

Appendix E

**Botanical Survey of Kaloko Properties
Isle Botanica
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Botanical Survey
of
Kaloko Properties

North Kona
Island of Hawai'i

by

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INTRODUCTION

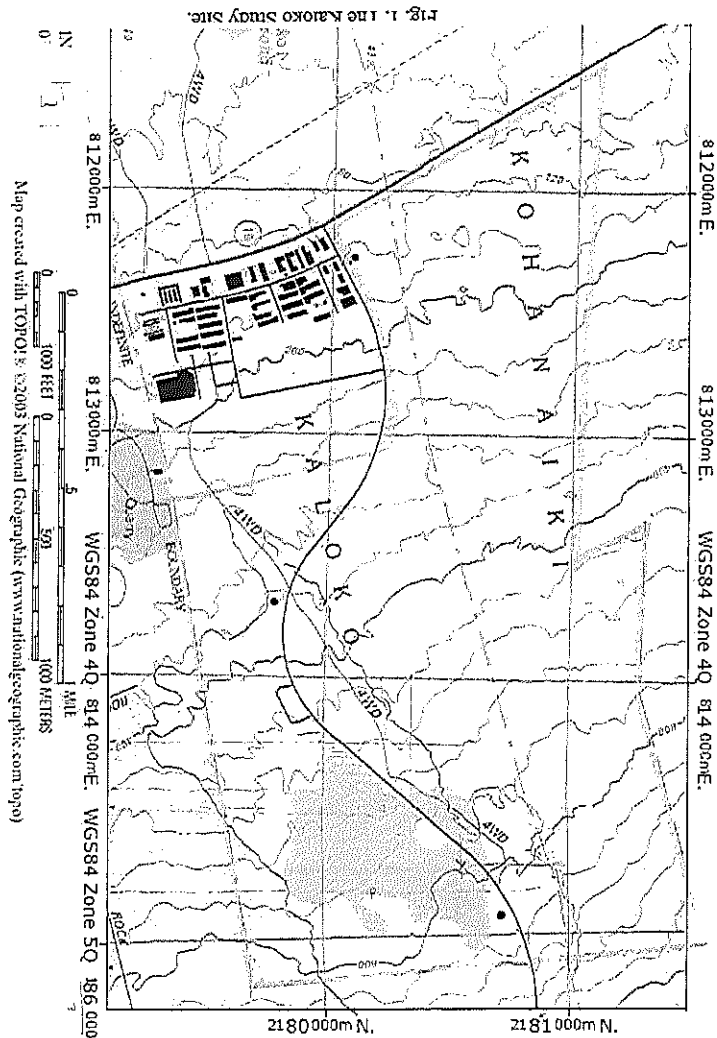
The current project site encompasses about 1296 acres located in North Kona on the island of Hawai'i. It is situated north of Kona town, and mauka of Ka'ahumanu Highway and the "Kaloko Light Industrial Subdivision," which includes Costco. It is bordered on the west side by the highway, and extends mauka (eastward) to eventually straddle both sides of Hina Lani Road (Fig. 1). The area comprises lava flows of various ages that are covered mostly with a highly disturbed scrub and grass vegetation. However, a relatively undisturbed dryland forest, one of the most biologically diverse yet most heavily damaged ecosystems in the State, covers one area comprising most of the southeastern portion of the property.

BACKGROUND

The USFWS has long recognized the importance of the dryland forest on the site for its unique assemblage of native plants, and has indicated their desire to preserve a portion of the property for its botanical value. They noted that the dryland forest located on the site is one of the last dryland forests still relatively free of introduced, alien grasses and cattle. The area has remained in such good condition because the substrate is a young lava flow that has acted as a deterrent to cattle, fire, and the spread of alien grasses (USFWS pers. comm. 2006). This patch of forest contains, or has contained, several federally listed endangered plant species: *'aiea* (*Nothocestrum breviflorum*), *ma'olalo* (*Neraudia ovata*), *Cyperus faurieri*, and *hala pepe* (*Pleomele hawaiiensis*). These species are also listed by the State as endangered species (DLNR 1998).

At least two botanical surveys in or adjacent to the area have been conducted. The first was carried out in conjunction with a proposed transmission line that would have crossed the property (CH2M Hill 1993). The second survey was done for the Kaloko town center (site of the present business district that includes Costco), which is adjacent to the current study site (Char and Associates 1995). The CH2M Hill botanical survey crossed the present study area, but also extended in either direction several miles, so the two areas are not exactly comparable. It listed the presence of 101 plant species in that corridor. Three of the species recorded are federally listed endangered species. Five individuals of the sedge *Cyperus faurieri* (known at that time as *Mariscus faurieri*) were noted growing on a single boulder at about 115 m elevation on the 'a'a flow. Two trees of *Nothocestrum breviflorum* were noted growing on the 'a'a flow at 110 m elevation. Two mature individuals of *Neraudia ovata* were noted growing on the 'a'a lava flow at 115 m elevation. The checklist for the Char and Associates botanical survey on the property adjacent to the present study site listed a total of 47 species present, but none of these are federally listed.

In 2003, the USFWS sent a team over for a reconnaissance of the site (USFWS 2003a & b). They noted finding one live specimen of *Neraudia ovata* in the study area, and reported making "a sweep of the area looking for the other four known plants but found none of them. We suspect they may be dead." They also noted the presence of good-sized individuals of *Bidens micrantha* spp. *ctenophylla* (*ko'oko'olau*) in low numbers and one dying *Pleomele hawaiiensis* (*hala pepe*) as well as several other native plant species.



METHODOLOGY

Before the fieldwork was carried out, a review of the literature was undertaken by the Principal Investigator (PI). The current status of the endangered species previously reported from the site was checked using the official database of threatened and endangered species (USFWS 2005). This list is identical to the State of Hawai'i list of threatened and endangered plant species. In addition, information about threatened and endangered plant species found in the area was extracted from the Hawai'i Natural Heritage Program database (Anon. 2005) of Federally listed plant species (Fig. 2).

After the review of the existing literature, a botanical field survey at the Kaloko site was conducted by a two-person botanical team consisting of the PI (Art Whistler) and a Field Assistant (Beate Neher), from 1 to 6 September 2006. All plant species encountered during the survey were recorded, along with an indication of their frequency. Particular care was taken in the area of dryland forest and other 'a'a areas, since this is where most of the native species and all of the endangered species have been reported. New lists were made for each vegetation type and/or day, and these were combined into a comprehensive checklist of all plants found at the study site (see Appendix). Notes were also taken on vegetation types present at the site, indicating the dominance and frequency of the plant species present. This was later analyzed and written up to form the vegetation section below.

Most of the species encountered during the fieldwork were familiar to the field team. Only one plant observed during the survey defied attempts at identification in the field. It was taken back to Honolulu to the Bishop Museum to compare with specimens there, and was eventually identified with the help of the Bishop Museum Herbarium staff.

THE VEGETATION

Four types of vegetation can be recognized on the Kaloko property: (1) Managed Land Vegetation; (2) *Leucaena* Scrub, which can be divided into a lowland subtype with extensive amounts of *Pennisetum setaceum* between the trees, and an upland subtype with *Kalanchoë pinnatum* and *Panicum maximum* dominating the ground cover; (3) Christmas-Berry Scrub that occurs on recent 'a'a flows, and which can be divided into two subtypes, one with only scattered Christmas berry trees and a few native species, the other with a similar, denser, scrub forest; and (4) Dryland Forest.

(1) Managed Land Vegetation

This comprises the areas of the parcel that are under periodic or frequent management, such as the edges of roads. It also includes the large quarry on the south side of the dryland forest. This is a relatively minor component of the overall vegetation on the property, and is entirely dominated by alien weedy species, such as the grasses *Digitaria ciliaris* (large crabgrass) and *Rhynchelytrum repens* (Natal redtop), and the dicot herbs *Tridax procumbens* (coat buttons), *Chamaesyce hirta* (garden spurge), *Chamaesyce hyssopifolia*, *Desmodium tortuosum* (Florida beggarweed), *Macroptilium lathyroides* (cow pea), *Boerhavia coccinea*, *Waltheria indica* ('uhaloa, a native species), and *Sida rhombifolia* (Cuba jute).

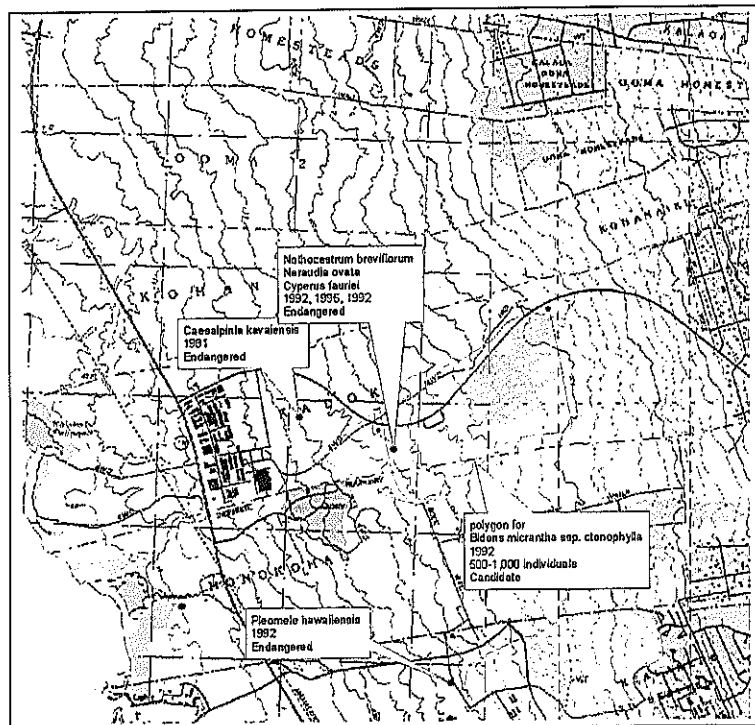


Fig. 3. Hawai'i Natural Heritage Program database of Federally Listed plant species.

(2) *Leucaena* Scrub

This is the type of vegetation found on areas of older lavas dominated by the alien scrubby tree *Leucaena leucocephala* (*koa haole*). It is not a homogeneous type of vegetation, since with increasing elevation along the north side of the road, its density and the species associated with it change. On the lower portions (Fig. 3), *koa haole* is mostly 1–2 m in height, scattered in an open-to-dense matrix of *Pennisetum setaceum* (fountain grass). Several other trees and shrubs are found here, but in low numbers. This includes the alien tree species *Prosopis pallida* (*kiawe*) and *Schinus terebinthifolius* (Christmas berry), the alien shrub *Acacia farnesiana* (*klu*), the Polynesian introduction *Morinda citrifolia* (*noni*), and the native shrubs *Dodonaea viscosa* (*'a'ali'i*), *Psychodora odorata* (*'alahe'e*), and *Sida fallax* (*'ilima*). Also present are plants such as the shrubs *Indigofera suffruticosa* (indigo) and *Waltheria indica* (*'uhaloa*), the herbs *Chamaecrista nictitans* (*lau-ia*), *Talinum triangulare* (talinum), and *Portulaca pilosa* (*'ihi*), and

the grasses *Rhynchelytrum repens* (Natal redtop) and *Heteropogon contortus* (*pili*). This might be better described as a mosaic vegetation, with patches of *koa haole* alternating with areas entirely dominated by the fountain grass, but this grass is also found in the partial shade of the *koa haole*, especially when its canopy is thin. It might equally validly be labeled as a fountain grass grassland with associated *koa haole* trees.

At the upper (eastern or mauka) end of the property, the *koa haole* is also dominant, but is denser and taller (2–4 m in height). Instead of forming a mosaic with fountain grass beneath, it forms a dense monodominant scrub forest (Fig. 4). Other tree species are interspersed with it, particularly the native trees or shrubs *Psychodora odorata* (*'alahe'e*), *Diospyros sandwichensis* (*lama*), and *Sophora chrysophylla* (*mamane*), and the alien trees *Schinus terebinthifolius* (Christmas berry) and *Grevillea robusta* (silk oak). The latter two are large and scattered, but appear to be invasive and spreading. The ground cover in this upper area is dominated by *Kalanchoe pinnatum* (air plant) and *Panicum maximum* (Guinea grass), with some *Pennisetum setaceum* (fountain grass) in patches (Fig. 5). The native herb *Peperomia leptostachya* (*'ala'ala-wai-mui*) is occasional on rocks. In disturbed areas across the road from this, next to the upper water tank, the *Leucaena* scrub has an understory of fountain grass (Fig. 6). This differs from the lowland type of *Leucaena* scrub in that the trees are taller and more densely arranged.

Leucaena scrub is classified as disturbed, since fires periodically sweep through the area and goats are known to be present. These two factors account for the dominance of alien species, which are better adapted to these disruptive conditions than are the native species. According to the flora of Hawai'i (Wagner et al. 1999), fountain grass "is rapidly expanding its range in the Kona district of Hawai'i." Introduced into the Kona District "in the early 1900s as an ornamental, [it] has aggressively spread and now dominates abandoned pastures, young lava flows, and burn areas. Fountain grass poses one of the most serious contemporary conservation problems because it is disrupting the more sparsely vegetated lowland native dry forests and shrublands, which contain several endangered and many candidate endangered plant species."

(3) Christmas-Berry Scrub

This is the type of vegetation on more recent lava flows, ones that are distinctly *'a'a* lava. An irregular tongue of this runs down the slope near the northern boundary of the study site. In the lower portion of the study site, this vegetation is very sparse on the inhospitable surface, but scattered trees of the alien *Schinus terebinthifolius* (Christmas berry) comprise the most common species (Fig. 7). Also found here are scattered individuals of the native trees or shrubs *Capparis sandwichiana* (*pua pilo*), *Psychodora odorata* (*'alahe'e*), *Metrosideros polymorpha* (*'ohi'a lehua*), *Myoporum sandwicense* (*naio*), as well as the introduced trees *Leucaena leucocephala* (*koa haole*) and *Morinda citrifolia* (*noni*).

The ground cover is also very sparse, with scattered clumps of *Pennisetum setaceum* (fountain grass) found mostly in pockets of soil or pahoehoe, and perhaps being the most common species found here. There were also a few patches of *Ipomoea indica* (*kowali-awa*) and *Coccoloba trilobus* (*huehue*), and even smaller amounts of the alien species *Nephrolepis multiflora* (hairy swordfern), *Lantana camara* (lantana), and *Pluchea carolinensis* (pluchea). Because the vegetation is so sparse, it hardly qualifies as vegetation at all, just scattered trees with equally scattered clumps of herbaceous species.

At higher elevations in this habitat on the same flow, where increasing rainfall and/or cloud cover makes the habitat more hospitable to trees, the vegetation comprises a low closed forest

(Fig. 8) dominated by Christmas berry, with lesser amounts of the native trees *Psydrax odorata* ('alahe'e), *Sophora chrysophylla* (mamane), and *Diospyros sandwicensis* (lama). Tall individuals of *Grevillea robusta* (silk oak) are scattered in the area. The native shrub *Dodonaea viscosa* ('a'ali'i) is sometimes common in clearings on the lava. No individuals of *Metrosideros polymorpha* ('ohi'a lehua), *Reynoldsia sandwicensis* ('ohe), *Pleomele hawaiiensis* (hala pepe), or *Myoporum sandwicensis* (naio) were found in this scrub forest. Because of the dense shade, very little ground cover is present, but that which is present comprises mostly *Panicum maximum* (Guinea grass) and *Kalanchoë pinnatum* (air plant). However, some fountain grass is found in clumps on the lava flow there.

Like the *Leucaena* scrub, this vegetation is classified as disturbed, since fires periodically sweep through the area, and goats are known to be in the area. It somewhat matches the description of the "Lowland Dry Shrublands" described in Wagner et al. (1999), which is described as occurring in leeward situations on most of the main islands, at 100 to 600 m elevation, and being open and not exceeding 3 m in height.

(4) Dryland Forest

This is the open to closed native forest (Figs. 9 and 10) occurring on the relatively recent lava flow comprising most of the central portion of the southern half of the study area. Because of the rugged 'a'a lava, the vegetation is difficult for feral grazing animals to visit. Over much of the area the trees are separated from each other, and this, combined with the virtual absence of fountain grass, has caused the area to be spared from grazing and wildfires. Consequently, the forest is relatively intact, and was home until recently, at least, to four endangered species: *Nothocestrum breviflorum*, *Neraudia ovata*, *Cyperus sauriei*, and *Pleomele hawaiiensis*.

The most common trees are probably the native species *Diospyros sandwicensis* (lama), *Psydrax odoratum* ('alahe'e), *Capparis sandwichiana* (pua pilo; often more of a shrub than a tree), and *Sophora chrysophylla* (mamane). Also occasional are the native trees *Metrosideros polymorpha* ('ohi'a lehua), *Reynoldsia sandwicensis* ('ohe), *Myoporum sandwicensis* (naio), and *Dodonaea viscosa* ('a'ali'i), as well as scattered individuals of the endangered tree-like monocot *Pleomele hawaiiensis* (hala pepe). The only alien tree species noted in this open forest were *Jacaranda mimosifolia* (jacaranda), the Polynesian introduction *Morinda citrifolia* (noni), *Schinus terebinthifolius* (Christmas berry), and *Leucaena leucocephala* (koa haole). The latter two species, especially Christmas berry, sometimes form clumps and in some places dominate the edges of the dryland forest. The southern boundary of this forest has recently been bulldozed in quarry activities, and fountain grass is spreading in this newly created disturbed habitat (Fig. 11).

The ground cover in the dryland forest is very sparse, due to the inhospitable growing conditions. The most common species in this category are *Lantana camara* (lantana), the native vines *Cocculus trilobus* (huehue) and *Ipomoea indica* (kowali-awa), *Pennisetum setaceum* (fountain grass), *Nephrolepis multiflorum* (hairy swordfern), and an escaped ornamental vine *Lophospermum erubescens* (larger roving sailor).

Overall, this vegetation comprises a good quality dryland forest, based upon the flora and the dominance of native species. The native flora is virtually the same as that found in the list of the native flora on the whole site shown in Table 1 (below), with the possible exception of *Heteropogon contortus* (pili), which was found elsewhere on the study site but not in the dryland forest.

THE FLORA

A total of 93 plant species (see Appendix) was recorded in the study area, but this does not include a few cultivated species planted along the roadsides. Twenty-five of the species encountered are native and eleven of these native species are endemic. Indigenous plants are species that are native to a region or place, but are also found elsewhere. Endemic plants are species restricted to a single region or area, i.e., in the case of Hawai'i, they are found only in Hawai'i. In biodiversity terms, the endemic status is the more important of the two categories, since if a species belonging to it is endangered or threatened in Hawai'i, it would likewise be classified globally. Indigenous species, however, can be classified as threatened or endangered in Hawai'i, but may be common elsewhere in the Pacific. Over 90% of the native plants in Hawai'i are endemic, one of the highest rates in the world.

The majority of the 93 species encountered during the survey are naturalized "alien" plants that were accidentally or intentionally introduced to Hawai'i, but which have now become established in the islands and can spread on their own. The checklist of Char and Associates (1995) included several other species found on the adjacent property that were not found during the present survey: *Bidens cynapiifolia* (beggar's tick), *Cucumis dipsaceus* (wild cucumber), *Tephrosia purpurea* ('auhuu), *Abutilon incanum* (hoary abutilon), *Boerhavia repens* (alena), and *Solanum americanum* (popolo). All of these except *Tephrosia purpurea* are herbaceous species that die back during the dry season, and consequently would likely turn up in the current study area during a survey in the rainy season. Three of them are native (or questionably so), but none are endemic.

Only one of the native species found during the present survey, *Pleomele hawaiiensis*, is a federally listed endangered species. Hawai'i Natural Heritage Program database map (Fig. 2) shows a record of *Caesalpinia kavaiensis* (uhiuhi) as occurring between the current study site and the industrial area, but the date on this record is 1981 and the tree has probably died by now, since it has not been recorded there since that time. (Also, it is located outside of the present study site.) A list of native species found at the study site is shown in Table 1. The other three endangered plant species, *Cyperus sauriei*, *Nothocestrum breviflorum*, and *Neraudia ovata*, previously reported from the dryland forest were not encountered during the present survey, and may have disappeared from the site.

DISCUSSION

Only one of the species encountered during the survey is Federally Listed as Threatened or endangered, *Pleomele hawaiiensis* (Fig. 12). According to the USFWS, "six to eight populations are currently known: one to three in the Puu Waawaa region of Hualalai on State-leased and private land, two in the Kaloko/Kaloa area on private land, two in the Kapua/Kahuku area on private land, and one on Holei Pali within Hawaii Volcanoes National Park. These populations total 250-300 individuals, of which over 75 are found at Kaloko. Kaloko represents one of only

Table 1. Native species found at the study site

| | pua kala | Endemic |
|---------------------------------------|----------|---------|
| <i>Argemone glauca</i> (Papaveraceae) | | |
| <i>Bidens micrantha</i> | | |

| | | |
|--|------------------|-------------|
| subsp. <i>ctenophylla</i> (Asteraceae) | ko'oko'olau | Endemic |
| <i>Capparis sandwichiana</i> (Capparaceae) | pua pilo | Endemic |
| <i>Chamaesyce celastroides</i> (Euphorbiaceae) | 'atoto | Endemic |
| <i>Cocculus trilobus</i> (Menispermaceae) | huehue | Indigenous |
| <i>Diospyros sandwicensis</i> (Ebenaceae) | lama | Endemic |
| <i>Dodonaea viscosa</i> (Sapindaceae) | 'a'ali'i | Indigenous |
| <i>Doryopteris decipiens</i> (Adiantaceae) | kumuniu | Endemic |
| <i>Heteropogon contortus</i> (Poaceae) | pili grass | Indigenous? |
| <i>Ipomoea indica</i> (Convolvulaceae) | koali-'awa | Indigenous |
| <i>Lipochaeta subcordata</i> (Asteraceae) | ----- | Endemic |
| <i>Metrosideros polymorpha</i> (Myrtaceae) | 'ohi'a lehua | Endemic |
| <i>Myoporum sandwicense</i> (Myoporaceae) | naio | Indigenous |
| <i>Osteomeles anthyllidifolia</i> (Rosaceae) | 'ulei | Indigenous |
| <i>Peperomia leptostachya</i> (Piperaceae) | 'ala'ala-wai-nui | Indigenous |
| <i>Plectranthus parviflorus</i> (Lamiaceae) | spurfloer | Indigenous |
| <i>Pleomele hawaiiensis</i> (Agavaceae) | halapepe | Endemic |
| <i>Psilotum nudum</i> (Psilotaceae) | moa | Indigenous |
| <i>Psydrax odoratum</i> (Rubiaceae) | alahe'e | Indigenous |
| <i>Reynoldsia sandwicensis</i> (Araliaceae) | 'ohe | Endemic |
| <i>Scaevola sericea</i> (Goodeniaceae) | naupaka | Indigenous |
| <i>Senna gaudichaudii</i> (Fabaceae) | kolomona | Indigenous |
| <i>Sida fallax</i> (Malvaceae) | 'ilima | Indigenous |
| <i>Sophora chrysophylla</i> (Fabaceae) | mamane | Endemic |
| <i>Waltheria indica</i> (Sterculiaceae) | 'uhaloa | Indigenous |

two known populations that are successfully regenerating" (USFWS 2006, pers. comm.). During the present survey, only about 24 plants were observed, but since counting individuals was not part of the project, this should not be judged to be indicative of a decline in the number of individuals currently there. The species is not included on the Hawai'i Natural Heritage Program Database map (Fig. 2).

Several other endangered species have been reported from the dryland forest area, but were not found during the present survey. According to the USFWS, the endangered *Nothocestrum brevifolium* is "historically known from 15 locations extending from the southern Kohala Mountains, south along the leeward side of the Big Island, to the South Point area. Currently, six populations are known. Two of the 53 known individuals of this species occur in Kaloko (USFWS pers. comm. 2006)." The Hawai'i Natural Heritage Program Database (Fig. 2) noted a location of the plant in the dryland forest and dates this record to 1992. Rex Palmer observed the plant growing in the dryland forest only three years ago (pers. comm. 2006). The Division of Forestry and Wildlife (DOFAW) representative Lyman Perry (pers. comm. 2006) noted his belief that "...*Nothocestrum* [has] not been observed in this area for quite some time...The nearest *Nothocestrum* locations that I know of are in Kaupulehu (above the road at the 28 mile marker in the NTBG 6 acre enclosure)." A site visit by USFWS personnel in 2003 looking at endangered species did not report finding it either (USFWS 2003 a&b).

A third endangered species, *Neraudia ovata*, has been reported from the dryland forest. Palmer (pers. comm. 2006) noted its presence there in 2003 growing under trees near to where homeless people are known to camp. The presence of a single flowering and fruiting plant was reported there in 2003 (USFWS 2003 a&b). Lyman Perry (pers. comm. 2006) noted "...*Neraudia* [has] not been observed in this area for quite some time...The nearest known location of *Neraudia* was the lava flow behind COSTCO on Hina Lani Street but those plants died in the last couple of years." The Hawai'i Natural Heritage Program Database (Fig. 2) shows its occurrence in the area in 1995.

A fourth endangered species has been reported from the dryland forest, the endemic *Cyperus fauriei* (formerly known as *Mariscus fauriei*). According to the USFWS, "only four populations are currently known: 20-30 plants on State owned land on Molokai, 22 plants in two populations on State owned land on the southern end of the island of Hawaii, and five plants in Kaloko, on private land" (USFWS pers. comm. 2006). This information about its presence at Kaloko is probably based on the record from the survey described in CH2M Hill (1993). The Hawai'i Natural Heritage Program Database (Fig. 2) shows its presence there in 1992, apparently also based on the CH2M Hill report.

The Hawai'i Natural Heritage Program Database map (Fig. 2) also shows a record of the federally listed-endangered tree *Caesalpinia kavalensis* (*uhiuhi*) as occurring in the area just west of the study site and east of the industrial area, but it apparently has not been seen for years and was not noted in the USFWS 2003 site visit report (USFWS 2003a&b).

CONCLUSIONS AND RECOMMENDATIONS

Based upon the survey, there are three main kinds of vegetation at the site: (1) disturbed scrub dominated by *Leucaena leucocephala* (*koa haole*) in combination with *Pennisetum setaceum* (fountain grass) in the lower part of the study site, and with *Kalanchoe pinnatum* (air plant) and *Panicum maximum* (Guinea grass) in the upper part; (2) disturbed scrub dominated by *Schinus terebinthifolius* (Christmas berry); and (3) relatively undisturbed dryland forest. The two kinds of disturbed vegetation occupy most of the site. The USFWS, based on notes from 1996, reported their belief that the dryland forest was approximately 200 acres (80 hectares) in area (USFWS pers. comm. 2006). By this reckoning, the disturbed vegetation comprises about 1100 acres (1296 minus 200) of the site. No Federally listed endangered or threatened plant species were recorded in this disturbed area.

The dryland forest is a different story. It constitutes valuable and irreplaceable habitat for Hawai'i's unique biota, and consequently has major cultural and biological significance. It is one of the last few remaining, relatively undisturbed patches of this dryland forest habitat in Hawai'i. Twenty-five native species were recorded from this site, eleven of them endemic to Hawai'i (i.e., found nowhere else in the world). Four of these (three found during previous surveys only, and one during the present and previous surveys) are federally listed endangered species. Some of these species are very rare since they are restricted to only a few localities. This combination of rare vegetation, rare native species, and federally listed endangered species make this remnant dryland very important to the biodiversity of Hawai'i. The USFWS is bound by law to protect these species and consequently they will need to protect this area of dryland forest where they occur. However, the USFWS has previously noted that they would not hinder any development plans for the areas of disturbed vegetation at the site if the dryland forest were to be set aside and given protection status (USFWS, pers. comm. 2006). Consequently, the

owners will have to negotiate with the USFWS and DOFAW on just how much land needs to be set aside for this protection. They may also have to overcome local opposition to the project, so they should make it clear that they are also interested in preserving these unique and rare species, within the confines of development for the major portion of the parcel.

It is also recommended that of some of the rare and endemic species occurring on the site or in the general area should be considered for any landscaping that will be done, such as around utility buildings and public structures. This would be a win-win situation. Some of the species make attractive ornamentals, and are already adapted to the dryland conditions at the site. Thus they require little maintenance and watering. Using rare or culturally significant species would also help to alleviate any local or governmental concerns that the project would be detrimental to the survival of these rare species. Some of these species are already being propagated by local gardeners and gardens, such as the nearby Amy Greenwell Garden. These may be available for purchase, or these individuals or gardens could be hired to do the local plant landscaping. Some species recommended for this are as follows:

- Aleurites moluccana* (*kukui*)—This species is a Polynesian introduction to Hawai'i rather than a native species, but it has important cultural significance since its seeds were traditionally used for night time illumination (hence its English name candle nut). Currently the seeds are used to produce massage oil and the fruits are fashioned into attractive, jet-black seed leis. It has gray-green leaves and large stature make it a popular ornamental tree in Hawai'i.
- Bidens micrantha* subsp. *ctenophylla* (*ko'oko'olau*)—An endemic shrub that was formerly a candidate, federally listed endemic species. It is restricted mostly to this part of the island of Hawai'i and has small, attractive, yellow, sunflower-like flowers (Fig. 13)
- Capparis sandwichiana* (*pua pilo*, *pua pilo*)—An endemic shrub or small tree with large, attractive white, fragrant flowers. It is relatively rare in Hawai'i, but does well on lowland lava flows.
- Erythrina sandwicensis* (*wiliwili*)—A spreading endemic tree with showy seasonal red flowers, found in the area, but not recorded from the study site. It is a popular, long-lived, native ornamental tree in Hawai'i that is related to the ornamental coral tree (*Erythrina variegata*).
- Metrosideros polymorpha* (*'ohi'a lehua*)—This is the indigenous, medium-sized tree covering much of the island, and has attractive red, powderpuff-like flowers. Some varieties also have attractive gray-green leaves. It is uncommon at the site, probably because the area does not get enough rainfall to allow it to flourish, but it dominates the intact forests upslope.
- Myoporum sandwicense* (*naio*)—An indigenous small tree or shrub with small, fragrant white flowers. Its English name is false sandalwood, indicative of its fragrant wood once used like sandalwood. The plant is easily grown from cuttings.
- Osteomeles anthyllidifolia* (*'ulei*)—A sprawling indigenous shrub that makes a nice shrubby ground cover. It has attractive but small, white, rose-like flowers (it is a member of the rose family).
- Pleomele hawaiiensis* (*halapepe*)—A federally listed endangered endemic species. This yucca-like plant is similar to the money tree (*Dracaena marginata*) that is a popular ornamental plant in Hawai'i.
- Psychotria odoratum* (*alaha'e*)—A small indigenous tree or shrub fairly common at the site, to which it is well adapted. It has attractive dark green leaves, thick canopy, and baseball-sized clusters of fragrant, attractive white flowers.

- Reynoldsia sandwicensis* (*'ohe*)—A large, fast growing endemic tree with an open canopy.
- Senna gaudichaudii* (*kolomona*)—Small indigenous tree with pale yellow flowers. It is similar to the scrambled eggs tree (*Senna surattensis*) that is a popular ornamental tree in Hawai'i, and which is also naturalized at the site.
- Sida fallax* (*'ilima*)—An indigenous shrub common at the site. It is a popular ornamental in Hawai'i, where the orange mallow-like flowers are fashioned into exquisite leis.
- Sophora chrysophylla* (*mamane*)—An endemic small tree or shrub common on the Big Island, especially at higher elevations. It has attractive yellow, sweetpea-like flowers and an unusual, bead-necklace-like pod.

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TABLE 1. PLANT SPECIES CHECKLIST FOR THE KALOKO PROPERTY

The following is a checklist of the vascular plants inventoried during the field studies on the Kaloko planned development area. The plants are divided into three groups, Ferns (including fern allies), Monocots, and Dicots. Within these groups, the species are presented taxonomically by family, with each family and each species in the family in alphabetical order. The taxonomy and nomenclature of the ferns follow Palmer 2003 and the flowering plants (Monocots and Dicots) follow Wagner *et al.* (1999). In most cases, common English and/or Hawaiian names listed here have been taken from St. John (1973) or Porter (1972). Native plants are shown in bold.

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English and/or Hawaiian name, when known.
3. Biogeographic status. The following symbols are used.
E = endemic (found only in Hawai'i).
I = indigenous (native to Hawai'i as well as other geographic areas).
P = Polynesian introduction (introduced to Hawai'i by Polynesians before the advent of the Europeans).
X = Introduced or alien (not native, introduced to Hawai'i, either accidentally or intentionally, after the advent of the Europeans).
4. Relative frequency (abundant, locally abundant, common, locally common, occasional, uncommon, rare).

| Species | Common Names | Status | Abundance |
|---|-----------------|--------|-----------|
| FERNS AND FERN ALLIES | | | |
| ADIANTACEAE (Maiden's-hair Family) | | | |
| <i>Doryopteris decipiens</i> (Hook.) J. Sm. | kumuniu | E | |
| NEPHROLEPIDACEAE (Sword Fern Family) | | | |
| <i>Nephrolepis multiflora</i> (Roxb.) Jarret ex Morton | hairy swordfern | X | |
| PSILOTACEAE (Psilotum Family) | | | |
| <i>Psilotum nudum</i> L. | moa | I | |
| POLYPODIACEAE (Common Fern Family) | | | |
| <i>Phymatosorus grossus</i> (Langsd. & Fisch.) Brownlie | laua'e | X | |
| MONOCOTS | | | |
| AGAVACEAE (Agave Family) | | | |
| <i>Pleomele hawaiiensis</i> Degener and I. Degener | halapepe | E | |

| Species | Common Names | Status |
|--|-----------------------|--------|
| COMMELINACEAE (Spiderwort Family) | | |
| <i>Commelina benghalensis</i> L. | hairy honohono | X |
| DIOSCOREACEAE (Yam Family) | | |
| <i>Dioscorea bulbifera</i> L. | bitter yam, hoi | P |
| POACEAE (Grass Family) | | |
| <i>Cenchrus echinatus</i> L. | sandbur | X |
| <i>Chloris barbata</i> (L.) Sw. | swollen fingergrass | X |
| <i>Dactyloctenium aegyptium</i> (L.) Willd. | beach wiregrass | X |
| <i>Digitaria ciliaris</i> (Retz.) Koeler | large crabgrass | X |
| <i>Eragrostis tenella</i> (L.) P. Beauv. ex Roem. & Schult. | love grass | X |
| <i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult. | pili grass | I |
| <i>Melinis minutiflora</i> P. Beauv. | molasses grass | X |
| <i>Panicum maximum</i> Jacq. | Guinea grass | X |
| <i>Pennisetum setaceum</i> (Forssk.) Chiov. | fountain grass | X |
| <i>Rhynchelytrum repens</i> (Willd.) C.E. Hubb. | Natal redtop | X |
| DICOTS | | |
| AMARANTHACEAE (Amaranth Family) | | |
| <i>Amaranthus viridis</i> L. | slender amaranth | X |
| ANACARDIACEAE (Mango Family) | | |
| <i>Schinus terebinthifolius</i> Raddi | Christmas berry | X |
| APOCYNACEAE (Periwinkle Family) | | |
| <i>Catharanthus roseus</i> (L.) G. Don | Madagascar periwinkle | X |
| ARALIACEAE (Panax Family) | | |
| <i>Reynoldsia sandwicensis</i> A. Gray | 'ohe | E |
| ASTERACEAE (Sunflower Family) | | |
| <i>Ageratum conyzoides</i> L. | ageratum | X |
| <i>Bidens micrantha</i> Gaud. subsp. <i>ctenophylla</i> (Sherff) Nagatga & Ganders | ----- | E |
| <i>Emilia fosbergii</i> Nicolson | red pualele, emilia | X |
| <i>Emilia sonchifolia</i> (L.) DC. | pualele, emilia | X |
| <i>Lipochea subcordata</i> A. Gray | ----- | E |
| <i>Pluchea carolinensis</i> (Jacq.) G. Don | pluchea | X |
| <i>Senecio madagascariensis</i> Poir. | fireweed | X |
| <i>Tridax procumbens</i> L. | coat buttons | X |
| BIGNONIACEAE (Bignonia Family) | | |
| <i>Jacaranda mimosifolia</i> D. Don | jacaranda | X |
| <i>Spathodea campanulata</i> P. Beauv. | African tulip tree | X |
| BUDDLEIACEAE (Butterfly-bush Family) | | |
| <i>Buddleia asiatica</i> Lour. | dogtail, heulo'ilio | X |
| Species | Common Names | Status |

| | | |
|---|--------------------------|--------|
| CACTACEAE (Cactus Family) | | |
| <i>Eyllocereus undatus</i> (Haw.) Britten & Rose | night-blooming cereus | X |
| <i>Opuntia ficus-indica</i> (L.) Mill. | prickly pear, panini | X |
| CAPPARACEAE (Caper Family) | | |
| <i>Capparis sandwichiana</i> DC | pua pilo | E |
| CLUSIACEAE (Mangosteen Family) | | |
| <i>Clusia rosea</i> Jacq. | autograph tree | X |
| CONVOLVULACEAE (Morning-Glory Family) | | |
| <i>Ipomoea indica</i> (J. Burm.) Merr. | koali-'awa | I |
| <i>Ipomoea obscura</i> (L.) Ker-Gawl. | bindweed | X |
| CRASSULACEAE (Stonecrop Family) | | |
| <i>Kalanchoe pinnata</i> (Lam.) Pers. | air plant | X |
| CUCURBITACEAE (Gourd Family) | | |
| <i>Coccinea grandis</i> (L.) Voigt | ivy gourd | X |
| <i>Momordica charantia</i> L. | wild bittermelon | X |
| EBENACEAE (Ebony Family) | | |
| <i>Diospyros sandwicensis</i> (A. DC.) Fosb. | lama | E |
| EUPHORBIACEAE (Spurge Family) | | |
| <i>Aleurites moluccana</i> (L.) Willd. | candlenut, kukui | P |
| <i>Chamaesyce celastroides</i> | | |
| (Boiss.) Croizat and Degener | 'atoto | E |
| <i>Chamaesyce hirta</i> (L.) Millsp. | garden spurge | X |
| <i>Chamaesyce hyssopifolia</i> (L.) Small | ----- | X |
| <i>Macaranga tanarius</i> (L.) Muell. Arg. | ----- | X |
| <i>Ricinus communis</i> L. | castor bean | X |
| FABACEAE (Pea Family) | | |
| <i>Acacia farnesiana</i> (L.) Willd. | klu | X |
| <i>Chamaecrista nictitans</i> (L.) Moench | partridge pea, lau-ki | X |
| <i>Crotalaria pallida</i> Aiton | smooth rattiepod | X |
| <i>Desmodium incanum</i> DC. | Spanish clover | X |
| <i>Desmodium tortuosum</i> (Sw.) DC. | Florida beggarweed | X |
| <i>Indigofera suffruticosa</i> Mill. | indigo, 'iniko | X |
| <i>Leucaena leucocephala</i> (Lam.) de Wit | koa haole | X |
| <i>Macroptilium lathyroides</i> (L.) Urb. | cow pea | X |
| <i>Pithecellobium dulce</i> (Roxb.) Benth. | 'opiuma, Manila tamarind | X |
| <i>Prosopis pallida</i> (Humb. & Bonpl.) Kunth | kiawe, mesquite | X |
| <i>Senna occidentalis</i> (L.) Link | coffee senna | X |
| <i>Senna gaudichaudii</i> (Hook. & Arn.) H. Irwin & Barneby | kolomona | I |
| Species | Common Names | Status |

| | | |
|--|------------------------|--------|
| FABACEAE (cont'd.) | | |
| <i>Senna surattensis</i> (N.L. Burm.) H. Irwin & Barneby | kolomona | X |
| <i>Sophora chrysophylla</i> (Salisb.) Seem. | mamane | E |
| GOODENIACEAE (Goodenia Family) | | |
| <i>Scaevola sericea</i> Vahl | naupaka | I |
| LAMIACEAE (Mint Family) | | |
| <i>Hyptis pectinata</i> (L.) Poir. | comb hyptis | X |
| <i>Plectranthus parviflorus</i> Willd. | spurflower | I |
| MALVACEAE (Mallow Family) | | |
| <i>Abutilon grandifolium</i> (Willd.) Sweet | hairy abutilon | X |
| <i>Malvastrum coromandelianum</i> (L.) Garcke | false mallow | X |
| <i>Sida fallax</i> Walp. | 'ilima | I |
| <i>Sida rhombifolia</i> | Cuba jute | X |
| MENISPERMACEAE (Moonseed Family) | | |
| <i>Cocculus trilobus</i> (Thunb.) DC. | huehue | I |
| MYOPORACEAE (False-sandalwood Family) | | |
| <i>Myoporum sandwicense</i> A. Gray | naio, false sandalwood | I |
| MYRTACEAE (Myrtle Family) | | |
| <i>Metrosideros polymorpha</i> Gaud. | 'ohi'a lehua | E |
| <i>Psidium guajava</i> L. | guava | X |
| NYCTAGINACEAE (Four-o'-Clock Family) | | |
| <i>Boerhavia coccinea</i> Mill. | ----- | X |
| PAPAVERACEAE (Poppy Family) | | |
| <i>Argemone glauca</i> (Nutt. ex Prain) Pope | pua kala | E |
| PASSIFLORACEAE (Passionflower Family) | | |
| <i>Passiflora edulis</i> Sims | passionfruit, liliko'i | X |
| <i>Passiflora foetida</i> L. | love-in-a-mist | X |
| PHYTOLACCACEAE (Pokeweed Family) | | |
| <i>Rivina humilis</i> L. | rouge plant | X |
| PIPERACEAE (Pepper Family) | | |
| <i>Peperomia leptostachya</i> Hooker & Arnott | 'ala'ala-wai-nui | I |
| PORTULACACEAE (Purslane Family) | | |
| <i>Portulaca oleracea</i> L. | common purslane | X |
| <i>Portulaca pilosa</i> L. | 'ihi | X |
| <i>Talinum triangulare</i> (Jacq.) Willd. | talinum | X |
| PROTEACEAE (Protea Family) | | |
| <i>Grevillea robusta</i> A. Cunn. ex R. Br. | silk oak | X |
| ROSACEAE (Rose Family) | | |
| <i>Osteomeles anthyllidifolia</i> (Sm.) Lindl. | 'ulei | I |
| Species | Common Names | Status |
| RUBIACEAE (Coffee Family) | | |

| | | |
|--|-----------------------|---|
| <i>Morinda citrifolia</i> L. | Indian mulberry, noni | P |
| <i>Psydrax odoratum</i> (Forst. f.) | | |
| A. C. Sm. & S. Darwin | alahe'e | I |
| SAPINDACEAE (Soapberry Family) | | |
| <i>Dodonaea viscosa</i> Jacq. | 'a'ali'i | I |
| SCROPHULARIACEAE (Snap-dragon Family) | | |
| <i>Lophospermum erubescens</i> D. Don | larger roving sailor | X |
| SOLANACEAE (Nightshade Family) | | |
| <i>Lycopersicon pimpinellifolium</i> (Jusl.) Mill. | currant tomato | X |
| STERCULIACEAE (Cacao Family) | | |
| <i>Waltheria indica</i> L. | 'uhaloa | I |
| VERBENACEAE (Verbena Family) | | |
| <i>Lantana camara</i> L. | lantana | X |
| <i>Stachytarpheta australis</i> Moldenke | owi | X |
| <i>Stachytarpheta cayennensis</i> (Rich.) Vahl | blue rat's-tail | X |



Fig. 3. *Leucaena* scrub at lower end of study site.



Fig. 4. *Leucaena* scrub on the north-central part of the study site.

Fig. 5. *Kalanchoë pinnata* dominating underneath a *Leucaena* canopy at north-central part of the site.

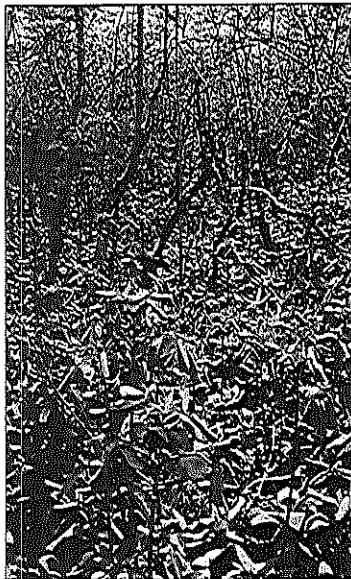


Fig. 6. Fountain grass growing under *Leucaena* trees.

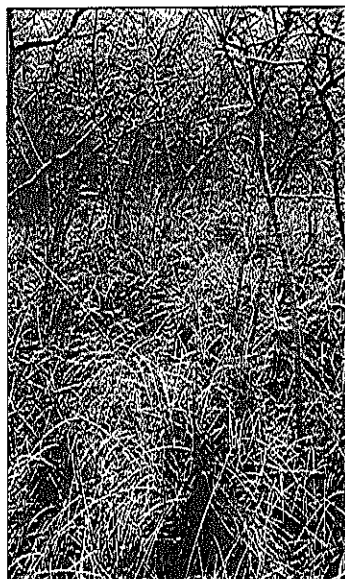


Fig. 7. Sparse Christmas-berry scrub at northeast corner of the study site.

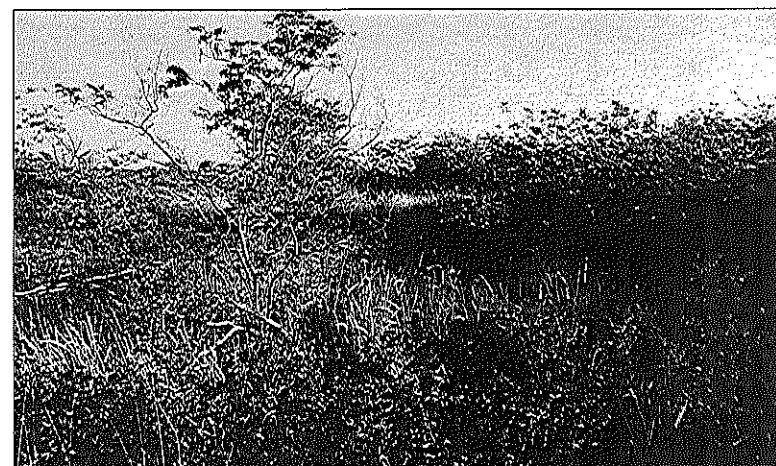


Fig. 8. Upper lava flow dominated by Christmas berry.



Fig. 9. Open lava in the dryland forest

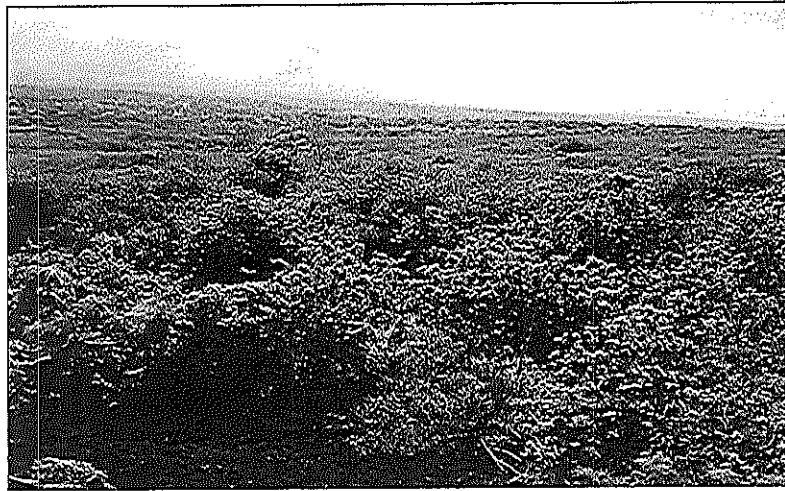


Fig. 10. Dense dryland forest.

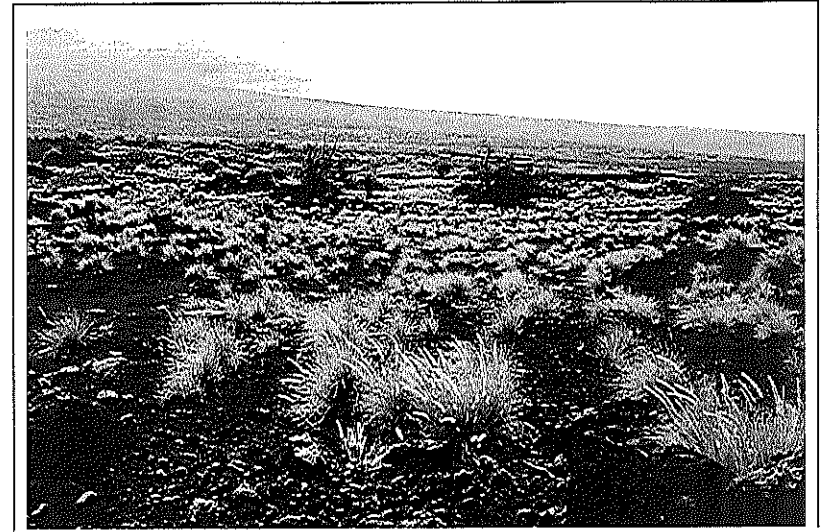


Fig. 11. Fountain grass coming up in old quarry site.



Fig. 12. *Pleomele hawaiiensis*.

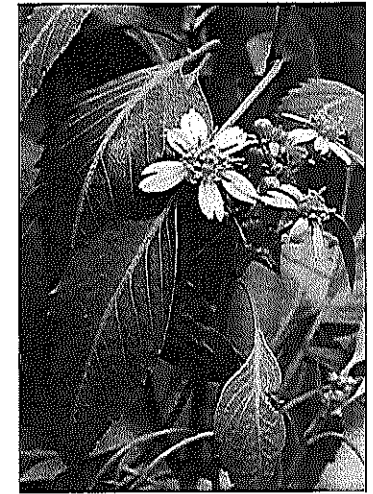


Fig. 13. *Bidens micrantha* subsp. *ctenophylla*.