only a few individuals seen.

MONOCOTYLEDONES

CYPERACEAE

Carex alligata F. Boott. 1867 (E:K,Mo,Ma,H)

Krauss (1950) notes of C. alligata: "...middle and upper forest, in open places in the forest, along ditches and roadsides; common." Though very common in many moist upper and middle elevation localities on East Maui, this species was noted by our survey only in the upper drainages of Manawainui at ca. 4700-5500 ft where it was somewhat rare in wet areas. It also occurs in the Manawainui planeze area east of Kaupo Gap (Higashino and Mizuno, 1976) and is common elsewhere on northern and northeastern Haleakala.

Carex macloviana D'Urv. var. subfusca (W. Boott.) Kuek. 1909
(I:Ma,H,w.U.S.A.)

Krauss (1950) states that C. macloviana in the Hawaiian Islands occurs in "the upper forest, in dry, sunny meadows and grassy ravines, usually over 5000 ft." Stemmermann et al. (1981) reported this species as "occasional in mesic to exposed areas throughout the Crater District, more frequent in Paliku area." Within our study area, C. macloviana can be found in upper Kaupo Gap of Haleakala National Park above 5000 ft, and uncommonly in moist subalpine scrub above the forest line in the Manawainui, Waiopai, and Wailaulau drainages. The species is uncommon on the outer southwestern slopes above 6000 ft in the Kula Forest Reserve (Hobdy, pers. comm.).

Voucher: ACM/LLL #404

Carex meyenii Nees 1843 (E:H.I.,exc.Niihau)

Krauss (1950) states that C. meyenii is found throughout the Hawaiian Islands "in zone D of Ripperton and Hosaka (1942), or middle forest between 600 feet and 3500 feet on ridges in full sun or in dense shade and on moist rocky ravine walls. Optimum development in semi-shade." On Maui this species can be found in both Acacia koa and Metrosideros-Acacia forests, as well as in relatively moist upper elevation shrubland.

Forbes collected C. meyenii in 1920 in "middle Auwahi" (#2047M). Stemmermann et al. (1981) gave its status for Haleakala National Park's Crater District as "occasional in wet forest between E. Kaupo Gap and Kuiki." We encountered it in east Kaupo Gap at 5220 ft; in Acacia koa forest in Wailaulau drainage at 4300 ft; and in the Manawainui drainage at 6200 ft.

Voucher: ACM #215, #235, #303

Carex wahuensis C.A.Mey. 1831

var. wahuensis (E:H.I.)

var. rubiginosa R.W.Krauss 1950 (E:O,Ma,H)

Krauss (1950) states regarding the variety wahuensis: "On all islands in ..the middle forest zone in shade or on open ridges in full sun, on soil or damp rocky ravine walls." Regarding variety rubiginosa, she states: "On Hawaii, Maui, rarely Oahu ..in the open forest in dry sunny cliff faces and open meadows, seldom in shade, usually over 4000 ft."

Forbes in 1920 collected var. wahuensis on the south slope (#1862M) at "Waiopaa" [=Waiopai?]. Forbes in 1920 also collected the var. rubiginosa of this species four times between Auwahi and Nuu districts.

Our survey noted this species (primarily as the var. rubiginosa) as rare in the Kula Forest Reserve, mostly above 5000 ft and in rocky areas at Auwahi; rare and scattered from Lualailua Hills to Pahihi; and locally common in eastern Kaupo Gap of Haleakala National Park.

Voucher: ACM/LLL #403

Cyperus hillebrandii Boeck. 1880 (E:K,O,Mo,Ma,H)

var. hillebrandii (E:K,Ma,H)

var. mauiensis (Hbd.) Kuek. 1956 (E:EMa)

Concerning C. hillebrandii, Hillebrand (1888) states: "Southern slope of Haleakala, Maui! on old lava fields, at an elevation of 3000-5000 ft." Forbes collected it in Kaupo Gap (#1133M) in 1920, noting only a single individual. Forbes also made collections at Kanaio (#1793M), near Lualailua (#1972M), at Auwahi (#2101), and in decadent forest on the SW rift (#2142M) near the present Kula Forest Reserve.

This survey noted C. hillebrandii only in the districts of Auwahi and Kanaio at 1600-2800 ft, where it is locally common in low scrub and in rocky areas.

Voucher: ACM #350 #364; RAH/LLL #145, #186

Cyperus laevigatus L. 1771 (I?:tropics)

Makaloa

Hillebrand (1888) states: "In and near sweet or brackish water, plentiful near Honolulu (Aliipakai)...The fine and highly prized Niihau mats are made of this plant." Degener (1950-F1.Haw.) adds: "Although the makaloa sedge is associated in the mind of the Islander with Niihau, where exquisitely fine, soft mats were made of it, it is native to marshy beaches and lowlands throughout the Islands. Besides mats, cords were made of it and a fiber useful in straining awa. On Niihau this

sedge was semi-cultivated by the old Hawaiians in both fresh and brackish water bogs. These historic stands in recent times have been crowded out by other sedges and partially destroyed by grazing sheep in spite of attempts to preserve them."

This rhizomatous species is found on the south slope only in a number of small brackish pools at La Perouse bay, Kanaio, Makee, and Nuu just above sea level. Cyperus laevigatus seems to grow best on the moist banks of drying mud-silt just above the water level. Though Hillebrand noted this species in the past as common, apparently habitat destruction and competition with exotic species are the primary reasons this species has become so scarce within the last century.

Voucher : ACM #583

Cyperus polystachyus Rottb. 1773 (I:Pantropical, most Pac. Isl.)
var. polystachyus (I:as above) var. pallidus Hbd. 1888
(I:Lehua Isl., Tahiti, Ma, H)

Hillebrand (1888), in describing C. polystachyus and var. pallidus, stated: "Very common on open grassy slopes; the variety on dry lava-fields of E. Maui and Hawaii! - Found all round the world in tropical and subtropical countries." Stemmermann (1981) states that this species is tolerant of brackish water.

Cyperus polystachyus is common in many parts of the study area at elevations below 3000 ft, particularly in rocky areas in the Kanaio district.

Fimbristylis pycnocephala Hbd. 1888 (I:H.I. to Solomon Isl.,
Laysan Isl.)

This coastal species is quite rare in the western part of the study area, being restricted to an area of 'a'a lava near sea level at Kanaio beach (R. Hobdy, pers. comm.). In the eastern coastal section near Kaupo, this species is quite common.

Machaerina angustifolia (Gaud.) Koyama 1956
(I:H.I., Polynesia)

Hillebrand (1888) gives the range of this species as: "Woods of the middle zone on all islands." Although fairly common locally elsewhere on East Maui, M. angustifolia is extremely rare on the south slope, restricted to rocky moist sites (especially sides of stream gullies) at 4500-5700 ft between Manawainui and Wailaulau drainages.

Machaerina gahniaeformis (Gaud.) Kern 1962 (E:L, Ma, H) 'Uki

Hillebrand (1888) states: "Hawaii! Maui! Lanai! on the high mountains from 3000 ft upward." Degener (1930) notes this species as common in "dry open woods" in Kilauea and on the upper slopes of Haleakala. Machaerina gahniaeformis is common on East Maui in the lower portions of the subalpine shrubland zone. It is most commonly found in rocky areas with sparse vegetation cover, such as cinder cone slopes.

This species can be found on the south slope at 6000-7500 ft from the Kula Forest Reserve area on the SW rift eastward to Kaupo Gap. Mitchell (1945) noted this species from Paliku, Oili Puu, and Kaupo Gap within Haleakala National Park, and it is still present, though uncommon, in those locations.

Voucher: ACM/LLL #398

Scirpus validus Vahl 1804 (I:Niihau, O, Mo, H, cosmopolitan)
'Aka'akai

Hillebrand (1888), referring to this species as S. lacustris, noted: "Common in standing water - Kapalama near Honolulu!"

Hobdy (pers. comm.) has found this species in the small brackish water pool in the Nu'u district just above Nu'u Bay, growing with Cyperus laevigatus.

IRIDACEAE

Sisyrinchium acre Mann 1867 (E:Ma, H) Mau'u-la'ili,
mau'u-ho'ula-'ili

This rare and inconspicuous grass-like iris was collected by Forbes on the south slope on Puu Ouli in 1920 (#2171M) with the note: "seen before but not in flower". We found it to be not uncommon at one location in the Manawainui drainage at 6600 ft. Based on scattered observations, it is present but rare from the Kula Forest Reserve (Hobdy) east to Manawainui at 6000-8000 ft. Pig rooting is currently very active in this area and, together with displacement by exotic grasses, threatens to eliminate it from all but very rocky sites.

JUNCEAE

Luzula hawaiiensis Buch. 1880 var. hawaiiensis (E:K, Ma, H)

Hillebrand (1888) states concerning this taxon: "High mountains of Hawaii, Maui! and Kauai, from 3000 ft upwards. In the plants from the higher elevations the leaves and bracts are

almost woolly at the base.." It occurs in moist subalpine shrubland and upper elevation forests around East Maui.

Luzula hawaiiensis is currently infrequent on the south slope in moist, upper elevation areas including Polipoli, Kahua, Manawainui, and upper eastern Kaupo Gap. Mitchell (1945) noted it from the Haleakala National Park portion of the study area along the Kaupo trail and at Waikekeehia near Paliku where it can still be found today.

LILIACEAE

Astelia forbesii Skottsb. 1934 Pa'iniu
ssp. forbesii (E:Mo, Ma)

This species is known from the south slope by a single Forbes 1920 collection (#2004), the only member of the genus recorded from the south slope. Astelia is a common epiphytic component of rainforest in Hawaii, but has been largely eliminated from terrestrial habitats by feral pigs. Astelia forbesii is still fairly common on the northeast and northwest outer slopes of Haleakala, as well as on West Maui and Molokai.

This species, not found during this survey, is probably locally extirpated.

Dianella sandwicensis H. & A. 1832 (E:H.I.) 'Uki'uki

Forbes collected D. sandwicensis in 1920 (#1999M) above Lualailua Hills on the south slope. We did not find this widespread species on the south slope except in upper Kaupo Gap (6000 ft), where it grows in cracks in pahoehoe lava. Hobdy has noted it in moist subalpine shrubland in the Kula Forest Reserve and along Kahikinui, east of Kahua at ca. 6000-7000 ft.

Pleomele auwahiensis St. John 1985 (H.Mann) N.E.Br. Halapepe
1914 (E:.)

Rock (1913) states: "The Halepepe is a.. dry district.. tree.. It is especially common on the aa (rough) lava fields on all the islands of the group, and is usually found at an elevation of from 1000 to 2000 ft... On the Kula slopes of Maui there once existed a forest of this tree, the remnants of which can still be seen." Rock also noted that Pleomele at Auwahi had narrower leaves than those from the Makawao area. Forbes in 1920 noted Pleomele and Osmanthus as codominants in the lower regions of forest from Lualailua to Auwahi.

Pleomele is still one of the most common trees at 2000-4000 ft on the rough, forested lava flows of Kaunauhane,

Kanaio, Auwahi, and Lualailua districts. In the upper part of this range, it is codominant with Osmanthus in the zone where kikuyu grass dominates the understory. A few scattered trees of this species still occur in pastures near Ulupalakua. Scattered individuals of P. aurea also occur in gulches of Nuu and Nakula. About two dozen trees occur in Kaupo gap within Haleakala National Park at 3600-5000 ft. Most of these occur on the steep ridge on the eastern Kaupo pali at 4700-5000 ft where an enclosure was built in 8/81.

Despite the large and still vigorous population of Pleomele which flowers (summer) and fruits (fall) prolifically, this species, like many others, has apparently not reproduced significantly in over a century. During the course of field work, we found only very few Pleomele seedlings and saplings. Rodent predation on seeds of Pleomele has been reported (C. Zimmer, Hawaii Volcanoes National Park, pers. comm.). We cannot confirm this for the south slope; seeds left in plots remained untouched.

Pleomele seeds in sterile media germinate in 1-2 months. Germination rates and seedling establishment in the nursery is fair (Bornhorst, Wooliams). Hobdy (pers. comm.) notes that he has obtained good germination rates, but only from fully ripe fruits. Obata (1972) reports that this species prefers drier substrates and does not do well in moist ground conditions. Specimen plants of south slope Pleomele are in cultivation at Maui and Wahiawa Botanical Gardens.

Voucher: RAH/LLL #207; J. Lau #1003

Smilax sandwicensis Kunth 1850 (E:H.I.) Hoi-kuahiwi, Aka'awa

Although abundant in few places on East Maui, this species occurs in a wide variety of habitats-rain forest, dry forest, open mixed forest. It is a sprawling shrub or a stiff woody climbing vine, sometimes nearly smothering its support tree.

Smilax sandwicensis is uncommon from Auwahi eastward at least to the Wailaulau drainage at 3100-5300 ft, where it grows as a dense shrub on rocky ridgetops or in thick mats on Acacia koa. Stemmermann et al. (1981) record it as "occasional, Kaupo Trail," in eastern Kaupo Gap. Our voucher was collected in eastern Kaupo gap in mesic Dodonaea scrub at 4800 ft where the species is occasional. West of Auwahi, a single vine was located by Hobdy along Plum trail below Polipoli Spring in damp shady forest.

Voucher: ACM/LLL #408

PANDANACEAE

Freycinetia arborea Gaud. 1824 (E:H.I.)

'Ie'ie

Hillebrand (1888) notes of F. arborea: "Common in the lower woods, climbing on trees or trailing over the ground in absence of trees, often forming impenetrable thickets." Our survey encountered occasional surviving remnants of this species in the 2500-4500 zone from Kanaio to Manawainui. This species is browsed by cattle and goats and generally excluded from level ground where it is accessible to herbivores. Higashino and Mizuno (1976) reported it as uncommon at 3500-4800 ft below Puu Ahulili on the Manawainui planeze east of Kaupo Gap.

Obata (1972) reports that this species germinates and establishes well from seed, but does not reproduce well from cuttings.

Pandanus odoratissimus L. f. 1781 (I:H.I., ?Ceylon)

Hala

Hillebrand (1888) states concerning Pandanus: "Common in dry plains of the lower regions, but extending up to elevations of 2000 ft. Nat. name 'Lauala' or 'Lauhala,' or simply 'Hala,' so called from the sweet scent of the male flowers. Coarse mats are made of the leaves."

In some areas of the lower windward slopes of Haleakala, Pandanus forms extensive coastal groves. On the south slope, however, it is restricted to a few sites where it persists from Hawaiian settlements, such as in brackish water ponds in the Kaunauhane district and at several sites in lower Kaupo. St. John (pers. com.) notes that Pandanus individuals on the leeward side of East Maui are quite similar to those on the windward side and may have been introduced by Hawaiians at these leeward sites (from the windward side).

POACEAE (GRAMINEAE)

Agrostis sandwicensis Hbd. 1888 (E:O,EMa,H)

Heu'pueo

Agrostis sandwicensis is known primarily from high elevation cinder flats and upper subalpine scrub on East Maui and Hawaii, but is also recorded from Oahu (perhaps in error) by Hillebrand (1888). On the south slope, it occurs in rocky, sparsely vegetated sites, usually above 8000 ft.

Cenchrus agrimonioides Trin. 1826
var. agrimonioides (E:O,L,Ma)

Kāmanomano

This rare species, not seen during this survey, is apparently endemic to East Maui, Lanai, and Oahu (Waianae Range), although Hillebrand (1888) notes concerning it: "On dry exposed ridges between 1000 and 3000 ft above the sea, probably on all islands, but chiefly on old lava fields of E. Maui and Hawaii." A related taxon from the Leeward Islands, originally described as C. agrimonioides var. laysanensis, was elevated to C. laysanensis by St. John (1975b). Cenchrus agrimonioides was first collected on East Maui by the U.S. Exploring Expedition botanists in 1841. Rock collected it at Auwahi in 1910. Forbes collected it twice on the south slope in 1920 near Auwahi (#2070M) and in the Lualailua district (#2031M). Regarding the former collection, made with Panicum sp. (#2071M), Forbes notes: "In troughs away from cattle."

Cenchrus echinatus L. 1753 var. hillebrandianus (Hitchc.)
F.Br.1931 (I:Polynesia)

This indigenous variety was considered by Hitchcock (1922) as a distinct species, C. hillebrandianus. It differs from C. echinatus s. str. in having villous or pilose versus glabrous foliage, as well as in minor floral characters. This taxon was reduced to the varietal rank by Brown (1931) in Flora of Southeastern Polynesia I.

Degener and Whitney (1937-Fl.Haw.) note: "It is obviously naturalized. If it were native, the early Hawaiians, who were barefoot and little clothed, would certainly have referred to this prickly grass in their 'unwritten literature.' "

This grass, especially common after the annual wet season, can be found all along the coastline of the study area up to elevations of a few hundred feet. In some areas, it grows together with the introduced form, Cenchrus echinatus s. str.

Deschampsia australis Nees ex Steud. 1854 (E:K,E/WMa,H)

This endemic bunchgrass persists as a major component of the subalpine vegetation of the south slope of Haleakala above 6000 ft. It can also be found on moist walls of periodic stream courses down at least to 4000 ft. Jacobi (1981) documented the damage done to this species by feral pigs on Kalapawili Ridge north of Haleakala crater. Although apparently not preferred by grazing animals, Deschampsia has in many areas of the south slope been replaced by the exotic grasses Sporobolus africanus, Danthonia, and Holcus lanatus in all but the rockiest sites.

Voucher: ACM/LLL #429; ACM #577

Eragrostis grandis Hbd. 1888 (E:H.I.)

Hillebrand (1888) gives the distribution of E. grandis as "high mountains of Molokai! E. and W. Maui!" Hitchcock (1922) notes of its habitat: "Slopes, ravines and open forest, mostly in partial shade." On the south slope and throughout most of East Maui, this species can be found on steep wet ridges and on the sides and faces of waterfalls, mostly at elevations above 4500 ft. Eragrostis grandis also grows in cracks in rock stream bed bottoms with Deschampsia australis (also above 4000 ft). Within Haleakala National Park, this species is scattered and uncommon on cliff and waterfall faces near Paliku and in eastern and western Kaupo Gap.

Voucher: RAH #98

Eragrostis variabilis (Gaud.) Hbd. 1888 (E:Leeward & H.I.)
Kāwelū, kalamalō, emo-loa

Hitchcock (1922) merged three species of Eragrostis recognized by Hillebrand into E. variabilis, noting: "A very variable species, especially as to the density of the panicle. I have been unable to coordinate characters so as to segregate distinct species...The three types look rather distinct but they all fall within the range of specimens cited below." One of the Eragrostis species described by Hillebrand (1888), E. phleoides, noted as being found "on old lava fields of Mt. Haleakala, Maui! between 3000 and 5000 ft above the sea." E. phleoides, marked by its dense, spikelike panicle, meets the description of several collections made by this survey near 2000 ft in the Kanaio district, growing with or near more typical E. variabilis. Eragrostis variabilis was found to be uncommon and sporadic in the Kanaio, Auwahi, and Lualailua districts at 1600-4000 ft. It was also found sparsely below this elevational band near Puu o Kali at 700-900 ft and noted by Hobdy (pers.comm.) at 50 ft above sea level at Kanaio beach."

Voucher: RAH/LLL #176; ACM/LLL #420

Heteropogon contortus (L.) Beauv. ex R. & S. 1817
(I:India,Polynesia)

Pili

Hitchcock (1922) notes: "Called by the Hawaiians pili grass and used by them to form the walls of huts by binding to the frame. Open rocky slopes." Whitney et al. (1939) state: "At present it is found on all the islands in dry rocky situations at lower altitudes though it seems to be rapidly diminishing in amount in some of these areas.. It is palatable when young, and in dry areas where feed is not abundant it is grazed by cattle when old and dry. Because of the shallow root system it is easily pulled up by grazing animals."

This indigenous species is dominant in some of Hawaii's arid lowlands. Within the study area, however, it is by no means widespread. It can be locally abundant, especially during or immediately after the wet season in some lowland sites, such as near Kanaio beach (Hobdy, pers.comm.). Forbes collected this species near Waiopai in 1920 (#1847M). This survey noted it as high as 1700 ft, in Alena district, where it was uncommon.

Panicum colliei Endl. 1836 (E:K,O,L,Ma)

This species was collected ca. 1840 by the botanists of the U.S. Exploring Expedition at the sand hills of Wailuku. Hitchcock (1922) characterized its habitat as "open ground in dry places on lee side of the islands." Whitney et al. (1939) state: "This species is found on the islands of Hawaii, Maui and Molokai in the same type of habitat as its relative, Panicum pellitum."

Hobdy (in litt.) has tentatively identified a Panicum collected on the western slope on lava flows near Puu o Kali as this species.

Voucher: Hobdy # 1011 (5 March 81)

Panicum nubigenum Kunth 1833 (E:K,O,Mo,L,H,EMa)

Hitchcock (1922) stated: "The most characteristic species of the leaside slopes and plains are several annual sorts of Panicum such as P. torridum, P. beecheyi, P. nubigenum, and P. lanaiense. These are all annuals that spring up abundantly after the winter rains. The Hawaiian name for all these is kakonakona."

Since Hillebrand (1888) considered P. nubigenum conspecific with P. pellitum, it is not possible to determine which species is referred to by his statement, "... Maui! plentiful on the bare slopes above Maalaea bay and elsewhere."

Rene Sylva and J. Rumel collected this species in 1978 in the Kaunauhane district with the note, "...approx. 1 mi Hana side of La Perouse Bay, 4 ft elev.; flat aa lava and dirt; full sun. 3 in. high, 4 in. broad. Lack of rain-dying. 100 mature individuals, no seedlings, 50 ft by 50 ft colony area. Threat by jeeps. Sparse population, kiawe, lantana, ilima."

Panicum nubigenum is restricted to coastal sites below an elevation of 50 ft on the western and eastern edges of the south slope study area. On the western side, this species is scattered but not uncommon from Papaka Kai district east to Manawainui (Hobdy pers. comm.) On the eastern edge of the study area along the Kaupo district coast, this species is sporadic in remnant native strand vegetation.

Panicum pellitum Trin. 1826 (E:EMA?)

Whitney et al. (1939) state of P. pellitum: "This grass is endemic to the Hawaiian Islands and is found abundantly in dry rocky areas at low altitudes on the islands of Maui and Molokai. It forms a large part of the forage on nearly barren areas where practically nothing else will survive. For this reason it is a valuable asset to Hawaiian ranges, although it is of limited distribution." Similar in distribution to P. torridum, this annual East Maui endemic occupies sites from just above the strand vegetation to lower elevation dry forest. Rock collected it in 1910 at Auwahi (#8708). Forbes collected it in 1920 (#2069M, #2087M) on the south slope, apparently in the Auwahi or Kanaio district at ca. 2000-3000 ft. An unidentified collector for the Hawaii Sugar Planters' Association also collected P. pellitum at Kihei in 1936 (BISH).

Panicum pellitum was noted by this survey in the Kanaio and Auwahi districts at ca. 1600-2400 ft and at several sites east of Puu o Kali on the western slope at 700-1000 ft. Hobdy (pers. comm.) reports this species at Makena, Kanaio beach and at Wai'ilio. Despite its wide distribution, this wispy annual is nowhere common and is threatened at many sites, due to grazing, fire, and displacement by introduced annuals such as Bidens pilosa.

The former abundance and subsequent depletion of this species is strongly suggested by this note on a 1913 herbarium collection (Anon., in sched. at BISH): "Ulupalakua and Haleakala, from low to middle elevations, for 2-3 months only, following the rainy season or in winter months. A valuable fattening grass."

Panicum tenuifolium H. & A. 1832 (E:L,Ma,H)

Hillebrand collected this perennial species from several unspecified localities on Haleakala in the 1850's. Forbes collected it in 1920 on the south slope in the Nu'u district at "Waiopaa," a place name which may correspond to the present day name Waiopai (an interpretation consistent with the chronology of Forbes' east to west progress across the south slope). Whitney et al. (1939) state of the distribution of P. tenuifolium: "Very abundant at high altitudes on the island of Hawaii and occasionally found on Maui and Lanai. It is a valuable grass on the high altitude ranges in these areas, apparently very palatable and able to grow in rather dry, windswept areas, where the soil is rocky and shallow."

The most recent study area collection of P. tenuifolium was by G.E. Olson in 1937 from 4770 ft along the trail in eastern Kaupo Gap in Haleakala National Park, with the note: "Grass 16 in. high. Grows in shade or moderately wet old lava flows." The species may have been eliminated from the Kaupo Gap area due to competition from kikuyu grass.

Panicum torridum Gaud. 1829 (E:"O to H & Leeward Is.")

Large size and dense pubescence distinguish the annual P. torridum from other closely related annual species of this variable genus in Hawaii. Whitney et al. (1939) state: "Along with other native species of Panicum, it forms a valuable part of the forage in dry situations where the introduced species will not survive." Thick mats of this species are sporadic and scattered during the wet season in the study area from just above sea level to ca. 1000 ft, though it is less common in upper elevational range. Panicum torridum is found on the western slope at Puu o Kali at ca. 1000 ft; at Puu Olai at ca. 200 ft; and on the southern coastal flanks (Kahawaihapapa, Makee, Kanaio beach, Manawainui beach, Hobdy, pers. comm.) east to Manawainui district.

Panicum xerophilum (Hbd.) Hitchcock 1922 (E:O,Mo,L,Ma)

Hillebrand (1888), who considered this taxon a variety of P. nephilophilum, stated: "On dry exposed ridges of Oahu! Lanai! and Maui! Maalaea." Panicum xerophilum has been collected in low to middle elevation sites of both East and West Maui (more common on East Maui). Collections have been made in recent years in dry, disturbed sites such as roadways in sugar and pineapple plantations and in pastures. Whitney et al. (1939) state: "An endemic annual, rather abundant in the dry areas at low altitudes on the islands of Hawaii and Maui. It is especially plentiful near Kawaihae, Hawaii and Makena, Maui. In these areas it becomes a rather important part of the forage, and along with Panicum torridum, Panicum pellitum, Panicum colliei and Heteropogon contortus, affords a large part of the available feed."

This species was not encountered by this survey, but is probably present. We suspect that we have overlooked this ephemeral annual because of its similarity to other annual Panicum species.

Sporobolus virginicus (L.) Kunth 1829 (I:pantropics)
'Aki'aki, Mānienie-maoli

Stemmermann (1981) states: "Perennial grass with buried rhizomes and erect branches...Found in coastal marshes and other coastal habitats, usually rooted in sand....Pan-tropical; indigenous to most Pacific Islands."

This species was present but rare in the study area in the sandy areas between La Perouse Bay and Kanaio beach in the strand zone. In some locations, it binds its sandy substrate, preventing erosion from the strong, steady winds that often blow on these coastal flats.

Voucher: ACM #588

Trisetum glomeratum (Kunth.) Trin. ex Steud. 1854

(E:L, Ma, H)

Pili-uka

Degener and Whitney (1938-Fl.Haw.) state concerning T. glomeratum: "A variable grass peculiar to higher elevations of Hawaii, East Maui and Lanai, growing usually in fog swept barren lava plains or brushy mountainsides." On East Maui, it has a broad range of habitat from alpine rockland to mesic parkland forest and montane bog conditions.

Forbes collected this species in 1920 above Puu Ouli in Kanaio. Today, though restricted primarily to the upper subalpine zone (7000-9700 ft), it can occasionally be found on open lower ridges down to 5500 ft. Grazing and competition with introduced grasses may have eliminated this species from what in the past may have been a more extensive lower elevation range.

RUPPIACEAE SJ15

Ruppia maritima L. 1753

var. pacifica St. John & Fosberg f. pacifica 1939 (I:H.I.& Trop. Pac.)

Hillebrand (1888) notes of this species: "In shallow waters along the coast, found by Chamisso and the naturalists of Capt. Beechey's Expedition, also by the writer on the southern shore of Molokai."

Neal (1965) states: "The tassel pondweed.. distributed along coasts in many parts of the world, is commonly found in Hawaii submerged in brackish pools and ponds. Representatives of this plant in Hawaii and some other parts of the Pacific have been designated as a form (f. pacifica St. John & Fosberg)."

Within the study area, this species is restricted to a number of brackish water pools located on the southwestern flank of East Maui, both on the western and eastern sides of La Perouse bay. Located in rough aa lava just above sea level, these pools support a small but unique biotic community. The plants in these pools are completely submerged and vary greatly in height depending on the individual pool depth. These pools also support populations of the rare endemic shrimp Halocaridina rubra, found only in brackish pools on Oahu, east Maui and Hawaii (Ann Fielding, pers. comm.). These small bright red shrimp favor the Ruppia as sites to feed and congregate.

Voucher: ACM #566

FERNS AND FERN ALLIES (only two very rare species included)

LYCOPODIACEAE

Lycopodium manni (Hbd.) Skottsb.

This species was described by Hillebrand from material from "mountains above Maalaea bay," West Maui. Lycopodium manni has also been collected on Kauai, East Maui and Hawaii, but known extant populations occur only in the latter two locations. This species appears to be an obligate epiphyte, seemingly associated with mesic Acacia koa/Metrosideros polymorpha forests (Higashino, ms). Lycopodium manni grows on the trunks of Acacia koa, Metrosideros polymorpha and Dodonaea eriocarpa at the Kaupo-Manawainui planeze populations of East Maui first reported by Higashino and Mizuno (1976).

This survey encountered this species at a single site. In a moist protected gulch in the upper western branch of Manawainui (Kahikinui) drainage at 5300 ft, six individuals were located growing on the trunks of two Acacia koa trees. Further exploration in the area failed to reveal any new populations. As this area is being severely impacted by feral herbivores, this species is likely to be extirpated within a few decades or less from the study area unless measures are taken to protect it.

Voucher: ACM #310

OPHIOGLOSSACEAE

Ophioglossum concinnum Brack.

Pololei

Hillebrand (1888) noted of this species: "On grassy plains on the isthmus of Maui!.. Appears only in spring after the first rains." Robinson (1912) noted, "On ground, appearing after rains; often near the seashore or in soil that has been taken from the shore."

This survey noted this species rare and scattered from Makena and Cape Kinau-Ahihi eastward to the district of Alena. Most populations occur below 50 ft above sea level; however, O. concinnum was collected at 1200 ft at the easternmost site in Alena district. Though quite rare and seasonal, this species can have large numbers of fronds clustered at a site.

DISCUSSION

Overview of the Distribution and Status of Native Plant Species on Haleakala's South Slope.

Our investigations in the study area have documented the current and/or past status of 237 species of native flowering plants and 51 species of ferns and fern allies. This survey located a number of species which had not been recorded in the study area for many years (e.g., Abutilon menziesii, Acacia koaia, Dubautia reticulata, Hibiscus brackenridgei, Pelea adscendens, Ranunculus mauiensis, Scaevola gaudichaudi, and the extremely rare fern ally, Lycopodium mannii). St. John feels recent collections in other genera (Cyanea, Cyrtandra, Labordia, Phyllostegia, Sicyos) from the study area represent new undescribed taxa.

The native flowering plants of the study area include 204 species (86%) of dicots and 33 species (14%) of monocots, mostly sedges and grasses. Of the 237 species, 204 species (86%) are endemic to the Hawaiian Islands. Of the flowering plants, 49 species (21%) are endemic to the island of Maui. Another 17 species of flowering plants in the study area have subspecies or varieties endemic to the island of Maui. In total, 66 species (28%) of flowering plants of the study area are endemic or have infraspecific taxa endemic to the island of Maui. Twenty-two of 137 genera (16%) represented in the study area are endemic to the Hawaiian islands.

Of the 237 species of native flowering plants recorded from the study area, 46 species (19%) have not been encountered by this survey or noted within recent times by others, and are considered extirpated from the study area. Of these, 23 species have surviving populations elsewhere in the Hawaiian Islands, though in some of these cases the study area populations represent endemic infraspecific taxa. The remaining 23 species (10% of the total number of species recorded) are apparently extinct. Of these extinct species, 20 species were endemic to the study area and the now denuded western Kula slopes.

Of the surviving 191 species of native flowering plants in the study area, we consider 89 species (47%) to be threatened. We define threatened as meaning vulnerable to extirpation in the study area within a few decades or less. Although this analysis is obviously subjective, we feel we have been rather conservative in our assessment and more taxa may possibly fall into this category.

Of the 237 species, 28% were trees, 32% were shrubs, 25% were herbs (including grasses), and 15% were vines. Of the 66 tree species, 15% are extirpated, 52% are considered threatened and 33% considered "safe." Of the shrub species, 27% are extirpated, 39% are considered threatened and 34% are

considered "safe." Of the herb species, 10% are extirpated, 27% are considered threatened and 63% are considered "safe." Of the vine species from the study area, 43% are extirpated, 26% are considered threatened and 31% are considered "safe."

As can be seen from the above analysis, plant forms were differentially affected by perturbations. Trees have not suffered the extirpation rates of other groups, yet comprised the highest percentage of threatened species in any group. The general good status of the herb class is likely due to the tenacious persistence of the grasses (Poaceae) and sedges (Cyperaceae). The families Lamiaceae and Cucurbitaceae account for the high percentage of extirpated and threatened vine species. Only about a half (53%) of the surviving species can be evaluated as being "safe."

Voucher specimens of native and alien species were collected wherever possible. Some material (e.g. Ranunculus mauianus) was not collected due to the rarity of the species in the study area. The final repository for these herbarium specimens is the Herbarium Pacificum of the B. P. Bishop Museum in Honolulu, Hawaii.

In some plant groups, we have encountered taxonomic problems. Examples of the types of difficulties were:

1) The lack of a complete taxonomic treatment.

Many Hawaiian genera have not been reworked significantly since Hillebrand (1888), e.g. Bobea, Zanthoxylum, Wikstroemia. Often, these genera may be marked by highly variable species. Characterizing these species simply and accurately without merging genuinely distinct populations may be a difficult if not impossible task. In variable genera, such as Sicyos and Cyrtandra, the lack of a comprehensive treatment is sorely missed. Our hope is that the distributional and ecological information during this survey will aid specialists in future taxonomic treatments.

2) The publication of differing taxonomic treatments, each of which may have merit. The Hawaiian flora, though relatively low in numbers of species, is marked by genera with clusters of monophyletic species groups. Species may occupy adjacent biological zones, and even hybridize where habitats overlap. Other genera are notable for species with broad ecological amplitudes and polymorphic morphologies. These tendencies all represent evolutionary approaches to deal with diverse and overlapping habitats available for colonization by founder species and their descendents. The wide range of habitats results from a steep elevational and climatic gradient found in the study area and elsewhere in the Hawaiian Islands.

What morphological and geographical groupings of plant individuals constitute a biological species is subject to variable interpretation with changing standards over time.

Differential weighting of taxonomic characters may result in fundamentally differing interpretations, based on the same material.

Variability between treatments is usually based on a disagreement of the size of the basic biological unit, the species. Authors with the concept of the species as a broad, encompassing, variable unit work toward a convenient yet realistic taxonomic treatment. Workers with a narrower tolerance for variability in their species concept feel that discrete yet accurate biological groupings are not only present but perhaps also inevitable in a mature insular system with diverse environments and abundant barriers to gene exchange.

Examples of contrasting treatments based on the same material are: Jacquemontia - Robertson (1974) and St. John (1976b), Lipochaeta - Gardner (1979) and St. John (1973; Pittosporum - Haas (1977) and St. John (1977b), Santalum - Stemmermann (1980) and St. John (1984). In such cases, where possible, we have tried to reflect both treatments.

3) The lack of good voucher material needed to make positive species identifications. Partly, this was due to the inaccessibility of many of the collecting locales in conjunction with the flowering and fruiting seasonality of the taxa involved. Much of the flora of the seasonal dry forest may only be represented with good collection materials in a few months during and after the rainy season (e.g., annual Sicyos and Panicum spp.).

Just as the lack of good voucher material has impeded work on some species, the paucity of past herbarium collections made from the study area has prevented full use of this otherwise valuable resource. This situation holds true even for those taxa considered endemic to the study area. It is obvious that prior to this survey, relatively little botanical fieldwork had been done in the study area since the visits of Joseph Rock and Charles Forbes in 1910-1920.

In many cases, taxonomic problems may never be resolved due to the reduction or extirpation of populations or of entire taxa. Examples of such groups in the study area include the following genera: Canavalia, Cyrtandra, Gouania, Haplostachys, Phyllostegia, Pittosporum, Solanum, Stenogyne, Tetramolopium, Vicia, Zanthoxylum, and the families Lobeliaceae and Cucurbitaceae. Certainly, the ecology of many native taxa will never be understood. We stand at the threshold of losing the opportunity to gather taxonomic and ecological knowledge for other surviving taxa.

Perhaps the most striking overall conclusion that can be drawn from our analysis of the biota of this leeward system is the evidence of former species richness, and in current

contrast, the present state of degradation. In some species, we feel without immediate protective action (which in many cases is unlikely), we are documenting the last populations in the study area. Though additional individuals of these taxa may conceivably exist, the numbers of recorded individuals from the study area indicate a poor chance for ultimate survival. These are: Alectryon macrococum (9 individuals), Cyanea sp. nov. (formerly two individuals, now one individual), Drypetes phyllanthoides (2), Pelea adscendens (1), Pelea cf. mucronulata (3), Pelea multiflora (12), Phyllostegia sp. novum (1 colony), Pittosporum glabrum (1), Zanthoxylum hawaiiense (9), and Zanthoxylum kuaense (6-8). Though other south slope taxa may have low population numbers, those mentioned above because of reproductive and/or habitat related problems appear to most perilously approach extirpation. Five of the ten species noted above (Cyanea, Pelea, and Phyllostegia) are endemic to the study area.

One of the primary barriers to long-term survival for many species is inability to successfully reproduce by seed. For the majority of the native flowering plant species in the study area, this survey observed little or no evidence of successful reproduction. Dodonaea eriocarpa and Wikstroemia monticola are seemingly the only native species which appear to be maintaining vigorous, abundantly reproducing populations in spite of habitat degradation. In some areas, it is quite possible that there has actually been an increase in the cover of these species due to the activities of browsing mammals.

Of the 237 species of native flowering plants recorded in this survey, 108 species (46%) have also been recorded as naturally occurring (or having occurred in the past) within Haleakala National Park. Of the 51 species of ferns and fern allies, 47 species (92%) also occur within Haleakala National Park (See Table 4). Native flowering plant species, historically recorded but now considered extirpated within the study area section (Kaupo Gap) of Haleakala National Park include: Argyroxiphium sandwicense, Argyroxiphium virescens, Hillebrandia sandwicensis, Panicum tenuifolium, Phytolacca sandwicensis, Stenogyne haliakalae, and Stenogyne rotundifolia.

Table 5 shows results of an assesment of numbers of native species occurring in each of twenty 500 ft elevational bands between sea level and the 10,000 ft summit of Haleakala's south slope. Greatest development of tree species occurred at the 2500-4500 ft level (Figure 27). Greatest total species richness occurred in the 2000-5500 ft level (Table 5).

How many south slope species became extinct during the centuries of Polynesian settlement, and the subsequent expansion of European grazing animals into the study area preceding the earliest botanical explorations? The remains of plants, except for pollen in peat, decompose without a trace.

Table 4. Summary status of native vascular flora on Haleakala's leeward slopes.

	Total	Flowering Plants	Pteridophytes
Total # of species	288	237	51
# of indigenous spp.	54	33	21
# spp. endemic to H.I.	234	204	30
% spp. endemic to H.I.	81%	86%	59%
# spp. endemic to Maui	51	49	2
% spp. endemic to Maui	18%	21%	4%
# extirpated spp.	N.A.	46	N.A.*
% extirpated spp.	N.A.	19%	N.A.*
# threatened spp.	123	89	34
% threatened spp.	43%	38%	67%
# of spp. also found in Haleakala N. P.	155	108	47
% of spp. also found in Haleakala N. P.	54%	46%	92%

 * Since historical occurrence and status of fern species was not analyzed in this study, no analysis of extirpated fern species is possible here.

Table 5. Numbers of native flowering plant species occurring in each of twenty 500 ft elevational bands on Haleakala's leeward slope.

	Elevational range(ft.)	Number of species in zone				
		<u>TREES</u>	<u>SHRUBS</u>	<u>HERBS</u>	<u>VINES</u>	<u>TOTAL</u>
1.	0-499	5	14	24	10	53
2.	500-999	5	15	12	8	40
3.	1000-1499	11	17	14	9	51
4.	1500-1999	16	18	15	9	58
5.	2000-2499	27	16	15	10	68
6.	2500-2999	32	16	10	9	67
7.	3000-3499	34	16	7	8	65
8.	3500-3999	30	14	8	6	58
9.	4000-4499	35	17	12	8	72
10.	4500-4999	25	19	14	7	65
11.	5000-5499	21	24	16	8	69
12.	5500-5999	13	22	18	2	55
13.	6000-6499	9	22	18	2	51
14.	6500-6999	3	15	11	0	29
15.	7000-7499	2	14	7	1	24
16.	7500-7999	2	11	5	1	19
17.	8000-8499	2	8	6	1	17
18.	8500-8999	2	5	5	0	12
19.	9000-9499	1	5	6	0	12
20.	9500-10,000	0	5	6	0	11

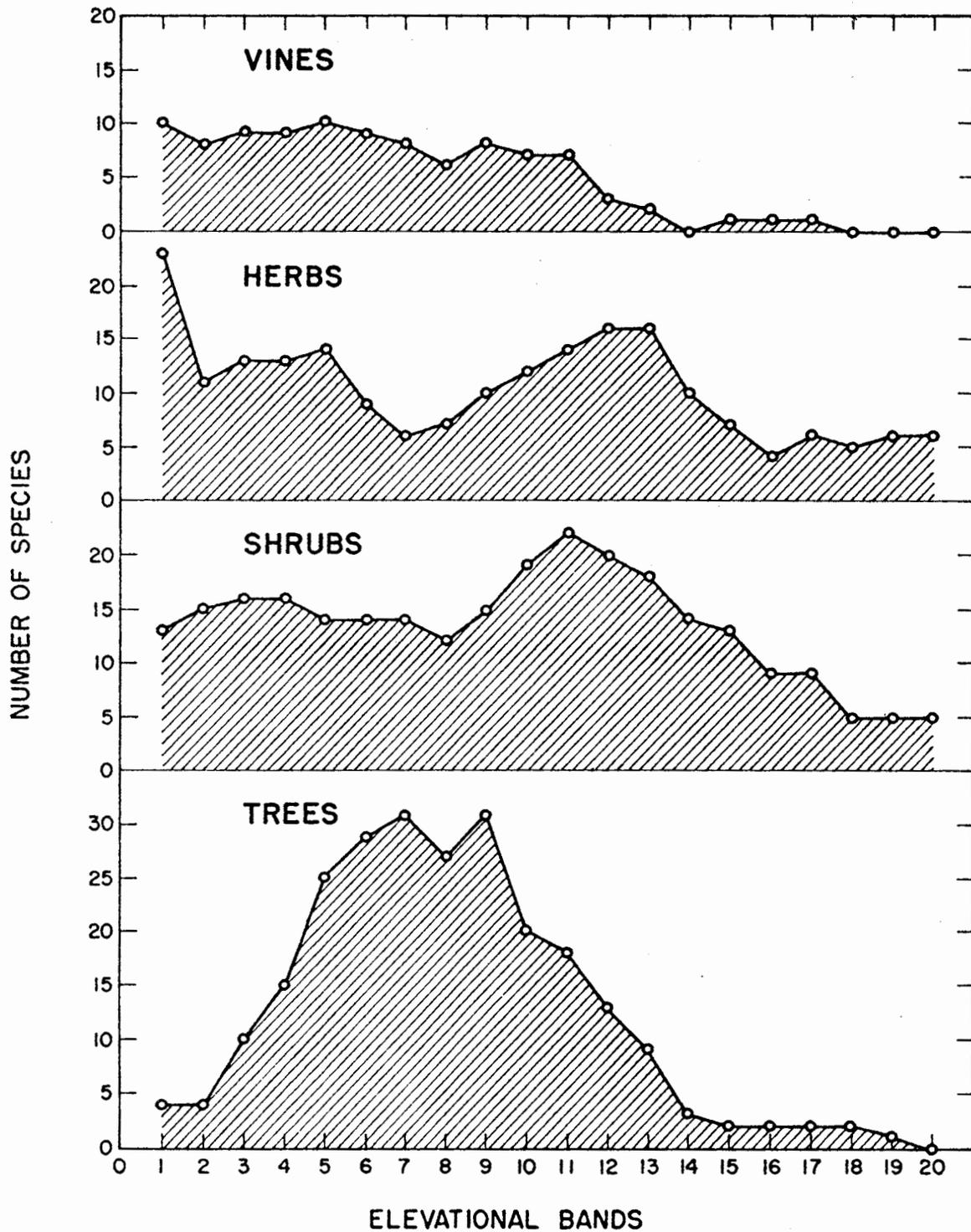


Figure 27. Graphs showing numbers of plant species at each 500ft elevational band for four growth forms on the south slope of Haleakala, East Maui. (1 = 0-55ft, ...20 = 9500-10,000ft).

In exploring the fossil record of another biological group, the Hawaiian birds, Olson and James (1982a,b) have recorded a remarkable diversity of pre-Polynesian birdlife. The diversity would have been unpredictable, without the fossil evidence, judged just on the modern Hawaiian avifauna. We feel a similar situation may very likely also be true of the flowering plants.

The only concrete botanical support for this speculation on early plant extinctions is the work of St. John (1976a;1978b;1979d) in the British Museum with flowering plants collected by David Nelson on Hawaii island in 1779. Analysis of collections from the first formal European contact in the Hawaiian Islands has resulted in the description of 15 endemic species, not otherwise known. The first century of the impacts caused by browsing animals may have been responsible for a disproportionate number of flowering plant extirpations. Our lack of knowledge regarding the nature of the pristine understory vegetation of the dryland forest of the study area seems due to the degree of disturbance prior to botanical exploration.

Why Worry about Loss of Plant Species of Leeward East Maui?

Deterioration of the leeward forests of the Hawaiian Islands is not a unique phenomenon among tropical forest ecosystems of the world (U.S. Interagency Task Force on Tropical Forests 1980, Myers 1979). However, extinction of endemic plant species is proceeding at a more rapid rate on leeward East Maui and similar areas elsewhere in the Hawaiian Islands than anywhere else in the United States. A survey during the mid-1970's (Fosberg and Herbst 1975, Smithsonian Institution 1975) considered nearly 50% of the flowering plant flora of the Hawaiian Islands to fall within the categories of recently extinct, endangered, or seriously threatened. Although Hawaii has only about 10% of the flowering plant taxa found in the 50 states of the United States, it has 34% of those considered by the Smithsonian Institution (1975) as seriously threatened or worse.

The Hawaiian biota is a highly significant part of the world's natural heritage. No other location on earth, not even the famed Galapagos Islands (much younger and nearer mainland sources for biota), illustrates so well the evolutionary phenomenon of adaptive radiation (Carlquist 1974). Many south slope species belong to genera or larger groupings which have undergone spectacular adaptive radiation in the Hawaiian Islands- Bidens, Cyanea, Dubautia-Argyroxophium, Pelea, Schiedea, Sicyos, Stenogyne, Tetramolopium, and others. In most of these groups, species from East Maui have already gone extinct, leaving only a few specimens in herbaria as testimony to their existence. The surviving taxa are extremely valuable subjects for studies on relatively rapid evolutionary adaptation to various types of physiological stress. For example, recent studies (Carr and Kyhos 1981; Robichaux 1984)

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6. Strand: La Perouse/Kanaio beach area.
This coastline contains some of most intact coastal vegetation remaining on Maui as well as elements of seasonal dryland forest. The primary threat to native vegetation here may be damage caused by off-road vehicles. (Management Category #1)

on the south slope. The highest priority site for protection within this area is the central gulch of Manawainui drainage at 4800-5400 ft, where a concentration of very rare native species have survived until now because of steep sides of the gulch. The area in general is currently being severely damaged by semi-feral cattle, as well as feral goats and pigs. Recovery potential of the forest still seems good primarily due to the excellent recovery potential of Acacia koa. Though the construction of a fence below this area will prevent further cattle ingress into these forests, feral goats and pigs, as well as semi-domesticated cattle, well above the fence line, are currently doing great damage. (Management Category #2)

2. Upper Dryland Forest: Auwahi and Auwahi-Kanaio boundary at 3000-4000 ft. This area has the greatest concentration of surviving native trees on the entire south slope and is the only large remnant of upper dryland forest. Unfortunately, the entire area is overrun by kikuyu grass - which presents very severe management problems, although selective control of this grass with glyphosate (Gardner and Kageler 1983) remains a possibility. Of the areas mentioned here as meriting consideration for preservation, this one presents the greatest problems for management and probably has significant economic value (good pasture for cattle). (Management Category #3)

3. Middle and Lower Dryland Forest: Kanaio district, 1200-2600 ft. This tract of rough aa lava (mostly State land under lease to Ulupalakua Ranch) contains some excellent remnants of native vegetation - especially near the border with Auwahi at ca. 2200- 2600 ft and below the road at 1200-1600 ft. Feral goats may be the greatest deterrent to reproduction of native species in this area. (Management Category #2?)

4. Middle and Lower Dryland Forest: Lualailua district at ca.900-3000 ft. Good remnants of these subzones occur on Hawaiian Home lands leased to Maui Factors, Inc., in the vicinity of Lualailua Hills. One of the best sites is a small concentrated patch of forest at ca. 2200 ft with Antidesma pulvinatum, Streblus sandwicensis, Bobea sandwicensis, and Osmanthus sandwicensis. Feral goats and domestic cattle seem to provide the greatest deterrent to reproduction in this area. Value of the area as pastureland appears marginal. (Management Category #2?)

5. Seasonal Dryland Forest: Lava flows below Puu o Kali near Kihei, Maui, at 600-1200 ft. This site on Hawaiian Home lands is one of the most intact lowland leeward forest remnants in the State. Native vegetation has survived on the lava flows apparently because of their unsuitability for ancient Polynesian agriculture, partial protection from fire by tracts of unvegetated lava, and absence of feral goats in the area. (Management Category #1 or #2)

Potential conservation sites might be usefully categorized as falling into one of three classes based on the extent of management required: #1) little or no management needed (only monitoring) other than legal protection from anthropogenic activities, such as development, off-road vehicles, etc.; #2) initial exclusion of feral/domestic mammals needed; otherwise requires little initial or sustained management but monitoring; or #3) exclusion of feral/domestic mammals needed; also needs initial or continuing application of intensive management such as introduced species control (e.g. weeds, rodents, carnivores, introduced birds, etc.), and perhaps a program of replanting selective native species.

In selecting the sites within the study area where conservation seemed most warranted, a set of criteria was developed. The initial setup and continued management of a natural area reserve can be costly. The greater the efficacy in site selection and land management, the larger a land area can be protected per given dollar. Some ecosystem types may have a greater capacity to be self-sustaining over the next century than others given equal protection. These are the sites that have often remained the most functionally intact native communities, often despite some perturbations. Such ecological sites are often harsh, stress-adapted ecosystems, arid or seasonally arid, with a lack of stable soil substrate, often nutrient deficient, in rocky and/or steep areas. In areas below about 3000 ft, there must be some feature, such as paucity of vegetation, that has protected vegetation from the effects of Polynesian and modern fire. Sites such as these are often impacted most severely by feral goats, the most agile of the introduced herbivores.

It is these stress-adapted ecosystems that perhaps should be the first priority in terms of conservation. After the initial management effort, these ecosystems should be functionally self-sustaining. Areas that are less intact or heavily invaded by alien species may be less self-sustaining. In one case, however the excellent reproductive potential of the dominant top-story species, Acacia koa, suggests forests dominated by this species may be capable of dramatic recovery. A success in natural area conservation will trigger further efforts; a perceived failure in this area may be a block to future efforts.

From an ecological point of view, we have identified the following areas as presenting the best possibilities for preserving representative tracts of montane cloud-belt forest, upper dryland forest, middle dryland forest, lower dryland forest, seasonal dryland forest, and/or strand vegetation:

1. Montane Cloud-Belt Forest: Acacia/Metrosideros forests from Manawainui to Wailaulau at 4000 ft to 6000 ft. Though heavily impacted this area of State and Hawaiian Home lands contains many species not found in the park or elsewhere

a partial sample of East Maui's leeward vegetation. Of the 239 native flowering plant species of the south slope, only 119 (49%) have been recorded within the boundaries of Haleakala National Park. The Kaupo Gap and adjacent Manawainui plane section of Haleakala National Park provides moderately good representation of south slope vegetation above 4000 ft, but reaches down to only 3850 ft and lacks representation of the lower zones. Of the 104 south slope flowering plant species ranging primarily above 4000 ft, 82% have been recorded in the park. Of those 120 ranging primarily below 4000 ft, only 22% have been recorded in the park. Of 66 tree species found on the south slope, over half are not found in the park.

Haleakala National Park provides good representation of alpine rockland, subalpine shrubland, and montane shrubland. With some koa forest, it provides at best poor representation of mesophytic cloud-belt forest. Some upper dryland forest elements are present, but only in low populations and in very marginal habitat—largely on a single steep west-facing ridge at the extreme upper limit of species ranges. These populations are quite interesting, but by no means constitute a basis for preserving a good sample of East Maui's dryland forest. In addition, they are located in a very difficult site for monitoring and ecological manipulation to assist regeneration.

Given present economic and political realities, not all that could be done to preserve native Hawaiian ecosystems will likely be accomplished. Large scale fencing and feral animal exclusion projects such as are being undertaken or contemplated by the NPS and Nature Conservancy on East Maui may not be applicable on leeward Haleakala outside the national park, for the following reasons: 1) Fencing, fence maintenance, and feral animal control is very expensive; other, more intact ecosystems would have to be rated as higher priority for large federal, state, or private fencing efforts; 2) Much of the most important land for conservation is private, state-owned or Hawaiian Home Lands, which might or might not be made available for conservation lease or purchase, but would at best be costly; and 3) The south slope will soon be the only remaining feral goat hunting area on Maui; local hunters may object to large-scale reductions by the State in the area available for goat habitat. Excellent opportunities would seem to exist, however, for strategic preservation within fenced exclosures of smaller samples of the best remnants of native vegetation.

How successfully can fenced exclosures serve as a tool for preservation of genetic diversity of Hawaiian plants? Could units as small as several hectares in size be self-perpetuating over a period of centuries? In spite of much theorizing in the literature regarding the required size of ecological reserves, there is no clear cut answer. We regard a network of such exclosures as the best short-term strategy for dealing with the biological impoverishment of leeward East Maui.

populations in the wild." Nevertheless, many would agree with Carlquist (1974), who has stated: "In 'saving' insular species from extinction, we must discriminate between short-term sanctuary and long-term survival. Breeding in zoos and maintenance in botanic gardens so far give no indications of long-term success on their own terms. Long-term success is possible only if sufficient areas of original habitat can be preserved."

Potential for in situ preservation

How successfully can fenced exclosures serve as a tool for preservation of genetic diversity of Hawaiian plants? Could units as small as several hectares in size be self-perpetuating over a period of centuries? In spite of much theorizing in the literature regarding the required size of ecological reserves, there is no clear cut answer. In our opinion, a well-planned conservation effort in the study area might be very effective in preventing further degradation of several unique ecosystem types. The best immediate opportunity for large-scale preservation of south slope vegetation on East Maui is within the Kaupo Gap portion of Haleakala National Park. The National Park Service as of publication of this report has a major management effort in progress, involving fencing the Crater District of Haleakala and reducing goat numbers. Such a program was carried out successfully at Hawaii Volcanoes National Park in the 1970's. This project will result in protection of important leeward montane ecosystems above 3850 ft.

One of the most valuable areas of native leeward vegetation within the park occurs on the steep cliffs of western Kaupo Gap at ca. 3850-7600 ft. The species composition found here is perhaps unique on East Maui. Very rare species such as Viola tracheliifolia, Schiedea haleakalensis, Plantago princeps, Bidens micrantha ssp. kalealaha, etc. are found on these cliffs along with common subalpine elements such as Sophora, Styphelia and Artemisia mauiensis. Specimens of Dubautia collected from this site exhibit characters of both D. menziesii and D. linearis (G. Carr, pers. comm.).

A mixed forest with a large number of tree species grows on the eastern floor and walls of Kaupo Gap at 3850-6000 ft. Acacia koa, Sophora chrysophylla, Metrosideros polymorpha, Myrsine lanaiensis and Dodonaea eriocarpa are the dominant species. The understory contains many native ferns. A small stand of trees on a steep west-facing ridge in eastern Kaupo Gap at 4700-5100 ft contains ten species of mesic or dryland forest trees, including five species not currently known elsewhere in the park- Nothocestrum cf. latifolium, Osmanthus sandwicensis, Planchonella sandwicensis, Psychotria mauiensis, and Zanthoxylum kauaense.

In spite of these and other important biological features in Kaupo Gap, National Park Service lands sustain no more than

examined in more detail. Displacement of native plant species by introduced plant species (which in most cases gained a foothold through continual disturbance by ungulates) appears to be a major cause for concern. Such displacement appears nearly complete in some situations- especially in the zone of kikuyu grass dominance, which corresponds largely with the richest surviving remnant of the upper dryland forest zone in Auwahi. If progress is to be made in preserving already rare elements of Hawaii's endemic biota, a better understanding of possible subtle breakdowns in the life cycles of native plants is needed. Meanwhile, we have no evidence which suggests that large numbers of native species are inevitably doomed to extinction due to unseen problems.

POTENTIAL FOR CONSERVATION OF NATIVE VEGETATION OF LEEWARD EAST MAUI.

Potential for ex situ preservation of rare leeward East Maui species

Some south slope species have been established at Maui Botanical Garden in Kahului and at a few other botanical gardens in the state. In general, cultivation of native Hawaiian species has proved extremely challenging. Obata (1971) and Wooliams (1976) have described the difficulties encountered on Oahu, many of which have been overcome with increasing experience. Efforts by Rene Sylva, an employee of Maui County assisted by volunteers, at the Maui Botanical Garden, have been outstanding. One problem encountered by Sylva, of course, is that of growing species from higher elevation habitats near sea level. Phytophagous insects, fungi, nematodes, and other problems with the soil microenvironment have been overwhelming for some species. However, as of September 1984, the following south slope species are among those seen in cultivation at the Maui Botanical Garden: Achyranthes splendens, Canavalia haleakalensis, Erythrina sandwicensis, Lipochaeta kamolensis, Pleomele aurea, Rauvolfia mauiensis, Reynoldsia mauiensis, Bonamia menziesii, and Nesoluma polynesianum.

The benefits of such work in botanical gardens are enormous, especially for educating the public as to the need for preservation in the wild and for contributing knowledge toward understanding ecology of rare species (Wooliams 1976, Heywood 1979). Conway (1980) has reviewed the role of "captive propagation" and concluded that in spite of serious problems, it does have an important though secondary place in conservation efforts. Budowski (1976) notes the "possibility of producing large populations of individuals of one plant species in a relatively short time and potential for well organized efforts to succeed in reestablishing viable

wild or captive populations (Beardmore 1983, Hamrick 1983). Evolutionary theory dictates that reduced genetic variation increases the probability of extinction. O'Brien *et al.* (1985) have suggested that the very low amount of genetic variability in the South African cheetah (*Acinonyx jubatus jubatus*) is responsible for great difficulty in captive breeding, high juvenile mortality in captivity and in the wild, and high susceptibility to disease.

Changes in microclimate, due to loss of native overstory and/or understory, which lead to unsatisfactory conditions for germination and/or establishment:

When browsing/grazing animals first move into a previously pristine forest site, they remove most herbaceous plants and parts of trees and shrubs below ca. 1.5 m, changing many interrelated environmental conditions of the forest floor. Consequences include higher solar radiation, higher temperature, lower atmospheric humidity, and lower soil moisture. These changes are often accompanied by soil compaction from trampling of ungulate hooves and loss of nutrients, especially nitrogen, by leaching. Such microenvironmental changes at and near ground level have profound effects on the germination and establishment of native species, including overstory tree species.

Alteration of the soil environment (e.g., disruption of mycorrhizal relationships, introduction of exotic soil microorganisms):

It has been suggested that the drastic change in soil microclimate resulting from establishment of dense mats of kikuyu grass may alter the physical and biological rooting environment beyond the tolerance limits of native tree species.

Absence of suitable sites for germination and establishment of native species due to the overwhelming presence of introduced species in many habitats:

Certain introduced species such as *Pennisetum clandestinum*, *Bidens pilosa*, *Sporobolus africanus*, *Holcus lanatus* and others are capable of dominating large areas with near exclusion of other plant species. These aggressive species tie up water, light and soil nutrients essential for establishment of seedlings of native species (a likely correct, but tentative conclusion based only on observation and lacking experimental support). This displacement by introduced plant species seems to be the single most important factor other than browsing in inhibiting reproduction of native species.

In summary, factors other than damage by feral and domestic ungulates are involved in interfering with survival of some native flowering plant species of leeward East Maui. These more subtle factors are only beginning to be recognized and

lowlands. It seems very likely that long term coevolution of Hawaiian birds and flowering plants, many in endemic Hawaiian genera, may have led to at least partial mutual interdependence for long-term survival. Loss of native bird species may disrupt the pollination, seed dispersal, and seed germination mechanisms of native plant species.

Native genera of the study area which probably are (or were) bird-pollinated include: Metrosideros, Erythrina, Sophora, Pleomele, Canavalia, Mezoneuron, Cassia, Myoporum, Santalum, Stenogyne, Geranium, Clermontia, Lobelia, Cyanea, Labordia, and Hibiscadelphus. Loss of pollinators can result in inbreeding depression and/or reduction in genetic diversity for species which are capable of self-pollination. Species which require outcrossing are, of course, without pollinators no longer able to reproduce sexually. There is the possibility that in some instances introduced birds may fill the former role of native birds, but this remains to be documented.

Birds may be the dispersers of certain native plant seeds and may be necessary for establishing new populations as well as increasing the genetic exchange in existing populations. Temple (1977) demonstrated that in the Mascarene Islands extinction of the dodo has resulted in near extinction of a native tree which required scarification in the bird's crop for germination. Similar relationships may have existed in the Hawaiian biota. Numerous Hawaiian plant genera such as Coprosma, Santalum, Rubus, Cyanea, and Clermontia produce fruits apparently adapted to bird dispersal. The fruits of many species of these genera are not eaten currently by native birds.

Extinction or local extirpation of insects critical to pollination of native plant species:

The magnificent insect fauna of the Hawaiian Islands has been severely impacted by man, primarily by habitat destruction and by accidental or purposeful insect introductions (Zimmermann 1970, Gagne 1982, Howarth 1983). Many pollinators of Hawaiian flowering plant species have presumably been lost, although our current lack of knowledge of details is pathetic. Bierzychudek (1981) has documented the quite significant reduction in seed set due to inefficient pollination which occurs in relatively intact ecosystems. If individuals of a species are self-incompatible, failure of pollination will, of course, result in lack of seed set. Even if potential pollinators are present, widely isolated self-incompatible individuals are very unlikely to set seed.

Catastrophic loss of genetic variability as a result of severe reduction in population size or loss of pollinator(s):

Insufficient work has been done to clarify relationships between genetic variation and vulnerability to extinction of

observed in the field at times. Nevertheless, few native species are reproducing in the sense of establishing new mature individuals from seed. We have been unable to determine, under the limitations inherent in our survey, to what extent this is simply due to browsing and to what extent other factors are involved. It is clear, however, that many species could reproduce if herbivores were eliminated. The following section examines what other factors might prevent reproduction of some species even without browsing pressure of herbivorous mammals.

Failure of the Weakest Link in Plant Life Cycles Due to Man-induced Changes.

What factors other than herbivory by introduced mammals may prevent reproduction of some persisting native species of leeward East Maui?

Introduction of an insect or pathogen which seriously reduces vigor of young or mature native plant species:

Examples of this phenomenon include the attack of the few remaining individuals of Drypetes phyllanthoides (Euphorbiaceae) as well as numerous other native tree species by the black coffee twig borer, Xylosandrus compactus (Gagné 1976, Hara and Beardsley 1979, Samuelson 1981). Numerous individuals of Antidesma pulvinatum (Euphorbiaceae) in the Lualailua district were partially defoliated, apparently by Chinese rose beetles, Adoretus sinicus. Several trees of Nothocestrum latifolium (Solanaceae) in the Kanaio district were partially defoliated by the three-lined potato beetle, Lema trilineata.

Predation on seeds by introduced rodents, birds, or insects:

Probable impact of rodents was discussed in an earlier section.

We found that seeds of Acacia koaia at Puu o Kali are attacked by the macadamia nut borer, Cryptophlebia illepidia. Wirawan (1974) found that at Mokuleia, northwest Oahu, many seeds of Canthium were infested with a moth, Orneodes objurgatella, which in some cases destroyed almost 100% of the fruits of each tree. Zimmermann (1948) believed this moth to be introduced.

Extinction or local extirpation of birds critical to pollination of native plant species and dispersal and/or germination of their seeds:

Reports of recently extinct fossil birds by Olson and James (1982a; 1982b) show that many bird species have been lost in the past 1500 years. They also show that many of these extinct species may have been primarily distributed in the

of Kaupo Gap resulted in "established reproduction" of Acacia koa after five years. They also found that the introduced grass Melinis minutiflora increased greatly with protection, suggesting that goats exert some control over Melinis. They concluded that the forest could partly recover if goats were eliminated, but exotics including Melinis would prevent full restoration.

Loope and Scowcroft (1985) have reviewed results of exclosure studies in Hawaii, including 14 in and near Haleakala National Park. A variety of trends are apparent in these 14 exclosures in habitats ranging from subalpine shrubland and dryland forest to montane bog and rainforest. Trends of individual exclosures indicate a broad spectrum of vegetation responses and potential of native species to survive under protection from feral herbivores. The exclosure supporting the most pessimistic view of recovery potential of native species was a site at 3200 ft in Auwahi, fenced in 1969 as part of a broad-based effort to preserve a portion of the botanically rich, relatively intact forest there. The specific site was chosen following a survey by Lennox (1967) for its particularly high concentration of rare trees- Ochrosia haleakalae, Pelea multiflora, Streblus sandwicensis, etc. The Nature Conservancy obtained a lease on the land and fencing was accomplished with assistance from Ulupalakua Ranch employees and others. Responsibility for care of the site was delegated to the Pacific Tropical Botanical Garden. Kikuyu grass (Pennisetum clandestinum) was just completing its invasion of the area at the time the exclosure was established and greatly increased its dominance in the first year following fence construction (Lennox et al. 1970). Due to exclusion of grazing, kikuyu grass became even more dense inside the exclosure than out, preventing any seedling establishment. In spite of dedicated efforts by Lennox and others, the project was unsuccessful and instigators became discouraged. The fence has not been maintained in recent years, and The Nature Conservancy agreed not to continue their lease in 1981. Meanwhile, substantial deterioration of the stand has occurred since the project began.

On the other hand, three exclosures at 4000-5100 ft in Kaupo Gap, established in 1977-81, show good recovery of some native species under protection. Osteomeles, Dodonaea, and Styphelia are recovering after five years in a badly damaged site in the western part of the gap, in spite of dominance of the ground cover by introduced grasses. Within a 2-year old fence enclosing rare dryland trees on the eastern wall of the gap, the following species have produced seedlings: Acacia koa, Coprosma stephanocarpa, Dodonaea eriocarpa, Myrsine lanaiensis, Planchonella sandwicensis, and Sophora chrysophylla. Seedlings of Acacia koa were already 1-2m tall.

This survey has found that most species on the south slope are producing seeds and that seedlings of many species can be

boundaries of Haleakala National Park. Assuming that large- or small-scale protection from browsing were a possibility for strategically located sites within a spectrum of south slope vegetation zones, what potential for recovery exists at this point in time?

Mueller-Dombois (1981a) has summarized historic thought regarding competition of native vs. introduced plant species on oceanic islands:

"A number of authors starting with Darwin (1859), Hooker (1867), and Wallace (1880) have gone on record to proclaim that introduced biota inevitably will displace the indigenous biota on oceanic islands, primarily because the latter are not equipped to compete with the former. This general hypothesis was reemphasized in this century again by Degener (1930), Carlquist (1965), and others. From observing the same relationships, other authors, such as Allan (1936), Egler (1942), Hatheway (1952), and Harris (1962), have concluded that the competitive capacity of a species is not determined by whether it originated on an island or continent. Egler and Hatheway, moreover, predicted from observations in the Hawaiian Islands that the indigenous biota eventually will succeed in the competitive struggle with aliens provided that humans do not interfere."

Remarkably little specific information dealing with survival and recovery of native Hawaiian vegetation under protection from browsing is found in the literature. Wirawan (1974) found that many native species of the dry forest at Mokuleia, northwestern Oahu, were reproducing well in an area with little damage to feral animals, in spite of the presence of numerous introduced plants. He detected local problems, however, including the apparent inability of Erythrina sandwicensis to reproduce in an area of dense Melinis minutiflora, an introduced grass.

Hawaii Volcanoes National Park was fenced and goats were drastically reduced during the mid- to late-1970's. Mueller-Dombois (1981a,b) found that elimination of goats from the coastal lowland ecosystem of Hawaii Volcanoes resulted in increased floristic and structural complexity, with the natives Canavalia kauensis and Ipomoea congesta becoming locally prominent in the vegetation. Williams (1980) found that Osteomeles appears to be displacing exotic grasses. Canthium odoratum was the most rapidly regenerating native tree. Dodonaea viscosa was reproducing well except for areas where dense mats of Melinis minutiflora were established. Mueller-Dombois (1981a) has suggested that the lowland ecosystem became sufficiently degraded prior to protection that spontaneous recovery of many native trees is unlikely.

Scowcroft and Hobdy (1986) found that fencing of a small area of koa parkland at 4000 ft in the Manawainui drainage east

Despite great degradation, Acacia koa forests have in small-scale experiments responded very positively to protection from browsing animals with vegetative and seedling reproduction (Spatz and Mueller-Dombois 1973, Scowcroft and Hobdy 1986). Although excellent potential for conservation of koa forests exists, there is every indication that stands will continue to deteriorate due to feral animal or domestic livestock browsing. Conversion of hardwood forest into pastureland is not especially productive economically, and yet the results of such land use are irreversible. The preservation of this unique ecosystem should be one of the highest conservation priorities of the peoples of Hawaii.

Farrell (1982) has pointed out the potential enormous value of the native Hawaiian biota to local people both directly and indirectly through the tourism industry. It is important to keep options open for future generations; as Hawaiian species continue to disappear, those that are left become perceived as more and more valuable. The state and the nation are in danger of losing an irreplaceable heritage which future generations may value more highly than this generation does.

An important related consideration is protection of watersheds and potential productivity of the land. It can, of course, be argued that so much irreversible damage has already occurred that efforts now would be too little and too late, and that introduced grasses currently provide the major assistance in preventing further loss of what soil still exists in much of the area. On the other hand, further loss of native plant canopy and ground cover in the ohia/koa forest of the mesophytic cloud-belt forest zone would result in additional massive soil erosion.

Prognosis for Recovery of South Slope Vegetation under Reduced Browsing Pressure

That degradation of south slope native vegetation is in an advanced stage is a reality which few, if any, would dispute. As would be the case for any such area with lands of mixed ownership in Hawaii or anywhere else, a recognized need for species preservation may have serious conflicts with other important uses. Although we have presented a case for preservation of unique Hawaiian species, we recognize that individual landowners have every right to their own views and land uses. In the case of State and Hawaiian Home lands, we know that managers must weigh many factors, of which attempted preservation of unique Hawaiian species is only one. Political and economic considerations are beyond the objectives and scope of this report. However, based on the cooperation we have received from virtually everyone contacted in this survey, we feel that we are not simply engaged in an academic exercise in discussing possibilities for partial restoration beyond the

are beginning to tap the tremendous potential that Hawaiian plant species may contribute toward understanding evolutionary mechanisms involved in speciation and adaptation to drought. Unfortunately, prime subjects for study are disappearing rapidly.

Plant species of leeward East Maui are also an integral and irreplaceable part of the Hawaiian heritage, a heritage valued by many Hawaiians and non-Hawaiians. Ancient Hawaiians depended on many species of the leeward flora for material, medicinal, and religious purposes including many species which are now rare. Hawaiian names are known for most species in the leeward flora.

A particularly noteworthy example of incipient loss of a valued resource is the degradation of koa (Acacia koa) forests on East Maui. Koa forests are one of the finest resources of the Hawaiian Islands, both in a cultural and a biological sense. The koa forests of Maui were among the best in the islands. Whitman (1979), writing in 1813, noted of the quality of koa from East Maui and Hawaii: "Owhyhee [Hawaii] and Mowee [Maui] furnish the best canoes." Holmes (1981) notes: "Of old, certain areas such as the mountains above Hilo and Kona and the slopes of Haleakala produced such an abundance of high quality canoe logs that a very disproportionate amount of the total canoes throughout the islands came from these sites." Compared to this abundance in the past, the koa forests of both East Maui and Hawaii have undergone tremendous degradation. What at one time may have been a continual band of mesic Acacia koa forests on the western and southern slopes of East Maui has been reduced to three relictual areas- 1) Waikamoi (northeast slope), 2) Manawainui to Wailaulau (south slope), and 3) east Kaupo Gap-Manawainui-Kipahulu (southeast slope). Holmes (1981) notes: "It has been estimated that today there is standing probably not much more than ten per cent of the amount of the Koa that existed at the time of Cook's arrival.. Fortunately some stands of Koa have survived, but even these are threatened by a deadly array of enemies, led by man. Koa has become a stranger in its own land."

Koa produces what is recognized as one of the finest quality and most beautiful hardwoods in the world. These trees were the overwhelming choice of the first Hawaiians for canoe building. The wood was put to other ethnobotanical uses and is still generally esteemed by local people as a symbol of Hawaii. From a biological standpoint, increasing evidence is suggesting that the Acacia koa forests may have the greatest diversity of native insects, plants and birds. Swezey (1954) wrote concerning the native insect fauna: "There are probably more endemic insect species attached to this koa complex than to any other generic group of trees in the Hawaiian Islands. Besides those species definitely attached to koa, there are many others, endemic and otherwise, which are associated with it in one way or another."

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APPENDIX I. LIST OF NATIVE FERNS AND FERN ALLIES OF LEEWARD HALEAKALA
by R. Hobby and A.C. Medeiros

	Approximate elevational range (ft)
ASPIDIACEAE	
* <u>Arachniodes carvifolia</u> (Kze.) Ching (I:K, Ma, L, Pacific)	5000-6000
* <u>Ctenitis rubiginosa</u> (Brack.) Copel. (E:K, O, Mo, Ma, L, H)	5000-6000
* <u>Cyrtomium caryotideum</u> (Wall.) Presl. (I:K, O, Mo, Ma, L, H, Asia, Pacific)	3000-6000
* <u>Dryopteris fusco-atra</u> (Hbd.) Robins (E:K, O, Mo, Ma, L, H)	4000-6000
* <u>Dryopteris glabra</u> (Brack.) Kze. (E:K, O, Mo, Ma, L, H)	4000-7000
* <u>Dryopteris hawaiiensis</u> (Hbd.) Robins (E:K, O, Ma, H)	4000-7000
* <u>Dryopteris</u> sp. novum unpub. Herat (E:Ma)	4000-6000
* <u>Dryopteris unidentata</u> (H.&A.) C.Chr. (E:H. I.)	4000-6000
var. novum unpub. Herat (E:Ma)	
* <u>Dryopteris wallichiana</u> (Spreng.) Hyl. (I:K, Mo, E/WMa, H, Trop. Amer.)	3000-7000
* <u>Polysticum haleakalense</u> Brack. (E:O, Ma, H)	4000-8000
* <u>Polysticum hillebrandii</u> Carrothers (E:Ma, H)	4000-6000
* <u>Polysticum</u> sp. novum ined. Wagner (E:EMA)	4000-7000
ASPLENIACEAE	
* <u>Asplenium adiatum-nigrum</u> L. (I:K, Ma, H, & Europe, Africa, Asia, Tropics)	4000-10,000
* <u>Asplenium contiguum</u> Kaulf. (I:K, O, Mo, Ma, H, Africa to Pacific)	4000-6000
* <u>Asplenium lobulatum</u> Mett. (I:K, O, Mo, Ma, H, Pacific)	4000-6000
* <u>Asplenium macraei</u> Hook. & Grev. (E:K, O, Mo, Ma, H)	4000-6000
* <u>Asplenium rhipidoneuron</u> Robins (I:K, O, Mo, Ma, H, Africa, Asia, Pacific)	2000-6000
* <u>Asplenium trichomanes</u> L. (I:O, Ma, H, N. Temp. to Trop. mtns.)	5000-10,000
ATHYRIACEAE	
* <u>Athyrium microphyllum</u> (Sm.) Alston (E:K, O, Mo, Ma, H)	4000-6000
* <u>Diplazium sandwichianum</u> (Presl.) Diels (E:K, O, Mo, Ma, H)	3000-7000
BLECHNACEAE	
* <u>Doodia kunthiana</u> Gaud. (E:K, O, Mo, Ma, L, H)	5000-6000
* <u>Sadleria cyatheoides</u> Kaulf. (E:K, O, Mo, Ma, L, H)	1000-7000
* <u>Sadleria squarrosa</u> (Gaud.) Maxon (E:K, O, Mo, Ma, H)	5000-6000

* = recorded from Haleakala National Park
[Nomenclature based on unpublished treatment by Dr. C.H. Lamoureux]

DAVALLIACEAE		
* <u>Nephrolepis exaltata</u> (L.) Schott	(I:H.I., pantropical)	2000-3000
DENNSTAEDTIACEAE		
* <u>Microlepia</u> cfr. <u>speluncae</u> (L.) Moore	(I:K,O,Mo,Ma, H, pantropical)	4000-7000
DICKSONIACEAE		
* <u>Cibotium glaucum</u> (J.Sm.) H. & A.	(E:K,O,Mo,L,Ma,H)	4000-6000
ELAPHOGLOSSACEAE		
* <u>Elaphoglossum hirtum</u> C.Chr.	(I:H.I., pantropical)	4000-8000
var. <u>micans</u> (Mett.) C.Chr.	(E:K,O,Mo,Ma,L,H)	
* <u>Elaphoglossum wawrae</u> (Luer) C.Chr.	(E:K,O,Mo,Ma,H)	5000-7000
GLEICHENIACEAE		
* <u>Dicranopteris linearis</u> (Burm.) Underw.	(I:H.I. & Asia, Pacific.)	4000-6000
GRAMMITIDACEAE		
* <u>Grammitis hookeri</u> (Kaulf.) Copel.	(I:H.I., Pacific.)	4000-6000
HEMIONITIDACEAE		
* <u>Coniogramme pilosa</u> (Brack.) Hieron.	(E:K,O,Mo,Ma,H)	4000-7000
HYPOLEPIDACEAE		
* <u>Hypolepis punctata</u> (Thunb.) Mett.	(I:O,Mo,Ma,Japan, Aust.,Polynesia)	5000-6000
* <u>Pteridium aquilinum</u> (L.) Kuhn	(I:Cosmopolitan)	2000-9000
var. <u>decompositum</u> (Gaud.) R.Tryon	(E:H.I.)	
LYCOPODIACEAE		
<u>Lycopodium mannii</u> (Hbd.) Skotsb.	(E:K,Ma,H)	5000-6000
* <u>Lycopodium venustum</u> Gaud.	(E:K,O,Mo,Ma,H)	6000-8000
MARATTIACEAE		
* <u>Marattia douglasii</u> (Presl.) Baker	(E:K,O,Mo,Ma,H)	4000-6000
OPHIOGLOSSACEAE		
* <u>Ophioglossum concinnum</u> Brack.	(E:K[?],O,Mo,Ma,H)	s.l.-2000
<u>Ophioglossum pendulum</u> L.		2000-3000
ssp. <u>falcatum</u> (Presl.) Clausen	(I:H.I., pantropical)	
POLYPODIACEAE		
* <u>Pleopeltis thunbergiana</u> Kaulf.	(I:K,O,Mo,Ma,L,H)	3000-8000
* <u>Polypodium pellucidum</u> Kaulf.	(E:H.I.)	6000-9000
var. <u>vulcanicum</u> Skotts. b.	(E:Ma,H)	
PSILOTACEAE		
* <u>Psilotum complanatum</u> Sw.	(I:H.I., Tropics)	5000-6000
* <u>Psilotum nudum</u> (L.) Beauv.	(I:H.I., Tropics)	2000-5000

PTERIDACEAE

* <u>Pteris cretica</u> L. (I:K,O,Mo,Ma,H,Tropics)	3000-8000
* <u>Pteris excelsa</u> Gaud. (I:H.I.,Asia,Pacific)	4000-7000
* <u>Pteris irregularis</u> Kaulf. (E:H.I.)	5000-6000

SELAGINELLACEAE

* <u>Selaginella arbuscula</u> (Kaulf.) Spring. (E:H.I.)	4000-6000
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SINOPTERIDACEAE

<u>Doryopteris decipiens</u> (Hook.) J.Sm. (E:H.I.)	2000-4000
* <u>Pellaea ternifolia</u> (Cav.) Link (I:K,O,Mo,Ma,H,Americas)	2000-8000

THELYPTERIDACEAE

* <u>Amauropelta globulifera</u> (Brack.) Holtt. (E:K,O,Ma,H)	4000-7000
* <u>Christella cyatheoides</u> (Kaulf.) Holtt. (E:K,O,Mo,Ma,L,H)	4000-6000
* <u>Pneumatopteris sandwicensis</u> (Brack.) Holtt. (E:K,O, Mo,Ma,H)	3000-7000
* <u>Pseudophegopteris keraudreniana</u> (Gaud.) Holtt. (E:K,O,Mo,Ma,H)	4000-6000

APPENDIX II. ELEVATIONAL DISTRIBUTION AND STATUS OF NATIVE FLOWERING PLANTS OF LEEWARD
HALEAKALA, MAUI, HAWAIIAN ISLANDS: A SUMMARY LISTING

	Elevational range (ft)	Life form
DICOTYLEDONES		
AIZOACEAE SJ155 Carpetweed family		
* <u>Sesuvium portulacastrum</u> (L.) L. 1759 (I:tropics)	s.l.-50	H
AMARANTHACEAE SJ151 Amaranth family		
<u>Achyranthes splendens</u> Mart. ex Moq. 1849 (E:O,L,E/WMa,Mo)	600-1200	S
var. <u>splendens</u> (E:L,E/WMa)		
# <u>Charpentiera obovata</u> Gaud. 1829 (E:H.I.)	2300-4200	T
# <u>Charpentiera ovata</u> Gaud. 1829 (E:H.I.)	ca.4000	T
# <u>Nototrichium sandwicense</u> (Gray in Mann) Hbd.1888 (E:Niihau,K,Mo,L,E/WMa,H)	700-2700	S
var. <u>dubium</u> Sherff 1950 (E:EMa)		
var. <u>lanaiense</u> Sherff 1950 (E:L,EMa)		
var. <u>leptopodum</u> Deg. & Sherff in Sherff 1950 (E:EMa)		
ANACARDIACEAE SJ220 Mango family		
# <u>Rhus sandwicensis</u> Gray 1854 (E:H.I.)	ca.3200	T
APIACEAE SJ263 Carrot family		
#* <u>Sanicula sandwicensis</u> Gray 1854 (E:Mo,Ma,H)	ca.6000	H
APOCYNACEAE SJ279 Periwinkle family		
* <u>Alyxia olivaeformis</u> Gaud. 1829 (E:H.I.)	2300-5400	V
var. <u>lanceolata</u> Hbd.1888 (E:O,Mo,L,Ma)		
var. <u>myrtillifolia</u> Gray ex Hbd. 1888 (E:L,Ma)		
# <u>Ochrosia haleakalae</u> St.John 1978 (E:EMa)	2800-4000	T
# <u>Rauvolfia mauiensis</u> Sherff 1947 (E:EMa)	300-2400	T
AQUIFOLIACEAE SJ221 Holly family		
* <u>Ilex anomala</u> H. & A. 1832 (E:H.I.)	4000-6000	T

APPENDIX II (cont.)

ARALIACEAE SJ258 Ginseng family

* <u>Cheirodendron trigynum</u> (Gaud.) Heller 1897 (E:H.I. exc. K)	3200-6200	T
<u>Reynoldsia mauiensis</u> Sherff 1952 (E:EMa)	800-2800	T
var. <u>mauiensis</u>		
var. <u>macrocarpa</u> Deg. & Sherff 1952		
#* <u>Tetraplasandra kavaiensis</u> (Mann) Sherff 1952 (E:K,L,E/WMa,H)	4000-5400	T
var. <u>intercedens</u> Sherff 1952 (E:EMa)		
#* <u>Tetraplasandra meiantra</u> (Hbd.) Harms 1898 (E:H.I.)	2800-4000	T
var. <u>leptomera</u> Sherff 1952 (E:EMa)		
var. <u>mauiensis</u> Sherff 1952 (E:EMa)		

ASTERACEAE SJ348 Sunflower family

!* <u>Argyroxiphium sandwicense</u> A.DC. 1836 (E:EMa,H)	8000-9500	H
ssp. <u>macrocephalum</u> (Gray) Meyrat 1983 (E:EMa)		
!! <u>Argyroxiphium virescens</u> Hbd. 1888 (E:EMa)	7000-8000	S
var. <u>virescens</u>		
#* <u>Artemisia australis</u> Less. 1831 (E:O,Mo,E/WMa)	s.l.-50, ca. 4700	S
* <u>Artemisia mauiensis</u> (Gray) Skottsb. 1927 (E:EMa)	3700-8000	S
var. <u>mauiensis</u>		
var. <u>diffusa</u> Skottsb. 1937		
#* <u>Bidens mauiensis</u> (Gray) Skottsb. 1920 (E:L,E/WMa)	10-150	H
#* <u>Bidens micrantha</u> Gaud. 1829 (E:Mo,L,E/WMa,H)	5600-6400	S
ssp. <u>kalealaha</u> Nagata & Ganders 1983 (E:L,E/WMa)		
<u>Dubautia linearis</u> (Gaud.) Keck 1936 (E:Mo,L,E/WMa,H)	1400-3200	S
* <u>Dubautia menziesii</u> (Gray) Keck 1936 (E:EMa,H)	5700-9800	S
#* <u>Dubautia plantaginea</u> Gaud. 1830 (E:O,L,Mo,E/WMa,H)	4500-5500	S
#* <u>Dubautia platyphylla</u> (Gray) Keck 1936 (E:EMa)	5400-7000	S
#* <u>Dubautia reticulata</u> (Sherff) Keck 1936 (E:EMa)	4500-5500	S
* <u>Dubautia scabra</u> A.DC. 1838 (E:Mo,L,E/WMa,H)	ca.5000?	S
! <u>Gnaphalium hawaiiense</u> Deg. & Sherff in Sherff 1949 (E:EMa,H)	ca.2000?	H
* <u>Gnaphalium sandwicense</u> Gaud. 1830 (E:Kure,Midway,O,Mo,L,E/WMa,H)	1500-2300, 9000-9500	H
# <u>Lipochaeta forbesii</u> Sherff 1933 (E:EMa)	900-1500	S
var. <u>forbesii</u>		
var. <u>sherffii</u> Degener & Clay 1949		
# <u>Lipochaeta kamolensis</u> Deg. & Sherff in Sherff 1951 (E:EMa)	750-950	S

<u>Lipochaeta</u> <u>lavarum</u> (Gaud.) A. DC. 1836 (E:Molokini, L, Mo, E/WMa, H)	10-2500	S
var. <u>lavarum</u> (E:Molokini, Mo, L, E/WMa, H)		
var. <u>ovata</u> Sherff 1933 (E:EMa)		
# <u>Lipochaeta</u> <u>lobata</u> (Gaud.) DC. 1836 (E:K, O, Mo, E/WMa)	ca. 40	S
var. <u>makenensis</u> Deg. & Sherff in Sherff 1960 (E:EMa)		
<u>Lipochaeta</u> <u>mauiensis</u> St. John 1984 (E:EMa)	ca.1600	S
<u>Lipochaeta</u> <u>rockii</u> Sherff 1933 (E:Mo, Ma)	40-1500	S
var. <u>dissecta</u> Sherff 1933 (E:WMa, EMa)		
!! <u>Tetramolopium</u> <u>arenarium</u> (Gray) Hbd. 1888 (E:EMa, H)	ca.2500?	S
ssp. <u>arenarium</u> (E:EMa, H)		
ssp. <u>ined.</u> Lowrey (E:EMa)		
!! <u>Tetramolopium</u> <u>conyzoides</u> (Gray) Hbd. 1888 (E:L, Mo, E/WMa, Ha)	?	S
* <u>Tetramolopium</u> <u>humile</u> (Gray) Hbd. 1888 (E:EMa, H)	8500-9700	H
ssp. <u>ined.</u> Lowrey (E:EMa)		
BEGONIACEAE SJ241 Begonia family		
#* <u>Hillebrandia</u> <u>sandwicensis</u> Oliver 1866 (E:K, O, Mo, E/WMa)	3900-5500	H
BORAGINACEAE SJ287 Heliotrope family		
<u>Heliotropium</u> <u>curassavicum</u> L. 1753 (I:H.I., Americas)	s.l.-40	H
BRASSICACEAE (CRUCIFERAE) SJ165 Mustard family		
#* <u>Cardamine</u> <u>konaensis</u> St. John 1945 (E:E/WMa, H)	ca.4450	H
CAPPARACEAE SJ164 Caper family		
<u>Capparis</u> <u>sandwichiana</u> DC. 1820	s.l.-2000	S
var. <u>zoharyi</u> Deg. & Deg. 1961 (E:Midway to Hawaii)		
CARYOPHYLLACEAE SJ157 Pink family		
#* <u>Schiedea</u> <u>haleakalensis</u> Deg. & Sherff in Sherff 1942 (E:EMa)	ca.6000-7000	S
!! <u>Schiedea</u> <u>implexa</u> (Hbd.) Sherff 1943 (E:EMa)	ca.5000	?S
CELASTRACEAE SJ222 Bittersweet family		
* <u>Perrottetia</u> <u>sandwicensis</u> Gray 1854 (E:H.I.)	4000-5600	T

APPENDIX II (Cont.)

CHENOPODIACEAE SJ150 Goosefoot family

*Chenopodium oahuense (Meyen) Aellen 1933 (E:H.I.)var. oahuense (E:H.I.)

10-2800

S

cfr. var. discospermum Fosberg 1962 (E:EMa)

6000-8000

S

CONVOLVULACEAE SJ283 Morning-glory family

#Bonamia menziesii Gray 1862 (E:H.I.)

1100-2400

V

Cuscuta sandwichiana Choisy 1841 (E:H.I.)

strand-50

V

*Ipomoea brasiliensis (L.) Sweet 1818 (I:Pantropic)

strand

V

*Ipomoea congesta R.Br. 1810 (I:H.I., Aust., Pac. Isl., Mex., W.I.)

10-2800

V

Ipomoea tuboides Deg. & van Ooststr. 1940 (E:H.I.)

20-2500

V

Jacquemontia sandwicensis Gray 1862 (E:H.I.)

s.l.-2000

V/S

var. sandwicensis (E:H.I.)var. tomentosa (Choisy) Hbd. 1888 (E:Kah, Mo, H, EMa)

CUCURBITACEAE SJ334 Gourd family

!!Cladocarpa hispida (Hbd.) St. John (E:EMa)

?

V

#Sicyocaria sp. ined. St. John (E:E/WMa)

ca. 5200

V

!!Sicyos hillebrandii St. John 1934 (E:EMa)

?

V

#*Sicyos microcarpus Mann 1867 (E:O, K, EMa)

ca. 50-6200?

V

Sicyos sp. ined. #1 (E:EMa?)

2400-3200

V

#Sicyos sp. ined. #2 (E:EMa?)

700-1400

V

EBENACEAE SJ273 Ebony family

Diospyros ferrea (Willd.) Bakh. 1933 (I:India to H.I.)

1000-4000

T

ssp. sandwicense (A. DC.) Fosberg 1939 (E:H.I.)var. sandwicense (A. DC.) Bakh. 1937 (E:H.I.)var. degeneri Fosberg 1939 (E:L, EMa)

EPACRIDACEAE SJ267 Epacris family

*Styphelia douglasii (Gray) F. Muell. ex Skottsb. 1925 (E:K, Mo, Ma, H)

-

S

*Styphelia tameiameiae (Cham.) F. Muell. 1867

2000-9800

S

var. tameiameiae (I: H.I. & Marquesas Isl.)

ERICACEAE SJ265 Heath family

*Vaccinium berberifolium (Gray) Skottsb. 1927 (E:Ma, H)

ca. 6000

S

*Vaccinium reticulatum Sm. 1819 (E:EMa, H)

6700-9700

S

EUPHORBIACEAE SJ210 Spurge family

# <u>Antidesma pulvinatum</u> Hbd. 1888 (E:K,O,Mo,E/WMa,L,H)	1900-2600	T
#* <u>Claoxylon sandwicense</u> Muell.-Arg. 1865 (E:H.I.)	3200-4000	T/S
var. <u>sandwicense</u> (E:EMa)		
# <u>Drypetes phyllanthoides</u> (Rock) Sherff 1939 (E:K,O,Mo,E/WMa,H)	2800	T
* <u>Euphorbia celastroides</u> Boiss. in A.DC. 1862 (E:H.I.)	10-6400	S/T
var. <u>amplectens</u> Sherff 1936 (E:H.I.)		
var. <u>mauiensis</u> Sherff 1936 (E:L,Ma)		
! <u>Euphorbia multiformis</u> H. & A. 1832 (E:H.I.)	ca. 1000?	S
!!var. <u>haleakalana</u> Sherff 1936 (E:EMa)		

FABACEAE SJ175 Pea family

* <u>Acacia koa</u> Gray 1854 (E:H.I.)	3200-6400	T
# <u>Acacia koaia</u> Hbd. 1888 (E:K,Mo,L,E/WMa,H)	800-2500	T
!! <u>Canavalia forbesii</u> St. John 1970 (E:EMa)	ca. 2750-2800?	V
# <u>Canavalia haleakalensis</u> St. John 1970 (E:EMa)	50-1650?	V
<u>Cassia gaudichaudi</u> H. & A. 1832 (I:H.I., Tahiti)	10-2200	S
<u>Erythrina sandwicensis</u> Deg. 1932 (E:H.I.)	10-2700	T
var. <u>sandwicensis</u>		
f. <u>sandwicensis</u> (E:H.I.)		
f. <u>lutea</u> St. John 1959 (E:Mo,L,Ma)		
! <u>Mezoneuron kavaense</u> (Mann) Hbd. 1888 (E:K,O,Ma,H)	ca. 3000?	T
* <u>Sophora chrysophylla</u> (Salib.) Seem. 1865 (E:K,O,Mo,L,E/WMa,H)	1500-9000+	T/S
* <u>Vigna marina</u> (Burm.) Merr. (I:H.I., Tropics)	strand	V
<u>Vigna sandwicensis</u> Gray 1854		
var. <u>sandwicensis</u> (E:L,Ma,H)	ca. 3000+	V
var. <u>heterophylla</u> Rock 1920 (E:Ma,H)	1500-3000	

FLACOURTIACEAE SJ238 Flacourtia family

#* <u>Xylosma hawaiiense</u> Seem. 1865 (E:K,O,L,E/WMa,Mo,H)	2200-4200	T
var. <u>hillebrandii</u> (Wawra) Sleumer 1938 (E:Mo,Ma,L,H)		

GERANIACEAE SJ196 Geranium family

#* <u>Geranium arboreum</u> Gray 1854 (E:EMa)	5600-6800	S
* <u>Geranium cuneatum</u> Hook. 1837 (E:EMa,H)	ca. 8000	S
var. <u>tridens</u> (Hbd.) Fosb. 1936 (E:EMa)		
! <u>Geranium multiflorum</u> Gray 1854 (E:EMa,H)	ca. 5000-6000	S
var. <u>canum</u> Hbd. 1888 (E:EMa)		

APPENDIX II (cont.)

GESNERIACEAE SJ307 <i>Gloxinia</i> family				
!!	<i>Cyrtandra begoniaefolia</i> Hbd. 1888 (E:EMa)		ca. 4500?	S
!	<i>Cyrtandra cordifolia</i> Gaud. 1829 (E:O,EMa)		ca. 5000	S
!!	var. <i>gynoglabra</i> Rock 1918 (E:EMa)			
!*	<i>Cyrtandra lysiosepala</i> (Gray) C. B. Clarke 1883 (E:Mo, E/WMa, H)		?	S
#	<i>Cyrtandra</i> sp. #1 (E:EMa)		4400-5450	S
#	<i>Cyrtandra</i> sp. #2 (E:EMa)		ca. 5300	S
GOODENIACEAE SJ346 <i>Naupaka</i> family				
#	<i>Scaevola chamissoniana</i> Gaud. 1833 (E:K, Mo, L, E/WMa, H)		ca. 5900	S
#	<i>Scaevola coriacea</i> Nutt. 1843 (E:H.I.)		ca. 40	S
#	<i>Scaevola gaudichaudi</i> H. & A. 1832 (E:H.I.)		ca. 750	S
*	<i>Scaevola taccada</i> (Gaertn.) Roxb. var. <i>sericea</i> (Vahl) St. John 1960 (I:H.I., trop.Pac.)		s.l.-40	S
LAMIACEAE (LABIATAE) SJ292 Mint family				
#	<i>Haplostachys haplostachya</i> (Gray) St. John 1973 (E:K, EMa, H)		ca. 2000	H
*	!!var. <i>haplostachya</i> (E:Ma)			
*	<i>Lepechinia hastata</i> (Gray) Epling 1940 (I:EMa, Socorro Isl., Baja Calif.)		2000-4000	S
*	<i>Phyllostegia brevidens</i> Gray 1862 (E:E/WMa, H)		?	V
!!	var. <i>pubescens</i> Sherff 1934 (E:EMa)			
!!	<i>Phyllostegia hillebrandii</i> Mann ex Hbd. 1888 (E:EMa)		?	V
!	<i>Phyllostegia mollis</i> Benth. 1831 (E:H.I. exc. H.)		?	V
#	<i>Phyllostegia</i> sp.		ca. 5300	V
#	<i>Stenogyne augustifolia</i> Gray 1862 (E:Mo, EMa, H)		?	V
!!	var. <i>mauiensis</i> Sherff 1934 (E:EMa)			
!!	<i>Stenogyne cinerea</i> Hbd. 1888 (E:EMa)			V
#	<i>Stenogyne crenata</i> Gray 1862 (E:EMa)		7000-8000	V
!!	<i>Stenogyne glabrata</i> (Hbd.) Sherff 1934 (E:EMa)		?	V
!!	* <i>Stenogyne halliakalae</i> Wawra 1872 (E:EMa)		ca. 3000-6000	V
!	* <i>Stenogyne rotundifolia</i> Gray 1862 (E:EMa)		ca. 5000	V
	var. <i>rotundifolia</i>			
!!	var. <i>oblonga</i> Sherff 1934			
!!	<i>Stenogyne vagans</i> Hbd. 1888 (E:EMa)		ca. 4000	V
LAURACEAE SJ163 <i>Laurel</i> family				
	<i>Cassytha filiformis</i> L. 1753 (I:"tropics")		400-2000	V

LOBELIACEAE SJ336 Lobelia family			
#* <u>Clermontia kakeana</u> Walp. 1835 (E:O,Mo,E/WMa)	4300-4800		S
!! <u>Cyanea arborea</u> (Mann) Hbd. 1888 (E:EMa)	ca. 3000-4000		S
!! <u>Cyanea comata</u> Hbd. 1888 (E:EMa)	ca. 3000-4000		S
! <u>Cyanea obtusa</u> (Gray) Hbd. 1888 (E:E/WMa)	5000-5500		S
! <u>Cyanea quercifolia</u> (Hbd.) Wimmer 1956 (E:Mo,EMa,H)	ca. 3000-4000		S
# <u>Cyanea</u> sp. nov. St. John ined. (E:EMa)	ca. 4900-5300		S
#* <u>Lobelia grayana</u> E. Wimmer 1948 (E:K,EMa)	4500-5600		S
LOGANIACEAE SJ275 Strychnine family			
# <u>Labordia</u> sp.	5000-5300		T/S
LORANTHACEAE SJ147 Mistletoe family			
* <u>Korthalsella complanata</u> (v. Tiegh.) Engler 1897 (E:H.I.)	3000-8000		H
<u>Korthalsella remyana</u> v. Tiegh. 1896 (E:O,Mo,L,Ma)	1650-2100		H
MALVACEAE SJ228 Mallow family			
# <u>Abutilon menziesii</u> Seem. 1865 (E:L,H,Ma)	600-1500		S
!! <u>Hibiscadelphus wilderianus</u> Rock 1911 (E:EMa)	2500-2600		T
# <u>Hibiscus brackenridgei</u> Gray 1838 (E:O,Mo,L,E/WMa,H,Kahoolawe)	1400		S
var. <u>brackenridgei</u> (E:L,E/WMa)			
* <u>Hibiscus tiliaceus</u> L. 1753 (I:trop.Pac.& Old World)	strand		T
* <u>Sida fallax</u> Walp. 1843 (I: H.I.,Pac. Isl.,China)	20-3000		S
MENISPERMACEAE SJ161 Moonseed family			
* <u>Cocculus lonchophyllus</u> Hbd. 1888 (E:Ma)	10-4900		V
MORACEAE SJ139,374 Mulberry family			
# <u>Streblus sandwicensis</u> (Deg.) St. John 1973 (E:K,O,L,Ma,H)	2100-4500		T
MYOPORACEAE SJ318 Naio family			
* <u>Myoporum sandwicense</u> Gray 1862 (E:H.I.)			
var. <u>sandwicense</u> (E:Niihau,K,O,Mo,L,Ma)	10-5000		T
var. <u>degeneri</u> Webster 1951 (E:EMa)	3800-5400		T

APPENDIX II (Cont.)

MYRSINACEAE SJ267 Myrsine family		
* <u>Myrsine lanaiensis</u> Hbd. 1888 (E:H.I.)	2000-5500	T
* <u>Myrsine lessertiana</u> A.DC. 1841 (E:H.I.)	3000-6400	T
MYRTACEAE SJ249 Myrtle family		
* <u>Metrosideros polymorpha</u> Gaud. 1830 (E:H.I.)	1400-6900	T
NYCTAGINACEAE SJ154 Four o'clock Family		
<u>Boerhavia diffusa</u> L. 1753 (I:Pac. Isl. & tropics)	s.l.-1100	H
<u>Pisonia brunoniana</u> Endl. 1833 (E:O,L,Ma,H)	2800-4400	T
! <u>Pisonia sandwicensis</u> Hbd. 1888 (E:H.I.)	ca. 2500?	T
OLEACEAE SJ274 Olive family		
<u>Osmanthus sandwicensis</u> (Gray) Knobl. 1895 (E:H.I.)	2200-5000	T
PAPAVERACEAE SJ164 Poppy family		
* <u>Argemone glauca</u> Pope 1929 (E:H.I.)	20-4000	H
var. <u>glauca</u> (E:Kauai to Maui)		
PHYTOLACCACEAE SJ155 Pokeberry family		
!* <u>Phytolacca sandwicensis</u> Endl. 1836 (E:K,O,Mo,Ma)	ca. 6000	H
var. <u>puberulenta</u> (Deg.) St. John 1940 (E:E/WMa)		
PIPERACEAE SJ133 Pepper family		
#* <u>Peperomia cookiana</u> C.DC. 1869 (E:K,Mo,L,E/WMa,H)	4000-5300	H
#* <u>Peperomia erythroclada</u> C.DC. 1913 (E:L,E/WMa)	ca. 5100	H
* <u>Peperomia leptostachya</u> H. & A. 1832 (I:H.I.,Polynesia, Austr.)	20-6400	H
* <u>Peperomia tetraphylla</u> (Forst. f.) H. & A. 1832 (I:Trop. Pac.,E.Indies,Africa)	3900-6000	H
PITTIOSPORACEAE SJ169 Pittosporum family		
!! <u>Pittosporum argentifolium</u> Sherff 1941 (E:E/WMa)	ca. 2000-3000?	T
var. <u>argentifolium</u> (E:EMa)		
var. <u>rockii</u> Sherff 1941 (E:E/WMa)		
var. <u>sessile</u> Sherff 1941 (E:EMa)		
#* <u>Pittosporum confertiflorum</u> Gray 1854 (E:O,L,E/WMa,H)	5600-6000	T
var. <u>confertiflorum</u> (E:E/WMa,H)		

<u>Pittosporum</u> <u>insigne</u> Hbd. 1888 (E:Mo,E/WMa)	ca. 3300	T
var. <u>insigne</u> (E:E/WMa)		
var. <u>micranthum</u> Sherff 1941 (E:EMa)		
! <u>Pittosporum</u> <u>terminalioides</u> Planch. ex Gray 1854 (E:O,L,Ma,H)	ca. 1500?	T
!!var. <u>mauiense</u> Sherff 1941 (E:E/WMa)		
PLANTAGINACEAE SJ318 Plantain family		
#* <u>Plantago</u> <u>princeps</u> C. & S. 1826 (E:K,O,Mo,E/WMa,H)	ca. 6100	S
var. <u>laxifolia</u> Gray 1862-6 (E:K,Ma,H)		
PLUMBAGINACEAE SJ270 Leadwort family		
<u>Plumbago</u> <u>zeylanica</u> L. 1753 (I:tropics of E.hemisphere)	40-3000	S
POLYGONACEAE SJ149 Buckwheat family		
!* <u>Rumex</u> <u>giganteus</u> Ait. 1811 (E:H,Mo,E/WMa)	ca. 5000	V
#* <u>Rumex</u> <u>skottsbergii</u> Deg. & Deg. 1971 (E:Nihoa,Mo[?],EMa,H)	ca. 6000	S
PORTULACAEAE SJ156 Purslane family		
<u>Portulaca</u> <u>cyanosperma</u> Egler 1937 (E:Lehua,K,O,H,EMa and elsewhere in H.I.)	10-2800	H
<u>Portulaca</u> <u>lutea</u> Soland. ex Forst. f. 1786 (I:H.I.,Pacific Isl.)	strand	H
# <u>Portulaca</u> <u>sclerocarpa</u> Gray 1854 (E:Kah,L,Ma,H)	40-2700	H
# <u>Portulaca</u> <u>villosa</u> Cham. 1831 (E:Nihoa,Kaula,O, Molokini,EMa)	ca. 20-50	H
PRIMULACEAE SJ269 Primrose family		
* <u>Lysimachia</u> <u>kipahuluensis</u> St. John 1971 (E:EMa)	4700-6800	S
RANUNCULACEAE SJ161 Buttercup family		
# <u>Ranunculus</u> <u>mauiensis</u> Gray 1854 (E:K,O,Mo,Ma)	ca. 5650	H
RHAMNACEAE SJ225 Buckthorn family		
# <u>Alphitonia</u> <u>ponderosa</u> Hbd. 1888 (E:K,O,L,Mo,E/WMa,H)	2000-4000	T
var. <u>auwahiensis</u> St. John 1977 (E:EMa)		
!! <u>Gouania</u> <u>lydgatei</u> St. John 1969 (E:EMa)	?	S
!! <u>Gouania</u> <u>pilata</u> St. John 1969 (E:Ma)	?	S

APPENDIX II (Cont.)

ROSACEAE SJ172 Rose family

* <u>Fragaria chiloensis</u> (L.) Duch. 1766 (I:H.I. & Alaska to Chile)	5000-6500	H
var. <u>sandwicensis</u> Deg. & Deg. 1961 (E:EMa,H)		
* <u>Osteomeles anthyllidifolia</u> Lidl. 1822 (E:H.I.)	1500-7500	S
* <u>Rubus hawaiiensis</u> Gray 1854 (E:K,Mo,Ma,H)	4800-7000	S

RUBIACEAE SJ319 Coffee family

# <u>Bohea sandwicensis</u> (Gray) Hbd. 1888 (E:Mo,L,Ma)	1900-2800	T
<u>Canthium odoratum</u> (Forst. f.) Seem 1866 (I:H.I.,Fiji,Polynesia)	1000-2400	T
* <u>Coprosma ernodeoides</u> Gray 1858 (E:H,Ma)	1850-9750	S
var. <u>mauiensis</u> St. John 1935 (E:Ma)		
* <u>Coprosma montana</u> Hbd. 1888 (E:Ma,H)	5500-9500	S
* <u>Coprosma stephanocarpa</u> Hbd. 1888 (E:Ma)	3600-6000	T
#* <u>Gouldia hillebrandii</u> Fosberg 1937 (E:Mo,E/WMa,H)	4500-5650	T
* <u>Gouldia terminalis</u> (H. & A.) Hbd. 1888 (E:H.I.)	4000-5000	T/S
#* <u>Hedyotis centranthoides</u> (H. & A.) Steud. 1840 (E:O,Mo,L,Ma,H)	ca. 4900	V
!! <u>Hedyotis foliosa</u> (Hbd.) Fosb. 1943 (E:EMa)	ca. 4000	V
#* <u>Psychotria mauiensis</u> Fosberg 1964 (E:EMa,L,Mo)	2400-4900	T

RUTACEAE SJ198 Rue family

# <u>Pelea adscendens</u> St. John & Hume in St. John 1944 (E:EMa)	ca. 4000	S/V
#* <u>Pelea clusiaefolia</u> Gray 1854 (E:H.I.)	5100-5400	T
var. <u>crassiloba</u> Stone 1966 (E:O,EMa)		
f. <u>degeneri</u> Stone 1966 (E:EMa)		
#* <u>Pelea grandifolia</u> (Hbd.) St. John & Hume in St. John 1944 (E:L,Ma,H)	4000-5500	T
var. <u>grandifolia</u> (E:Ma,H)		
var. <u>ovalifolia</u> (Hbd.) St. John 1944 (E:Ma,H)		
var. <u>terminalis</u> (Rock) Stone 1969 (E:EMa)		
! <u>Pelea haleakalae</u> Stone 1966 (E:EMa)	ca. 2000	T
#* <u>Pelea hawaiiensis</u> Wawra 1873 (E:L,Mo,Ma,H)	3000-4850	T
var. <u>hawaiiensis</u> (E:Ma,H)		
var. <u>pilosa</u> St. John 1944 (E:L,Ma)		
var. <u>racemiflora</u> (Rock) St. John 1944 (E:EMa)		
# <u>Pelea mucronulata</u> St. John 1944 (E:EMa)	2200-2700	T
# <u>Pelea multiflora</u> Rock 1911 (E:EMa)	2500-4000	T
!! <u>Pelea tomentosa</u> St. John & Hume in St. John 1944 (E:EMa)	ca. 3300	T
!* <u>Pelea volcanica</u> Gray 1854 (E:L,Ma,H)	ca. 4500?	T

# <u>Zanthoxylum hawaiiense</u> Hbd. 1888 (E:L,H,EMa)	2400-4900	T
##* <u>Zanthoxylum kauaense</u> Gray 1854 (E:K,Ma)	4600-5000	T
! <u>Zanthoxylum maviense</u> (E:Mo,L,E/WMa,H)	ca. 3000?	T
SANTALACEAE SJ148 Sandalwood family		
! <u>Exocarpus gaudichaudii</u> A.DC. 1856 (E:H.I.)	ca. 2600	S
* <u>Santalum ellipticum</u> Gaud. 1829 (E:H.I.)	1000-4200	T
# <u>Santalum freycinetianum</u> Gaud. 1829 (E:K,O,L,E/WMa,Mo. sensu Stemmermann) var. <u>auahiense</u> Stemmermann 1980 (E:Mo,E/WMa)	2700-4000	T
##* <u>Santalum haleakalae</u> Hbd. 1888 (E:EMa)	5500-8700	T
SAPINDACEAE SJ222 Soapberry family		
# <u>Alectryon macrococcum</u> Radlk. 1890 (E:K,Mo,E/WMa)	3170-3800	T
* <u>Dodonaea eriocarpa</u> Sm. 1819 (I:H.I. & Galapagos)	s.l.-7200	S/T
SAPOTACEAE SJ271 Sapodilla family		
<u>Nesoluma polynesianum</u> (Hbd.)Baill. 1892 (I:H.I.,Austral.Isl.,Rapa) f. <u>polynesianum</u> (E:O,Mo,L,Ma,H)	1400-2200	T
# <u>Planchonella auahiensis</u> (Rock) Skotts. 1926 (E:EMa) var. <u>auahiensis</u> var. <u>aurantia</u> (Hbd.) Pierre 1926	2500-4000	T
* <u>Planchonella sandwicensis</u> (Gray) Pierre 1890 (E:H.I.)	3000-5100	T
<u>Planchonella spathulata</u> (Hbd.) Pierre 1890 (E:O,L,Mo,Ma,H)	1500-2600	T
SAXIFRAGACEAE SJ169,369 Saxifrage family		
* <u>Broussaisia arguta</u> Gaud. 1830 (E:H.I.)	4500-5700	S
SOLANACEAE SJ298 Nightshade family		
* <u>Lycium sandwicense</u> Gray 1862 (I:H.I.,Polynesia)	strand	S
# <u>Nothocestrum latifolium</u> Gray 1862 (E:H.I.)	1200-4850	T
! <u>Nothocestrum longifolium</u> Gray 1862 (E:K,O,Mo,L,E/WMa,H)	?	T
!! <u>Solanum</u> sp. nov. St. John ined. (E:EMa)	?	S
!! <u>Solanum haleakalaense</u> St. John 1969 (E:EMa)	?	S
STERCULIACEAE SJ233 Cocoa family		
* <u>Waltheria americana</u> L. 1753 (I:Trop.Am.,H.I.)	10-2200	H

APPENDIX II (Cont.)

THYMELIACEAE SJ244 Akia family

<u>Wikstroemia elongata</u> Gray 1865 (E:Mo, Ma)		?	S
* <u>Wikstroemia monticola</u> Skottsb. 1972 (E:E/WMa)	500-4000		S
<u>Wikstroemia uva-ursi</u> Gray 1865 (E:O, Mo, Ma)		?	S

URTICACEAE SJ142 Nettle family

! <u>Neraudia sericea</u> Gaud. 1844 (E:Mo, L, Ma)	ca. 2200-4500		S
* <u>Pilea peploides</u> (Gaud.) H. & A. 1832 (I:H.I., Pac. Isl., Trop. Am.)	1450-6400		H
<u>Pipturus hawaiensis</u> Levl. 1911 (E:Mo, Ma, H)	3200-6400		S
var. <u>eriocarpus</u> (Skottsb.) Skottsb. 1944 (E:Ma)			
#* <u>Urera glabra</u> (H. & A.) Wedd. 1856 (E:H.I.)	3400-5200		S

VIOLACEAE SJ237 Violet family

#* <u>Viola tracheliiifolia</u> Gingins 1826 (E:K, O, Mo, Ma)	5000-6200		S
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ZYGOPHYLLACEAE SJ198 Tribulus family

#* <u>Tribulus cistoides</u> L. 1753 (I:tropics, cosmo.)	strand		H
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MONOCOTYLEDONES

CYPERACEAE SJ44 Sedge family

* <u>Carex alligata</u> F. Boott. 1867 (E:K, Mo, Ma, H)	4700-5500		H
* <u>Carex macloviana</u> D'Urv.	5000-6500		H
var. <u>subfusca</u> (W. Boott.) Kuek. 1909 (I:Ma, H, +w.U.S.A.)			
#* <u>Carex meyenii</u> Nees 1843 (E:H.I. exc. Niihau)	4300-6200		H
* <u>Carex wahuensis</u> C.A. Mey. 1831 (E:H.I.)	2800-6500		H
var. <u>wahuensis</u> (E:H.I.)			
var. <u>rubiginosa</u> R.W. Krauss 1950 (E:O, Ma, H)			
<u>Cyperus hillebrandii</u> Boeck. 1880 (E:K, O, Mo, Ma, H)	1600-2800		H
var. <u>hillebrandii</u> (E:K, Ma, H)			
var. <u>mauiensis</u> (Hbd.) Kuek. 1936 (E:EMa)			
<u>Cyperus laevigatus</u> L. 1771 (I?:tropics)	ca. 40		H
* <u>Cyperus polystachyus</u> Rottb. 1773 (I:Pantropical, most Pac. Isl.)	near s.l.-2500		H
var. <u>polystachyus</u> (I:as above)			
var. <u>pallidus</u> Hbd. 1888 (I:Lehua Isl., Tahiti, Ma, H)			

#*	<u>Fimbristylis pycnocephala</u> Hbd. 1888 (I:H.I.to Solomon Isl., Laysan Isl.)	strand	H
*	<u>Machaerina angustifolia</u> (Gaud.) Koyama 1956 (I:H.I., Polynesia)	4500-5700	H
*	<u>Machaerina gahniaeformis</u> (Gaud.) Kern 1962 (E:L, Ma, H)	6000-7500	H
*	<u>Scirpus validus</u> Vahl 1804 (I:Niihau, O, Mo, H, cosmo.)	ca. 40	H
IRIDACEAE SJ88 Iris family			
*	<u>Sisyrinchium acre</u> Mann 1867 (E:EMa, H)	6000-8000	H
JUNCACEAE SJ79 Rush family			
*	<u>Luzula hawaiiensis</u> Buch. 1880 (E:K, O, Mo, Ma, H) var. <u>hawaiiensis</u> (E:K, Ma, H)	5500-7000	H
LILIACEAE SJ80 Lily family			
!	<u>Astelia forbesii</u> Skottsb. 1934 (E:O, Mo, Ma) ssp. <u>forbesii</u> (E:Mo, Ma)	ca. 5500	H
*	<u>Dianella sandwicensis</u> H. & A. 1832 (E:H.I.)	6000-7000	H
#*	<u>Pleomele auwahiensis</u> St. John 1985 (E:Ma)	2000-5000	T
#*	<u>Smilax sandwicensis</u> Kunth 1850 (E:H.I.)	3100-5300	V
PANDANACEAE SJ14 Screw Pine family			
*	<u>Freycinetia arborea</u> Gaud. 1824 (E:H.I.)	2500-4500	V
	<u>Pandanus odoratissimus</u> L. f. 1781 (I:H.I. & ?Ceylon)	ca. 40	T
POACEAE (GRAMINEAE) SJ16 Grass family			
*	<u>Agrostis sandwicensis</u> Hbd. 1888 (E:O, Ma, H)	8000-9700	H
!	<u>Cenchrus agrimonioides</u> Trin. 1826 (E:Leeward H.I., O, L, Ma) var. <u>agrimonioides</u> (E:O, L, Ma)	1000-3000	H
	<u>Cenchrus echinatus</u> L. 1753 (Cosmo., adventive) var. <u>hillebrandianus</u> (Hitchc.) F. Br. 1931 (I:Polynesia)	strand-ca. 300	H
*	<u>Deschampsia australis</u> Nees ex Steud 1854 (E:K, E/WMa, H)	4000-9800	H
*	<u>Eragrostis grandis</u> Hbd. 1888 (E:H.I.)	4500-6500	H
*	<u>Eragrostis variabilis</u> (Gaud.) Hbd. 1888 (E:Leeward +H.I.)	1600-6400	H
	<u>Heteropogon contortus</u> (L.) Beauv. ex R. & S. 1817 (I:India, Polynesia, H.I.)	20-1700	H

APPENDIX II (Cont.)

(POACEAE cont.)

# <u>Panicum colliei</u> Endl. 1836 (E:K,O,L,Ma)	near s.l.-1500?	H
# <u>Panicum nubigenum</u> Kunth 1833 (E:K,O,Mo,L,H-EMa)	s.l.-50	H
# <u>Panicum pellitum</u> Trin. 1826 (E:EMa)	ca. 700-2400	H
##* <u>Panicum tenuifolium</u> H. & A. 1832 (E:L,Ma,H)	ca. 4770	H
<u>Panicum torridum</u> Gaud. 1829 (E:O. to H. & Leeward Isl.)	40-1000	H
<u>Panicum xerophilum</u> (Hbd.) Hitchc. (O,Mo,L,Ma)	50-1000?	H
<u>Sporobolus virginicus</u> (L.) Kunth 1829 (I:Pantropic)	strand	H
* <u>Trisetum glomeratum</u> (Kunth.) Trin. ex Steud. 1854 (E:L,Ma,H)	5500-9700	H
RUPPIACEAE SJ15 Ruppia family		
<u>Ruppia maritima</u> L. 1753	ca. 40	H
var. <u>pacifica</u> St. John & Fosberg		
f. <u>pacifica</u> 1939 (I:H.I. & Trop.Pac.)		

LEGEND

= threatened

! = extirpated

!! = extinct

* = recorded from Haleakala National Park

T = tree

S = shrub

H = herb

V = vine

APPENDIX III. SELECTIONS FROM FIELD NOTES OF C.N. FORBES

This section consists of excerpts taken from the handwritten field books of Charles N. Forbes, botanist at the B. P. Bishop Museum in Honolulu. These field notes constitute a significant portion of the total historical observations of a biological nature that are available pertaining to the study area. They were recorded by Forbes from March 1 through April 10, 1920 on a forty-one day collecting trip for the Museum through the study area. The transcription of these notes was greatly facilitated by S. H. Sohmer and the staff of the B. P. Bishop Museum. It is with the permission of Dr. Sohmer that these notes are published.

"Monday-March 1-1920

Truck to J. Burns, Kanaio. Collect on rough a-a. 2200 ft. at house."

"Tuesday March 2-1920

No helper obtainable. Collect in the a-a country near the trail."

"Wednesday March 3-1920

Go on to establish camp at Manawainui, the last water tank in open paddock country. Arrive at 12:00, go mauka at 1:00. Collect in gulch. Boy catches 3 pigs with dog."

"Thursday Mar.4-1920

So up to Puu Manu (Puu Pane), then to...Waihualele gulch and up ridge to the upland zone. Remnant of a dense forest overgrown with Eupatorium. Acacia koa, Metrosideros polymorpha, a few Cheirodendron gaudichaudii, Suttonia sp. [=Myrsine], Sophora chrysophylla.

-2 adzes-

-1 bottle [of] shells-"

"Friday Mar.5-1920

At Camp-fix plants. Mule lost and found (4 hours).
Waiopai gulch on rt. hand side of camp

"Sat.Mar.6-1920

Waiopai ranch. Nu'u. The last patch of forest with the exception of a small grove of about 1 acre. Forest comprised of Acacia koa most common. Metrosideros, Suttonia [=Myrsine], Cheirodendron, Coprosma, some Dracaena aurea [=Pleomele], Osmanthus sandwicensis, Myoporum sandwicense...Hillebrandia common in gulches. All overrun with Eupatorium miknoides [=E. adenophorum?]. So far have not seen any Gleichinia elongata [=Dicranopteris linearis]."

"Sun. Mar.7-1920

Gulch to left of Camp. Mule lost (2 hrs.), found at night (1/2 hr.)"

"Mon.Mar.8-1920

Far mauka above Puu Pane. Ohia dominant, some koa-touched by fire. Many old dead stumps. Vegetation except Eupatorium limited to the gulches."

"Tuesday Mar.9-1920

Rough lava flow down the Kaupo Gap which ends at Nuu. Visited the Nuu end. The lava's extremely rough and vegetated with scattered trees...Ipomoea insularis [=I. congesta] occurs, Waltheria, Eupatorium, Dodonaea viscosa [=D. eriocarpa] and the species collected."

"Wednesday Mar.10-1920

Shift camp to old camp site this side of house."

"Thursday Mar.11-1920

Laumau forest, comprised of plants collected with Osmanthus dominant, Dracaena second [=Pleomele]. Open scattered trees and much Eupatorium."

"Friday Mar.12-1920

Kaapilopilo and Kapakahawai [=Kahawaihapapa?] gulches. Ohia dominant, some Myoporum large trees, a few Sophora. Much Cyrtandra collected [?] in the gulches. Saw some Freycinetia arborea on one tree below. Transition gulches festooned [?] with Elaphoglossum hirtum. Big thunder storm and the gulches quickly run full and down to the sea in a short time."

"Sat. Mar.13-1920

Boy has to go on account of sick sister. At camp, forest east (Lualailua) Dracaena aurea [=Pleomele] dominant, Osmanthus common. Nothocestrum rather frequent, 1 clump of Erythrina monosperma [=E. sandwicensis], one specimen Reynoldsia sandwicensis and the plants collected. Trees rather far apart."

'Sun. Mar.14-1920

Auwahi, south slope of Haleakala. Forest west of camp, before reaching house. Osmanthus dominant, Dracaena [=Pleomele] second. Maba [=Diospyros] common in one place, Bobea very common as is Nothocestrum. Several Broussonetia trees 12 feet high, 4 inches diameter. Sideroxylon [=Planchonella] rare, Xanthoxylon 2 species not uncommon. Pseudomorus [=Streblus], Charpentiera not uncommon. Undergrowth of Lantana, Coreopsis, red mint [Salvia coccinea?]. The bark of nearly all the trees is grey and covered with lichens. Osmanthus bark is blackish from soot fungus."

"Monday Mar.15-1920

Boy returns in the evening. Forest above house. Very large trees Pterotropia [=Tetraplasandra] one at least 80 feet high & 1 1/2 feet in diameter. Osmanthus dominant, some large trees. Pseudomorus [=Streblus] with rounded dense heads, 1 ft. diameter, 35 ft. high. Xanthoxylon maviense [=X. hawaiiense?] oval rounded head, 40 feet high, over 1 ft. in diameter. Pelea knudsenii [=P. multiflora] very common, Maba sandwicensis [=Diospyros ferrea] uncommon, some Dracaena [=Pleomele] in lower part. Very little Metrosideros. Sideroxylon [=Planchonella] a few seen. Claoxylon frequent, some rather large 15 ft., a few Ochrosia. Undergrowth of Eupatorium, Bidens pilosa, Salvia coccinea. A few Carduus lanceolatus [=Cirsium vulgare] seen in the open, also Anagallis arvensis. Pittosporum rare. Charpentiera not uncommon (no Pisonia seen)."

"Tuesday Mar.16-1920

At Camp. Fix plants over open fire. Collect lichens in nearby forest."

"Wednesday Mar.17-1920

Lualailua. Boy wastes 2 hours of valuable time deciding whether he will quit or not. To the east and far mauka through forest and into the upland zone to a prominent pu'u [Puu Ali'i] about 1 mile below the edge of the crater. Upland zone mostly Cyathodes (Styphelia) tameimeiae in fruit now, very little Vaccinium and still less in fruit. Railliardia [=Dubautia] practically lacking, a few on the sides of gulches. Eupatorium clear to the top, but mostly shorter at the high elevations. Some Dodonaea but mostly in the gulches. Pteris aquilinum [=Pteridium aquilinum var. decompositum] forms some colonies, dead in places for some unknown reason. On the floor of some craters, Santalum haleakalae looking from a distance like Metrosideros. A little Sophora chyrsophylla. Further down, much Cyathodes [=Styphelia], Eupatorium, Osteomeles anthyllidifolia creeping form in flower and fruit, Coprosma ernodioides in fruit, none in flower, a little Coprosma montana, Vaccinium a little, Dodonaea, hardly any Railliardia [=Dubautia], Fragaria chiloensis, Lythrum maritimum common. Further down, open forest of Metrosideros with undergrowth of Lythrum maritimum, Fragaria chiloensis; in the gulches, Pteris cretica, Elaphoglossum hirtum in clumps, Polypodium pellucidum, etc. Further down, some Acacia koa, Myoporum sandwicense, Suttonia [=Myrsine], etc. Pteris excelsa. Goats common in the upland zone, Eevis common in the Ohia." [Eevis = 'I'iwi / Vestiaria coccinea]

Note at top of page: "Cone = Kohekamanawa place visited by a certain chief & queen."

"Thursday Mar.18-1920

Forest...on makai side of trail, then way down to the large red pu'u (Puunole) and below it Auahi. Very rough aa country and some soil. Opuntia dominant in places. On the aa and especially in gulches, Myoporum sandwicense, Erythrina monosperma [=E. sandwicensis] in fruit with open pods some with and many without leaves about equal numbers. Reynoldsia sandwicense in young leaf mostly which are copper colored, silvery Nototrichium badly eaten by cattle, a little of the yellow flowered Lipochaeta small bushes. Nothoecstrum (Aiea according to native). Very little if any Eupatorium below the lower government trail. Much Lantana camara. The puus are covered with grass-Paspalum. Upper forest first visited like that in vicinity of camp but rare trees including Bohea, Pittosporum, etc."

"Friday Mar.19-1920

Lualailua. Fix plants. Take 5 photographs in nearby forest. Collect weeds."

"Sat. Mar. 20-1920. Forest beyond stone wall beyond house up and back down to the double tanks. Kalualii-Middle Auwahi.

Open forest type with Osmanthus dominant, Dracaena [Pleomele] second at least in the lower part. In the upper or middle, Pelea (knudsenii) very common [=P. multiflora], next Sideroxylon (yellow fruited esp.) [=Planchonella auahiense], Myroxylon [=Xylosma], 2 species. Maba sandwicensis [=Diospyros ferrea] not uncommon. Claoxylon sandwicense common in places. Alectryon macrococcus about 15 trees seen. Cheirodendron and Aralia [=Tetraplasandra] frequent in upper part. Metrosideros rather rare. Euphorbia in rocky places but rare. Charpentiera infrequent. Undergrowth of Eupatorium, Bidens pilosa, Salvia coccinea, a little Lantana, 2 clumps of Nephrolepis exaltata, much Pteris [= P. cretica]. Much aa and rough country, loose rocks. In places especially on the upper border the trees covered with grey also rust colored Usnea."

"Sunday Mar.21-1920

Straight mauka from camp to the highest Puu called Kanahau (top is 8645 ft.) 1st...remnant of an Osmanthus forest with a little Ohia, above this dead trunks of Koa and Myoporum sandwicense. Kanahau was covered with snow earlier this year according to boy. Large patches of dead Pteris aquilinum [=Pteridium aquilinum var. decompositum] are probably an indicator of heavy frosts, also noticed on a previous trip. Upland zone Cyathodes [=Styphelia tameimeiae] dominant, rounded bushes far mauka. Osmanthus plentiful in a zone above previous first area. Scattered groves of Sophora, especially in the hollows. Many large patches of rough clinkery pahoehoe with colonies of Pellaea ternifolia. Coprosma ernodioides common. Cop. [=Coprosma] montana rather rare. Railliardia [=Dubautia] very rare. Fragaria chiloensis below. (Lythrum) maritimum very

common...Polypodium pellucidum, Pteris aquilinum [=Pteridium aquilinum var. decompositum], etc."

"Monday March 22, 1920

Fix plants-all morning. Move to new camp below the double water tanks called Kalualii."

"Tuesday March 23-1920

Pakiloi mauka and Kamana below this, both below the trail. Forest west of camp. A rich varied forest with perhaps Dracaena [=Pleomele] dominant, not very much Osmanthus. Myroxylon [=Xylosma] common, Pittosporum and Sideroxylon [=Planchonella] not very common. Pelea, Xanthoxylon, Nothocestrum, Myoporum,...Cyathodes [=Styphelia], Dodonaea, (Railliardia sterile bushes) [=Dubautia]. Euphorbia. No Metrosideros seen."

"Wednesday Mar.24-1920

Auwahi. Through the forest east..., then back and mauka through brush country with Cyathodes [=Styphelia], Dodonaea and Osteomeles dominant, some scrubby Sophora & a few other scattered trees especially Myoporum, then down the last forest and back to camp. E. forest upper part Osmanthus dominant, Dracaena [=Pleomele] dominant below. Sideroxylon [=Planchonella], Pelea,...some Metrosideros, Pseudomorus [=Streblus], Myroxylon [=Xylosma], a little Nothocestrum, Ochrosia, one Alectryon macrococcus, Pipturus and Neraudia, Euphorbia lorifolia [=E. celastroides mauiensis], Myoporum, Dodonaea, Cyathodes [=Styphelia], Nephrolepis exaltata, Pteris [=P. cretica], Asplenium kaulfussii, Railliardia [=Dubautia], Osteomeles..."

"Thursday Mar.25-1920

In camp to dry plants in the morning, send boy to Burns in afternoon. Rest of day fixing plants."

"Friday Mar.26-1920

Forest east in morning to take pictures. Heavy rains, return, take bath, shave, etc. then go... mauka to collect. Boy returns at 7:20PM."

"Saturday March 27-1920

Mauka east of camp. Osmanthus and Dracaena [=Pleomele] dominant in places, above Pelea multiflora, Cheirodendron Maba [=Diospyros], Osmanthus very common. Pterotropia [=Tetraplasandra] far up...Sideroxylon [=Planchonella] common, three species seen. Ochrosia sandwicensis [O. haleakalae] common in places (milky juice)."

"Sunday Mar.28-1920

To E end of forest east (Kealii forest) and then makai for a long distance, then go below the government trail through Kamana and inspected the black lava. Good view to the sea, supports nothing in makai end except lichens and a few weed...gradually more vegetated upland especially in the troughs with Reynoldsia sandwicensis, Rauvolfia sandwicensis [=R. mauiensis], Nothocestrum, Nicotiana glauca, Erythrina monosperma [=E. sandwicensis], etc. ...pocket at Kamana with Cassia gaudichaudii, Lantana camara, Dodonaea viscosa [=D. eriocarpa], Opuntia, Rauvolfia, Sophora, Nothocestrum, Asclepias curassavica, Argemone mexicana [=A. glauca?], Salvia coccinea, Pteris decipiens [=Doryopteris decipiens]."

"Monday March 29-1920

Fix plants in camp. Take pictures in forest over towards house (East)."

"Tuesday March 30-1920

Heavy rain all day. Collect in forest west on this side both mauka and makai."

"Wednesday Mar.31-1920 Auwahi. Forest above the double tanks and my camp 4. Take photographs and collect shells."

"Thursday Apr.1-1920

Move back to base, too far to reach next camp. [?] Fix plants."

"Friday Apr.2-1920

Boy does not come to work. Wait until 1:30 then go west and makai."

"Saturday Apr.3-1920

Boy does not come to work. So mauka on mule and west and then down."

"Sunday Apr.4-1920

So mauka to Puu Ouli with Burns boy. Leave 8:00, arrive 10:00. Collect on ridge and old crater east."

"Monday Apr.5-1920

Boy comes for pay. Burns boy comes at 6:30 PM. Go east along edge of upper forest. Puu Ouli."

Misc. notes at end page in notebook Nos. 1127M-2147M:
"Camp 2- 2500
Camp 3- 2650-2700

Kaunoa= Bryophyllum calycina
acc. of guide [?]

March-1920
Hills below our second camp are Lualailua Hills. Very prominent landmark...

Puunani = game of jackstraws played with corn

Kaioea = a bird...large...a turkey...40 or 50 years ago on Ulupalakua slopes. seen by Brown [=Burns?] grandmother

Koloa = crow Forest east-Kealii forest

Antone Gomes
William Moaneliha"

New Notebook 2148M-2705M
"Trip continued from field book Nos. 1127M to 2147M.
Elev. of house is 4450 ft.
In camp at Puoule Puu Ouli 4354.
Tuesday Apr. 5-1920

So mauka to a large flat vegetated with grass and a grove of Sophora chrysophylla. So up to the Puu of which this is the crater and then to the wire Ranch boundary fence and gate. Go down Kula slope to dead forest along the edge of a gully and back by another gully. Fence gate locked. After lunch ride animals to Kanahau. Leave animals and walk to the summit of Haleakala and see the crater from the beginning of the sliding sands trail. Several pit craters and many cones but all red and apparently very old. Bunch grass [=Deschampsia australis?] the highest plant followed closely by rounded Cyathodes Tameiameiae." [=Styphelia tameiameiae]

"Wednesday April 6-1920
Fence line west of camp in the afternoon. Fix plants in the morning. Mule runs away. Last remains of forest with Sophora chrysophylla, Myoporum sandwicense, Pterotropia hawaiiense [=Tetraplasandra kavaiensis?], Coprosma rare. Several pit craters with vegetation mostly Sadleria."

"Thursday April 7-1920
Forest west and along the Kula side for a long ways. Up to a Puu with caves, a camping place, back by way of Polipoli water hole. Remnants of forest with large trees of Myoporum, Sophora, Metrosideros, Cheirodendron, a few Suttonia [=Myrsine]."

"Friday April 8-1920

Kula side to photograph. Dry out blotters in afternoon."

"Saturday April 8-1920

Far east up and down and along fence lines...above and below.
E. to a straight line with Puu manu hills.[=Puu Pane? see March
4-

1920] Take photographs."

"Sunday Apr.9-1920

Fix plants and return to Burns."

"Monday Apr.10-1920

Take road to Kula just this side of Sanatarium where there is a
patch of aa forest with Osmanthus, Dracaena [=Pleomele],
Reynoldsia 1 seen. Nothocestrum, etc."