COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

DEPARTMENT OF BOTANY

UNIVERSITY OF HAWAII AT MANOA

HONOLULU, HAWAII 96822

808-948-8218

TECHNICAL REPORT #9

HALE 1975 RBI NARRATIVE

Contribution Number CPSU/UH 011/3

NATIONAL PARK SERVICE

Contract #CX8000 6 0031

Clifford W. Smith, Unit Director

The National Park Service and the University of Hawaii signed the memorandum of agreement establishing this Cooperative National Park Resources Studies Unit on March 16, 1973. The unit provides a multidisciplinary approach to studies on the biological resources in the National Parks in Hawaii, that is, Hawaii Volcanoes National Park, Haleakala National Park, City of Refuge National Historical Park and Puukohola National Historic Site. Through the Unit Director, projects are undertaken in areas identified by park management. These studies provide information that will facilitate the development and implementation of resource management programs. The involvement of University faculty and students in the resource management of the National Parks in Hawaii lends to a greater awareness of the problems and needs of the Service. At the same time research not directly or immediately applicable to management is also encouraged through the Unit.

HALEAKALA NATIONAL PARK

RESOURCES BASIC INVENTORY

1975

NARRATIVE REPORT

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ABSTRACT

Three areas, the northwestern outer slope between 7,000 and 10,000 feet, the Ko'olau Gap between 5,500 and 6,500 feet and the Kau-pō Gap--Lau-'ulu Trail, were studied. Twenty sites were sampled within these areas and observations made on three other areas. Two sites, the Maka-wao Forest Reserve at 5,900 feet and the Ko'olau Gap ('Āina-hou) at 5,560 feet, just outside the northern boundary of the Park, were also visited. Specimens of flowering plants, ferns, mosses, liverworts, lichens and insects were collected. Census observations were made on the birds.

Determinations on all the flowering plants, ferns and birds have been completed. The determination of many species from the other groups will not be complete until authorities elsewhere have had an opportunity to study them.

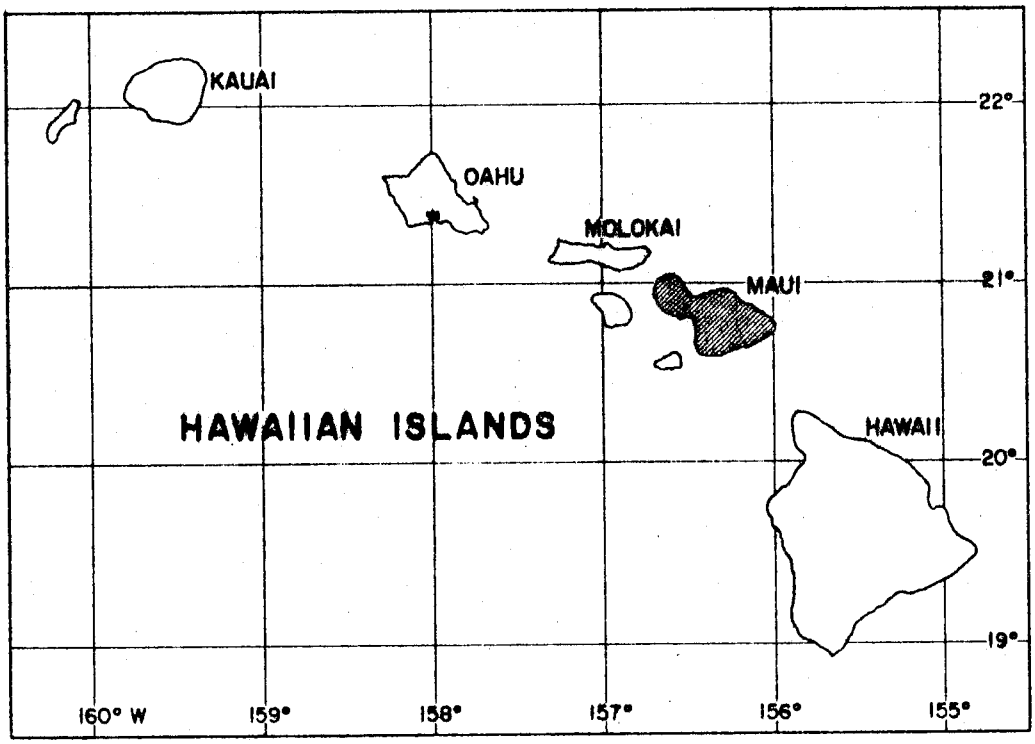
Some recommendations are included for future studies. Several potential management problems are also submitted; they are on the control of goats, pigs and the blackberry.

INTRODUCTION

Haleakala National Park is located on the island of Maui in the Hawaiian Archipelago (Fig. 1). This inventory of the biological resources of Haleakala National Park was initiated in June 1975. The inventory is confined to the crater and immediate surrounding area. Kī-pahulu Valley is excluded from this study for various reasons, the principal reason being the necessity for a rigorously planned survey program which will have the minimum impact in this undisturbed area.

The inventory will be in three phases. The first phase, described in this report, is the sampling of three major transects up the crater: the first transect being up the outer northwest slope, the second up the Ko'olau Gap, and the third up the Kau-pō Gap to the top of the Lau-'ulu Trail. These transects sample all major ecosystems in the crater except for the rainforest just outside the eastern rim. The second phase will concentrate on the crater and crater wall; while the third phase will emphasize the crater rim and further studies in the Kau-pō Gap.

Fig. 1. Map showing location of Haleakala National Park in reference to the Island of Maui and the Hawaiian Archipelago.


KAUAI
OAHU
MOLOKAI
MAUI
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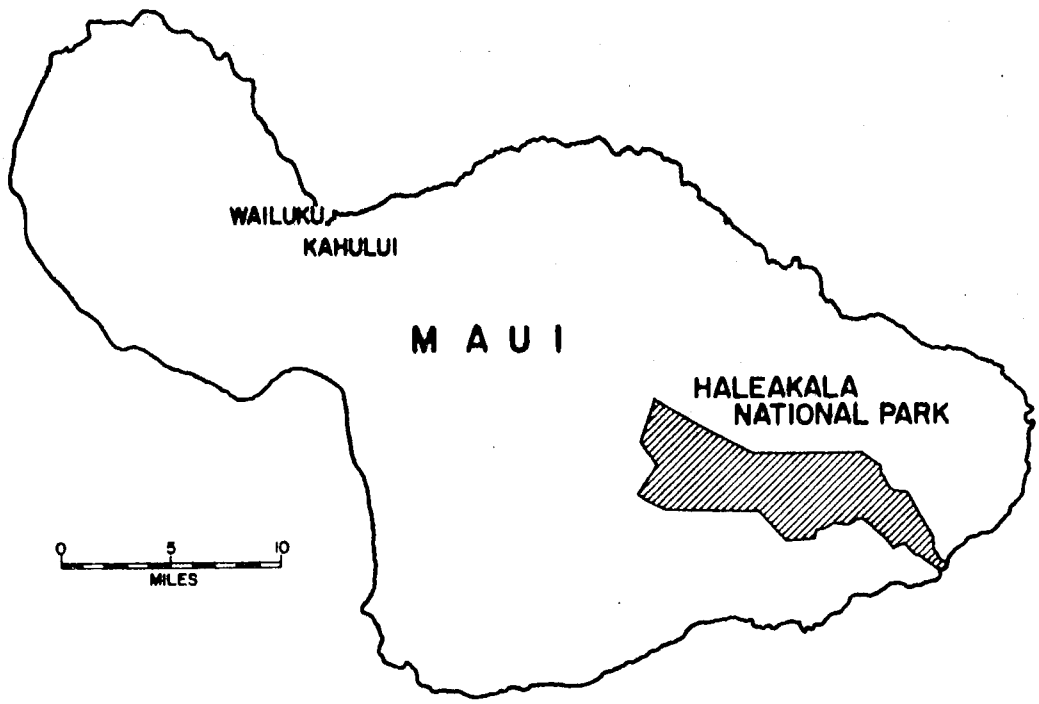

WAILUKU
KAHULUI
M A U I
HALEAKALA
NATIONAL PARK
0
5
10
MILES

METHODS AND MATERIALS

Within each of the three major transects several sites were sampled. (Figs. 2-5.) The rationale for collecting in each site is explained in the report on each site. In the northwest outerslope area and the Kau-pō Gap/Lau-ʻulu Trail area the collecting sites were made along an altitudinal gradient. Though this approach was originally intended for the Ko'olau Gap area we did not complete the upper altitudinal segment of the study. This area will be inventoried in the summer of 1976. In the lower elevations of the northwestern outer slope observations were made in some of the gullies as well as the more typical slope face.

At each site, an area typical of the general vascular plant vegetation was chosen. After walking through the area a consensus of general observations was obtained concerning the characteristics of the ecosystem in that area. The vegetation was described in the following terms:

Dominant species in each stratum

The average height of each species

The percentage cover of each species

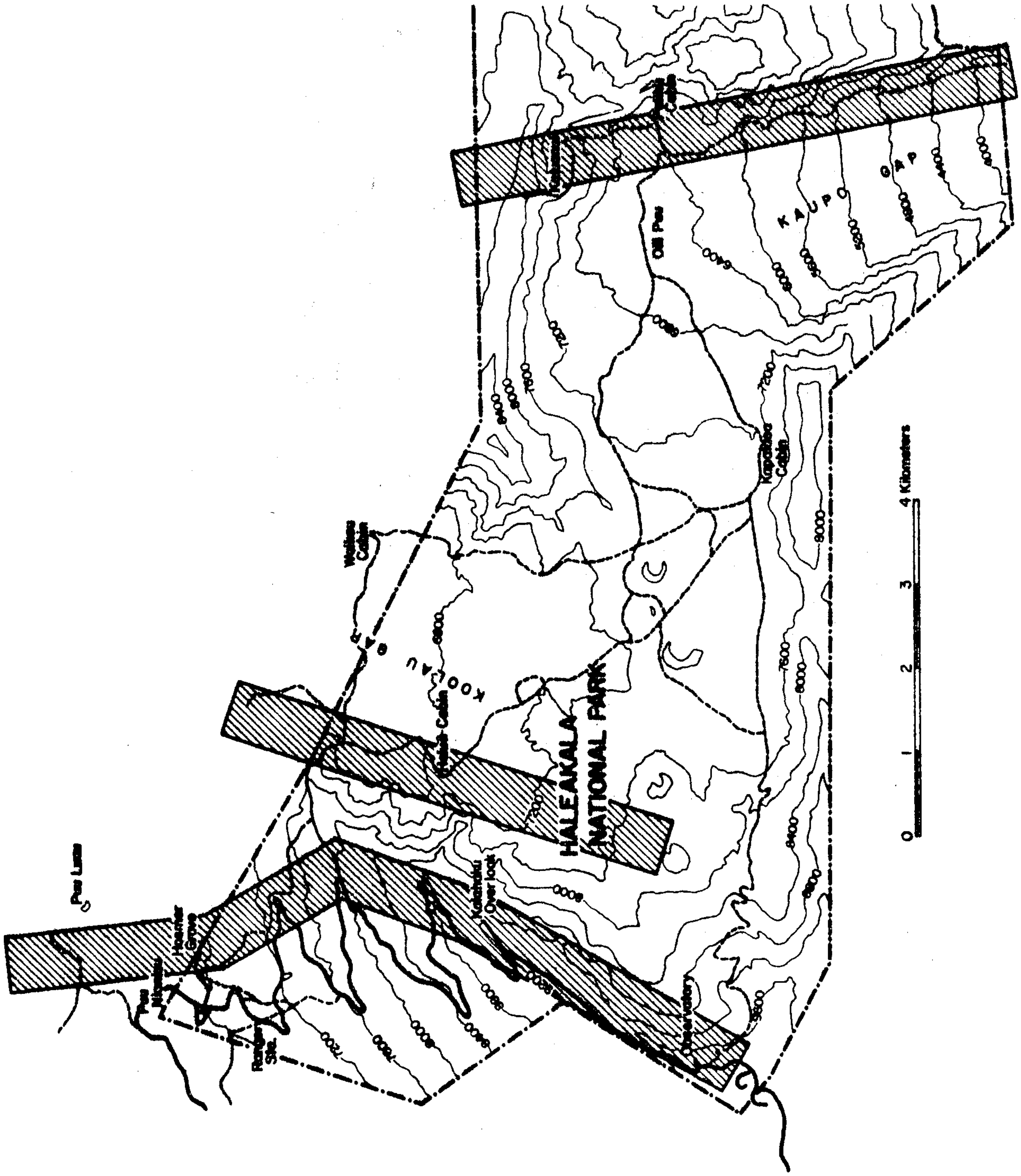
The whole area was then sampled intensively by the various specialists in the party.

The names of flowering plants conform to those in St. John (1973). This does not imply that we necessarily agree with the taxonomy presented in this checklist. However, the list is the most complete one published so far

on Hawaiian flowering plants and we have conformed to it to avoid confusion. Fosberg and Herbst's (1975) list of rare and endangered species also utilizes the names published in this checklist.

The common and Hawaiian names are taken from Pukui and Elbert (1971) and Porter (1972). The names are those that are most frequently in use today. However, in certain areas other names may be used by native-speaking Hawaiians particularly in East Maui.

Fig. 2. Map showing the location of the three transects studied during the 1975 Resources Basic Inventory of the Haleakala National Park Crater District.


HALEAKALA NATIONAL PARK
KOOLAU GAP
KAUPO GAP
0 1 2 3 4 Kilometers

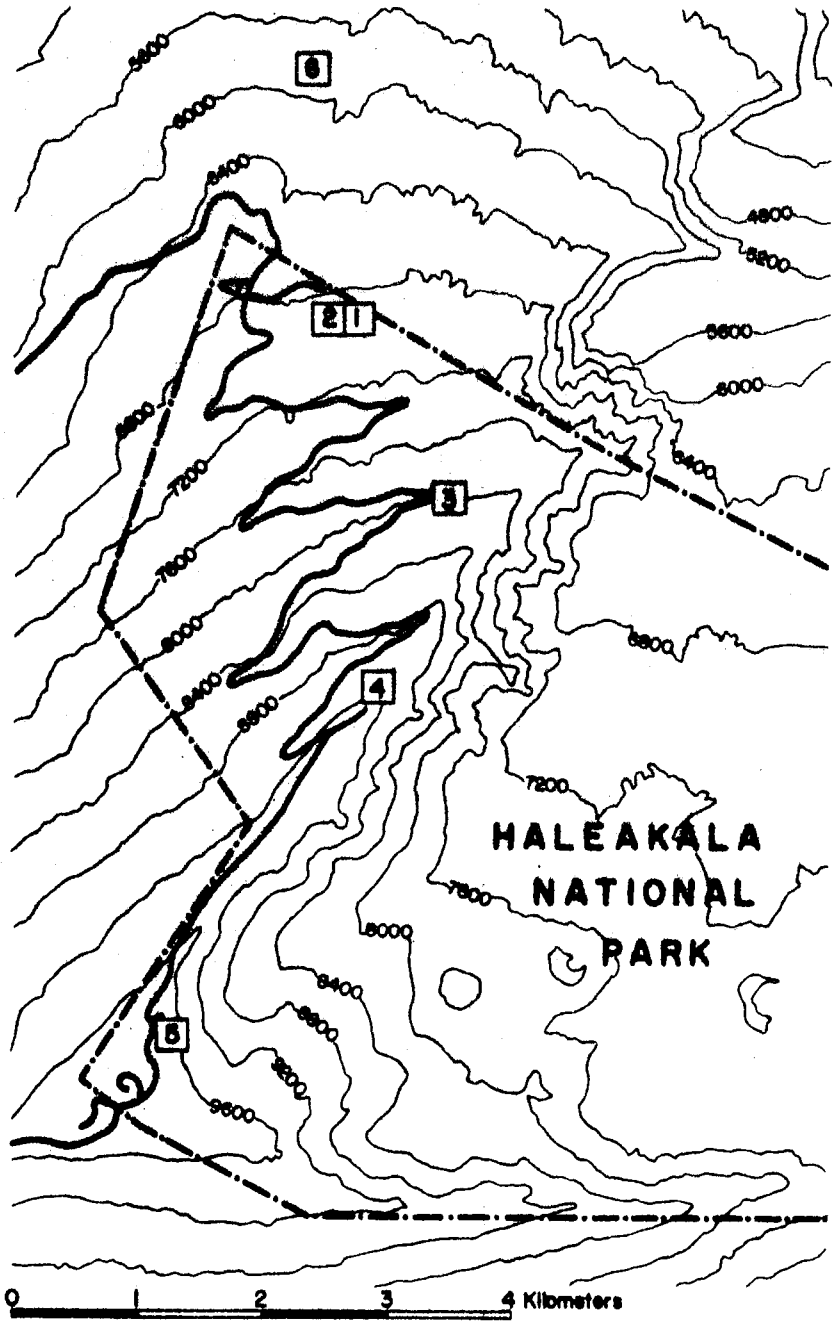


Fig. 3. Map showing the location of Study Areas 1-6 for the 1975 Resources Basic Inventory of the Haleakala National Park Crater District.

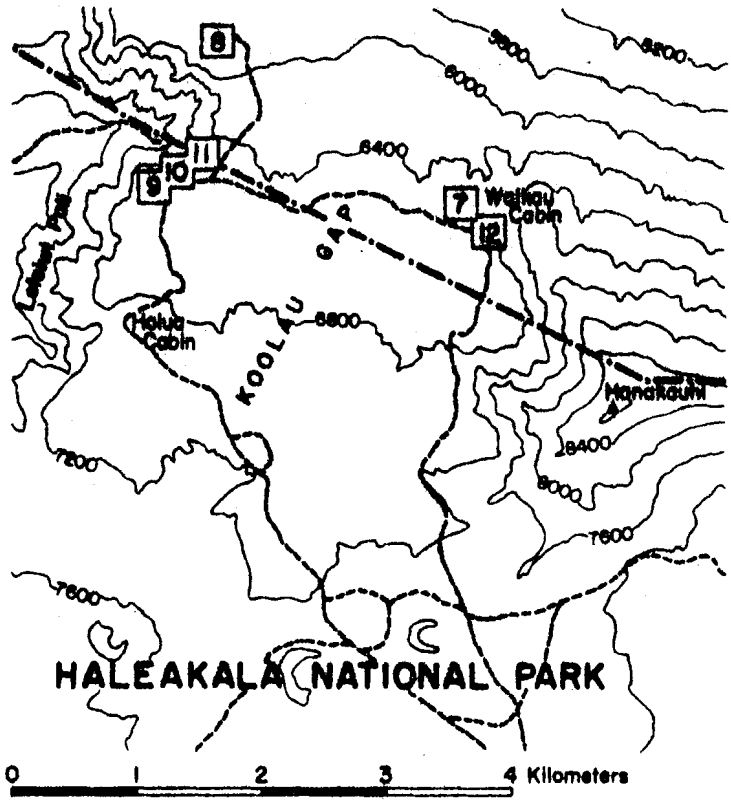


Fig. 4. Map showing the location of Study Areas 7-12 for the 1975 Resources Basic Inventory of the Haleakala National Park Crater District.

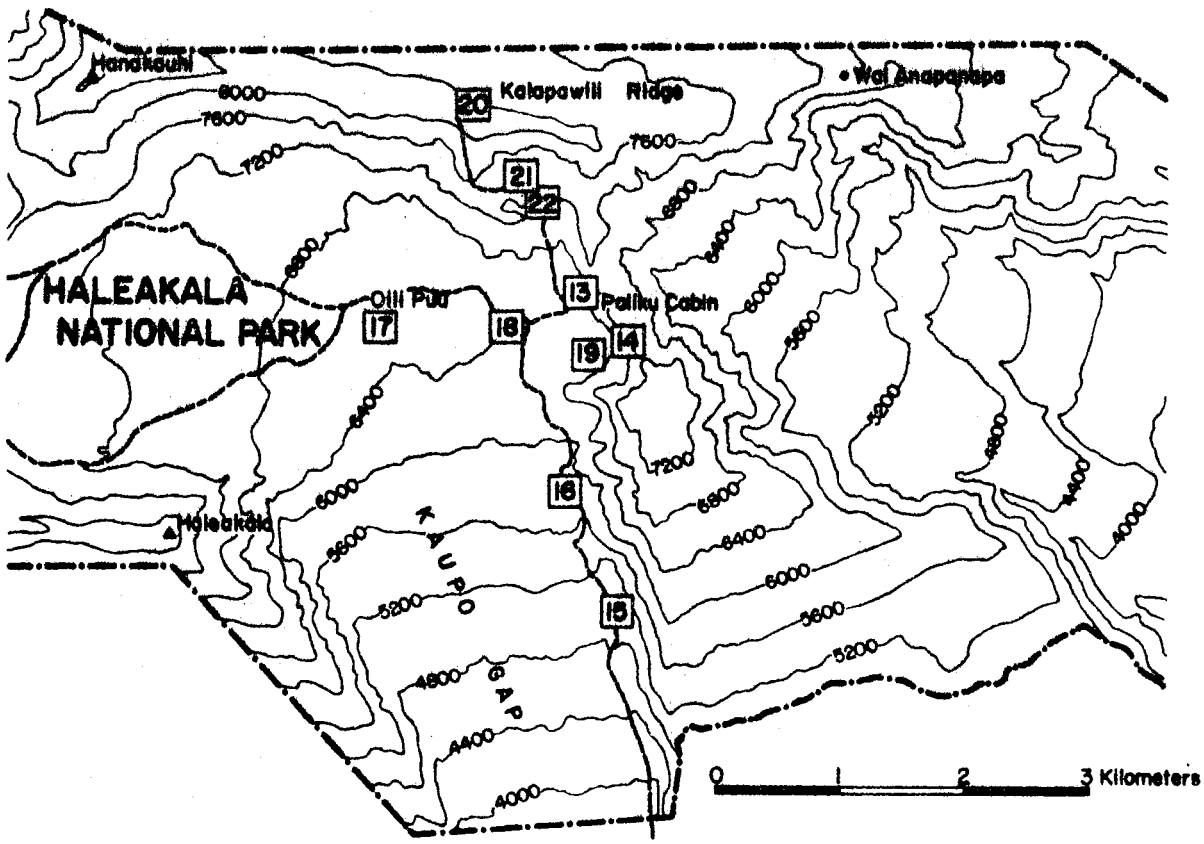


Fig. 5. Map showing the location of Study Areas 13-22 for the 1975 Resources Basic Inventory of the Haleakala National Park Crater District.

Study Area #1

Map reference: N 20° 46' 18"
W 156° 14' 18"

Location:

One eighth of a mile to the east of Hosmer's Grove Camp Site and at about the same elevation. See Fig. 3 (p. 8).

Elevation: 6,700 ft. (3,233 m)

Aspect:

The gully faces north yet it is protected from most of the prevailing winds by its depth and narrowness.

General Description:

Deep (approx. 60 ft.) gully with steep sides. Slope 70-90° on eastern side, 50-80° on western side. The gully is one of the major drainage canals on the northern slope leading into Wai-ka-moi Stream. It was dry when we collected but from the characteristics of the stream bed--large smooth boulders, deep splash pools and layers of debris high up on the shrubs -the gully must be subject to occasional flash floods.

Soil type:

Rock land, area where exposed rock covers 25-90 percent of the surface (USDA Soil Survey 1972). In the area studied the soil was dark brown to almost black at the surface with a substantial litter layer in places. The soil below the surface is a light brown and occasionally over one foot deep in places. There is a good evidence of stratification in isolated areas.

Surrounding area:

Except downstream, the area is surrounded by a *Sophora-Coprosma montana* (Māmane-Pilo) dominated community. It is protected from high winds from below by the well established conifers planted in Hosmer's Grove.

Climate:

The area is subjected to frequent immersion in cloud. The average annual precipitation is approximately 50 inches. The prevailing trade winds blow up over the slopes below.

Rationale for studying this area:

The area lies just within the National Park boundary on the outer north to northwest slopes. This area when compared with Study Area #2 should give a comprehensive picture of the whole area at this elevation. It also forms the lower portion of a transect along the outer northwestern slope of Haleakala Crater from the National Park boundary to the summit.

Number of specimens collected:

Flowering plants	31
Conifers	1
Ferns	12
Mosses and Liverworts	30
Lichens	72

General comments:

The area is somewhat atypical of the surrounding ecosystem. The vegetation is not homogeneous, there being a distinct clumping of species in various regions of the gully.

The clumping did not appear to be the result of environmental gradients which in turn affected the microhabitats. A more probable explanation is that the species present, *e.g.*, *Metrosideros* ('Ōhi'a), were representative of the vegetation of lower elevations. They were established in this region which is beyond or at the fringe of their normal range where they survived and flourished in isolated protected pockets.

The gully has a more diverse flora than the surrounding natural areas. This is probably the result of several factors including:

I. the protection from long exposure to direct sunlight and strong winds afforded by the gully,

II. the higher soil-water regime due to the area acting as a drainage canal. Standing water was observed in three or four places, and

III. the link afforded by the gully between the *Metrosideros-Acacia koa* ('Ōhi'a-Koa) forest below and the *Sophora-Coprosma* (Māmane-Pilo) scrub of the surrounding area, that is, the more mesic gully may act as a transitional zone between the forest and scrub communities.

Although *Metrosideros* ('Ohi'a) is the dominant species present in terms of cover, there are very few trees present, and there was no indication of any regeneration. These two facts would indicate that the vegetation in the gully is in a state of flux and not of a truly climax nature. Rather it may be a fragile ecosystem which is subject to the fortuitous invasion by different organisms.

Vegetation of Study Area #1

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G. Forst.) Gray	'Ōhi'a-lehua	40	30 ft. (10m)	E	Few flowers.
2	*Styphelia tameiameiae* (Cham.) F. Muell.	Pūkiawe	10	10 ft. (3m)	E	
	Sophora chrysophylla (Salisb.) Seem.	Māmane	5	10 ft. (3m)	E	Flowering.
	Dodonæa sandwicensis Sherff	A'ali'i	5	10 ft. (3m)	E	
Ground	*Holcus lanatus* L.	Yorkshire fog	20	1 ft. (0.3m)	X	In isolated pockets, probably the result of pig grubbing.
	Polypodium pellucidum Kaulf.	'ae	1	1 ft. (0.3m)	E	
Epiphytes	The lichen genera *Pseudocyphellaria* and *Usnea* are common. *Macromitrium intricatum* and *Orthotrichum hawaiicum* are the only mosses but these two species are very uncommon.					

Locality:	Two hundred yards east of Hosmer's Grove.
Description:	Steep-sided sixty-foot deep gully with occasional stream, subject to flash floods.
Date studied:	12 June 1975.
Total vegetation cover:	90 percent.

* E = Endemic, I = Indigenous, X = Exotic

Study Area #2

Map reference: N 20° 46' 18"
W 156° 14' 23"

Location:

One hundred yards beyond and above (to the south of) the Hosmer's Grove Camp Site. See Fig. 3 (p. 8).

Elevation: 6,740 ft. (3,250 m)

Aspect: North facing

General description:

Undulating region of the outer northern slope of the mountain. The slope is from 10-40° in a northerly direction and draining into a system of gullies which feed into larger gullies as in Study Area #1 leading into Wai-ka-moi Stream.

Soil type:

Very stony land. Fifty to 90 percent of the surface is covered with stones and boulders (USDA Soil Survey 1972). The area has a relatively shallow humic soil derived from volcanic ash between the frequent boulders. The top soil is dark brown to black but becoming lighter about one to three inches below the surface. The soil is rarely more than six inches deep.

Surrounding area:

The area is surrounded on all sides except below (to the north) by a scrub community similar to the area studied. Only below is the area protected from strong winds by the well-established conifer plantation at Hosmer's Grove.

Climate: The weather and rainfall are similar to Area #1.

Rationale for studying this area:

See comments concerning Area #1.

Number of specimens collected:

Flowering Plants	17
Ferns	2
Mosses and Liverworts	11
Lichens	36

General comments:

This area is dominated by *Sophora chrysophylla* (Māmane) and *Coprosma montana* (Pilo) with no *Metrosideros* ('Ōhi'a) present. However, *Metrosideros* is present in the gullies close by. Conditions are obviously not suitable for the establishment of 'Ōhi'a though there is no apparent reason why it should not be present in the scrub form; perhaps it cannot compete with the species present.

This area is heavily damaged by feral pigs. Many pockets are being converted to grassland as a consequence of this disturbance. It is our opinion that unless something is done to control the pigs in this area a radical change in the ecosystem will occur. The reestablishment of the natural ecosystem would take decades, if it were to occur at all. The pigs appear to have a preference for the *Sophora* (Māmane) in this region although no statistically valid data to prove this observation have been gathered. The damage to the root system appears to be devastating. Seedlings and suckers are also uprooted preventing the regeneration of the Māmane in

Vegetation of Study Area #2

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Sophora Chrysophylla* (Salisb.) Seem.	Māmane	30	9 ft. (3m)	E	Pig damage around roots
	Coprosma montana Hbd.	Pilo	10	6 ft. (2m)	E	Fruits but no flowers
2	*Styphelia tameiameiae* (Cham.) F.Muell.	Pūkiawe	30	3 ft. (1m)	E	
	Vaccinium reticulatum Sm.	'Ōhelo	10	3 ft. (1m)	E	
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Bracken fern Kīlau	1	2-3 ft. (1m)	I	
	Geranium cuneatum var. *tridens* (Hbd.) Fosb.	Hinahina	1	2-3 ft. (1m)	E	Flowering
Ground	*Holcus lanatus* L.	Yorkshire fog	5	1 ft. (0.3m)	X	Flowering in pockets, probably the result of pig grubbing
	Coprosma ernodeoides Gray	Kukae-nene	5	0.3 ft. (0.1m)	E	Male and female plants flowering
	Rumex acetosella L.	Sheep sorrel	1	0.5 ft. (0.2m)	X	Flowering

Hypochaeris radicata L.	Hairy cat's ear	1	0.3 ft. (0.1m)	X	Flowering

Epiphytes The lichen genera *Pseudocyphellaria, Alectoria* and *Usnea* were common along with some crustose species. *Macromitrium intricatum* *Orthotrichum hawaiicum* are the most common mosses.

Locality: One hundred yards above Hosmer's Grove.

Description: Māmane-Pilo scrub on gently sloping, rock covered ground.

Date studied: 12 June 1975.

Total vegetation cover: 95 percent.

* E = Endemic, I = Indigenous, X = Exotic

this area. Apart from the overall problem of disturbance to the ecosystem, the disturbance could have a deleterious effect on the more aesthetic value of the area.

Some conifer seedlings are becoming established in the region and should be uprooted. They are exotic plants which have escaped from Hosmer's Grove, and, if not removed, they could form a coniferous forest. Though the establishment of such a forest is good land management it is not the typical Hawaiian ecosystem in such an area.

Study Area #3

Map reference: N 20° 45' 19"
W 156° 13' 51"

Location:

Area around the beginning of the Hale-mau'u Trail. See Fig. 3 (p. 8).

Elevation: 8,000 ft. (2,667 m)

Aspect: The area faces north and is exposed to the elements.

General Description:

Sloping, undulating topography with shallow (20 feet [6.6 m] deep) gullies whose sides slope no more than 40° except in the stream bed where they may have steep banks. The gully beds are smooth rock from erosion by water. Again the evidence suggests the gullies are subjected to occasional flash flooding. They do not have a constant stream of water. The area has an overall downhill slope of 20-30°.

Soil type:

Very stony land. Fifty to 90 percent of the surface is covered with stones and boulders (USDA Soil Survey 1972). The coarse soil is shallow and sparse, and rarely deeper than four inches. There is a thin layer of humus overlying the brown soil in protected areas. Though the general area is classified as very stony land, stones and boulders cover only 50-60 percent of the surface in the study area.

Surrounding area:

The area is surrounded on all sides by a vegetation similar to the study area except the road and trail head to the west. The area covered in the sampling was large and apparently internally consistent throughout. The possibility of human disturbance in an area so close to a trail and the road was considered. However, disturbance was discounted. First, the terrain in the gullies is difficult, and second, there was little evidence of rubbish or damage.

Climate:

The area is not normally immersed in cloud banks. The average annual rainfall is 40 inches. The majority of this rainfall comes from a few major storms.

Rationale for studying this area:

This area is approximately 1,000 ft. above Areas #1 & 2. The program sampled the NW outer slope of the mountain every thousand feet. In this way it was hoped to sample the major changes in the ecosystem as they vary with elevation and the associated environmental parameters.

Vegetation of Study Area #3

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Sophora chrysophylla* (Salisb.) Seem.	Māmane	10	6-7 ft. (2m)	E	Flowering
2	*Coprosma montana* Hbd.	Pilo	5	4-5 ft. (1-1.7m)	E	
	Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	30	4 ft. (1.3m)	E	
	Vaccinium reticulatum Sm.	'Ōhelo	30	4 ft. (1.3m)	E	
Ground	*Geranium cuneatum* Hook. var. *tridens* (Hbd.) Fosb.	Hina-hina	1	1-5 ft. (0.5m)	E	Flowering
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau	5	1 ft. (0.3m)	I	
	Holcus lanatus L.	Yorkshire fog	5	0.75 ft. (0.3m)	X	
Epiphytes	*Pseudocyphellaria* sp. and *Usnea* sp.					

Locality: Area around Halemau'u Trailhead.

Description: Māmane-Pūkiawe-'Ōhelo scrub community on gently sloping stony land.

Date studied: 13 June 1975.

Total vegetation cover: 85 percent.

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* E = Endemic, I = Indigenous, X = Exotic

Number of specimens collected:

Flowering plants	15
Ferns	4
Mosses and Liverworts	15
Lichens	20

General comments:

The area is similar to Study Area #2 with respect to the general appearance of the ecosystem and the species present. However, the vegetation is more homogenous. Evidence of pig damage is minimal. The shrubs are lower and never grow above 6 ft. (2 m) high. Boulders and stones are much more evident and there is less soil and humus.

Study Area #4

Map reference: N 20° 44' 22"
W 156° 14' 12"

Location:

Just to the north of the Kala-haku Lookout and to the edge of Leleiwi Pali. See Fig. 3 (p. 8).

Elevation: 9,320 ft. (3,107 m)

Aspect:

The area faces north and slopes downward in a northerly direction.

General description:

An area of large rock outcrops interspersed with areas, often very large, of coarse cinder. There is little evidence of gully formation. The area is quite steep (20-50° slope).

To the east lies a precipitous cliff, the Lele-iwi Pali. The remaining sides are bounded by the highway.

Soil type:

Very stony land. Fifty to 90 percent of the surface is covered with stones and boulders (USDA Soil Survey 1972). The coarse cinder soil is loose and shallow, though it is deep in places. There is no evidence of humus.

Surrounding area:

To the east and in part to the south lies Haleakala Crater. The north leads downslope to the first three areas described. To the west lies a large area of similar topography and vegetation.

Climate:

The area is subject to an average annual rainfall of 40 inches. Most of this rain comes from a few storms. Winds blowing up the Lele-iwi Pali come over the crater rim and directly over the area studied. However, the area is not normally immersed in clouds. There are only a few days in the year when the area is not subjected to direct sunlight. Thus the climate is harsh.

Number of specimens collected:

Flowering plants	12
Ferns	3
Mosses and Liverworts	8
Lichens	25

Rationale for studying this area:

This area is approximately 1,000 ft. above Study Area #3.

Vegetation of Study Area #4

There is only one stratum, a sparse ground layer:

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
Ground	*Styphelia tameiameiae* (Cham.) F.Muell.	Pūkiawe	5	1 ft. (0.3m)	E	
	Deschampsia australis Nees ex. Steud.		5	1 ft. (0.3m)	E	Definite signs of regular spacing of clumps.

Locality: Kala-haku Lookout.

Description: Very sparse *Styphelia* (Pukiawe) community on cinder between rocky outcrops.

Date studied: 13 June 1975.

Total vegetation cover: 5 percent.

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* E = Endemic, I = Indigenous, X = Exotic

The program sampled the NW outer slope of the mountain every thousand feet. In this way it was hoped to sample the major changes in the ecosystem as they vary with elevation and the associated environmental parameters.

General comments:

Several exotic plant species were present which we feel were brought in by visitors to this popular lookout. This conclusion is supported by the fact that the exotic species are especially prevalent in the areas around the lookout. Three weed species are particularly prevalent:

Erodium cicutarium (L.) L'Hér. ex Ait. (Heron's bill)

Medicago lupulina L. (Black medic, trefoil)

Plantago lanceolata L. (Narrow-leaved plantain)

There is no evidence of pigs in the area. However, several goats were seen and some of the shrubs show evidence of browsing.

It is uncertain whether or not a comparison between the vegetation inside and outside the Silversword Enclosure would be legitimate. However, a casual observation revealed a higher vegetation cover within the enclosure than without. Whether goat or human disturbance is responsible is not known. The area would be an ideal site for evaluating the response of the ecosystem to disturbance by people and by goats. It is probably true to say that the visitor carrying capacity of the Park should be determined in areas such as this where the ecosystem is so fragile.

Study Area #5

Map reference: N 20° 42' 58"
W 156° 15' 12"

Location:

Eastern and southeastern slope of White Hill at the summit of Haleakala. See Fig. 3 (p. 8).

Elevation: 10,000 ft. (3,333 m)

Aspect:

The area slopes eastward and down into the Haleakala Crater.

General description:

Predominantly rocky outcrops characterized by the white andesite blocks. There is no evidence of water erosion though the area has cinder only in pockets protected from the prevailing winds out of the crater. The area covers the easterly slope for about 300 ft. (100 m) downslope, and is bordered to the south by the Sliding Sands Trail.

Soil type:

Very stony land. Fifty to 90 percent of the surface is covered with stones and boulders (USDA Soil Survey 1972). The coarse cinder soil is loose and sparse being found predominately in prockets protected from the prevailing winds. There is no humus present.

Surrounding area:

To the south and west are extensive areas of cinder. To the north and east are areas of similar topography and vegetation as in the study area.

Climate:

The area receives an average annual rainfall of 40 inches. The area is not normally immersed in cloud. Same as Study Area #4.

Vegetation:

Total cover around one percent. One cannot describe strata in an area so depauperate. *Raillardia menziesii* Gray is the most common shrub. *Hypochaeris radicata* L. and *Tetramolopium humile* (Gray) Hbd. are the most common herbs. There are no epiphytes.

Number of specimens collected:

Flowering Plants	7
Ferns	3
Mosses and Liverworts	6
Lichens	9

Rationale for studying this area:

This area is approximately 1,000 ft. above Area #4. The program sampled the NW outer slope of the mountain every thousand feet. In this way it was hoped to sample the major changes in the ecosystem as they vary with elevation and the associated environmental parameters.

General comments:

A barren area which has been disturbed by humans and probably by goats. People have a habit of tucking rubbish in the crevices of rocks which is unfortunate because much of the vegetation is confined to these crevices. One endemic species, *Tetramolopium humile* (Gray) Hbd. is generally confined to the crevices.

Study Area #6

Map reference: N 20° 47' 21"
W 156° 14' 21"

Location:

Maka-wao Forest Reserve immediately below Pu'u-nianiau. See Fig. 3 (p. 8).

Elevation: 5,900 ft. (1,967 m)

Aspect: North facing.

General description:

The area consists of a reasonably even terrain with a gentle northerly slope from 15-30° and occasional steep-sided gullies. The area is heavily forested with a dense undergrowth.

Soil type:

Honomanū-Amalu association, (USDA Soil Survey 1972). However, it is felt that the soil in the area collected approximates the Amalu peaty silty clay particularly in the level,

undissected areas. The soil is spongy, frequently saturated with water but not sticky, yet it is peat-like due to the high humus content.

Surrounding area:

The area to south, upslope from the site, is pasture-land with occasional *Metrosideros* ('Ōhi'a) trees. All other sides are surrounded by an ecosystem similar to the study site.

Climate:

The area is frequently immersed in cloud. The average annual rainfall is 100-125 inches.

Rationale for studying this area:

Although this area is outside the National Park, it lies close to the Park and the Wai-ka-moi Stream but at a lower elevation (850 ft.) than Areas #1 and #2. Therefore the area is of considerable importance in making comparisons between the ecosystem in the lower elevations of the north and northwesterly region of the Park. It may act as a reservoir for species that could infect the Park area.

Number of specimens collected:

Flowering plants	21
Ferns	24
Mosses and Liverworts	50
Lichens	87

General comments:

This area has an extremely rich flora and fauna. Much of it, however, is not related to the vegetation in the northwestern region of the Park, due probably to considerable

differences between the areas in soil and climate. However, the survey of this area will provide a basis for comparison with the eastern region of the Park (e.g. Kī-pahulu Valley). There is no indication of pig damage in the area, an observation confirmed by the abundance of the fern, *Marrattia douglasii*, a favorite of pigs. In areas adjacent to the area studied there is evidence of pig damage (a few trails and wallows) but the damage is minimal.

This is the only area surveyed this past summer which is of a species-rich "rainforest" type, although it is at a rather high elevation. A find such as the moss, *Pilotrichella mauiensis*, is outstanding, as it has been collected only once or twice previously from Maui and only about 4 times from these islands. The richness of this undisturbed area is well illustrated by the abundance of taxa such as the moss, *Hookeria acutifolia*, which requires deeply shaded, undisturbed litter and weed-free mud banks.

The finding of epiphyllous bryophytes also was significant; this was the first time that epiphyllous mosses (on *Athyrium*) have been recorded in the Hawaiian Islands.

There were very few exotic plants found in this study area. Those that were seen were found in the disturbed bed of the intermittent stream and probably carried in from the pastureland above. The periphery of the forest reserve is badly disturbed probably by cattle which have broken down the fence in the area. There are numerous grass and other weedy herbs in glades formed under the canopy of the mature trees.

Vegetation of Study Area #6

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G.Forst.) Gray	'Ōhi'a-lehua	50-60	90 ft. (30m)	E	Some with dead tops
	Acacia koa Gray	Koa	10-20	90 ft. (30m)		
2	*Cheirodendron trigynum* (Gaud.) Heller	'Ōlapa	5	30 ft. (10m)	E	
	Myrsine lessertiana A.DC.	Kolea-lau-nui	10	25 ft. (8m)	E	
	Ilex anomala H. & A.	Kāwa'u	1	20 ft. (7m)	E	
	Pelea sp.	'Alani	1	15 ft. (5m)	E	No specimen collected. No flowers or fruit.
3	*Styphelia tameiameiae* (Cham.) F.Muell.	Pūkiawe	1	9 ft. (3m)	E	Very large shrubs growing in streambed.
	Coprosma montana Hbd.	Pilo	1	9 ft. (3m)	E	
4	*Athyrium microphyllum* (Sw.) Alston	'Akōlea	30	4-6 ft. (2m)	E	Two species not easily distinguished in the field so observations lumped.
	A. sandwichianum Presl.	Hō'i'o			E	

Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	30	4-6 ft. (2m)	I
Asplenium praemorsum Sw.	'Iwa'iwā-a-Kāne	20	4-6 ft. (2m)	E
Marattia douglasii (Presl.) Baker	Pala	10	4-6 ft. (2m)	E

Epiphytes There are many epiphytes in this area. A few specimens of the fern *Elaphoglossum hirtum*, mosses including *Pilotrichella mauiensis*, *Barbella trichophora* and *Homaliodendron fabellatum*, lichens particularly of the family Stictaceae are the dominant forms.

Location: Maka-wao Forest Reserve immediately below Pu'u-nianiau.

Description: Mixed *Metrosideros-Acacia* ('Ōhi'a-Koa) tropical rain forest.

Date studied: 15 June 1975.

Total vegetation cover: 100 percent.

* E = Endemic, I = Indigenous, X = Exotic

Study Area #7

Map reference: N 20° 11' 38"
W 156° 45' 12"

Location:

One quarter mile west of Waikau Cabin. See Figs. 2 and 4 (pp. 7 and 9).

Elevation: 6,200 ft. (3,067 m)

Aspect: The area faces north and down the Ko'olau Gap.

General description:

A pāhoehoe lava field with an overall gentle slope of not more than 10°. The terrain is undulating with numerous depressions, small caves, mounds and outcroppings.

Soil type:

The general area is very stony land, with 50 to 90 percent of the surface covered by stones and boulders (USDA Soil Survey 1972). Within the study area pāhoehoe lava rock covers ninety percent of the ground. Cinder ash has accumulated in the crevices to produce a thin coarse soil. However, many plants are established in cracks in the lava.

Surrounding area:

To the east the area is bordered by the eastern cliff of the Ko'olau Gap at the base of which is a grassland growing on alluvium deposited by a fairly large but ephemeral stream. To the north (up the Gap) is an a'a lava field which has less cover due to the drier climate in that area. Below (to the south) the vegetation increases with an occasional *Metrosideros* ('Ōhi'a) tree. To the west there is an ecosystem similar to

to the study area on both pāhoehoe and a'a lava flows.

Climate:

The area is frequently enveloped in cloud especially around midday but is usually cloud-free and hot. The temperature and humidity change very rapidly during the early morning and again at dusk due to the rapid heating and cooling of the black lava rock. The average annual rainfall is 50 inches a year.

Rationale for studying this area:

This area was chosen as being generally representative of the lava flow ecosystem in the Ko'olau Gap. We had intended to sample an area east of Hōlua Cabin on our return trip from Pali-kū to the Park HQ. However, that trip was later cancelled. The collection around Hōlua Cabin will be included in next year's survey.

Number of specimens collected:

Flowering Plants	11
Pteridosperms	9
Mosses and Liverworts	21
Lichens	16

General comments:

This area would be described by an ecologist as in the early stages of succession. Lichens, particularly *Stereocaulon vulcani* (Bory) Ach., are very common even on the otherwise bare lava rock. The activity of these organisms is responsible for a major portion of the degradation of the lava in soil formation. *Racomitrium lanuginosum*, also found

Vegetation of Study Area #7

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Styphelia tameiameiae* (Cham.) F. Muell.	Pūkiawe	10	2-3 ft. (1m)	E	
2	*Vaccinium reticulatum* Sm.	'Ōhelo	30	1 ft. (0.3m)	E	
Ground	*Stereocaulon vulcani* (Bory) Ach.		40	1 in. (2.5cm)	I	
	Racomitrium lanuginosum		5	1 in. (2.5cm)	I	Particularly on tradewind side of rock.

Location: One quarter mile west of Waikau Cabin.

Description: Open *Styphelia* (Pūkiawe) scrub on pāhoehoe.

Date studied: 16 June 1975.

Total vegetation cover: 40 percent.

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* E = Endemic, I = Indigenous, X = Exotic

in large quantities in protected sites, will contribute a large quantity of humus to the developing soil. Another very common species in the area is *Cladonia* (subgenus *Cladina*) *leiodeia* H. Magn. which occurs in the larger, protected areas in the lava flow.

The vegetation along the Waikau Trail is not homogenous. The percent cover of flowering plants is higher on the Hale-mau'u side when compared with Waikau. Also, *Geranium multiflorum*, *Raillardia* sp. and *Holcus lanatus* (Yorkshire fog) are found toward the Hale-mau'u side only. The abundance of an unknown species of *Stereocaulon* also increases toward the Hale-mau'u side of the gap, while *Stereocaulon vulcani* and *Cladonia leiodeia* increase toward the Waikau side of the gap. There is little evidence of any damage by animals in the area. The probable source of the few exotics in the area, e.g. *Holcus lanatus* L. (Yorkshire fog) and *Oenothera laciniata* Hill (Evening primrose), is the pack horses which occasionally use the Trail. There are occasional goat droppings but there is no obvious browsing damage. However, the area and its adjacent regions is reputedly a stronghold for goats. *Racomitrium* is very common on the N (tradewind) side of rock mounds, etc. It is the only common bryophyte. However, a number of "rainforest" elements, probably wind blown up the gap, are established in very sheltered cracks and niches: *Thuidium, Herberta, Macromitrium, Frullania.*

Waikau Cliffs Checklist

While at Waikau we made a checklist of the following plants and ferns growing on the face of the cliff just south of the cabin at 6,600 ft. (2,200 m). The vegetation formed three distinct zones.

At the base:

Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	I*
Fragaria chiloensis (L.) Duch.	'Ōhelo-papa	E
Pteridium aquilinum (L.) Kunth. var. *decompositum* (Gaud.) Tryon	Bracken fern	E
Rubus hawaiiensis Gray	'Ākala, 'ākalakala	E
Vaccinium reticulatum Sm.	'Ōhelo	E

On the scree slopes:

Coprosma ernodeoides Gray var. *mauiensis* St. John	Kūkae-nēnē	E
Lythrum maritimum HBK.	Pūkāmole	X
Deschampsia australis f. *haleakalaensis* (Skottsb.) Skottsb.	---	E
Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	I
Elaphoglossum hirtum var. *micans* (Mett.) C.Chr.	'Ēkaha	E
Holcus lanatus L.	Yorkshire fog	X
Hypochaeris radicata L.	Gosmore	X
Styphelia tameiameiae (Cham.) F. Muell.	Pūkiawe	E
Vaccinium reticulatum Sm.	'Ōhelo	E

On the cliff face:

Coprosma ernodeoides Gray var. *mauiensis* St. John	Kūkae-nēnē	E
Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	I
Elaphoglossum hirtum var. *micans* (Mett.) C.Chr.	'Ēkaha	E
Hypochaeris radicata L.	Gosmore	X

* E=Endemic, I=Indigenous, X=Exotic

Lobelia grayana E. Wimm.	'Ōpelu	E*
Luzula hawaiiensis Buch.	---	E
Lysimachia cf. *remyi* Hbd.	Kolokolo kuahiwi	E
Metrosideros collina (J. R. & A. Forst.) Gray	'Ōhi'a-lehua	E
Polypodium pellucidum Kaulf.	'Ae	E
Pteris excelsa Gaud.	Waimaka-nui	I
Raillardia menziesii Gray	Na'ena'e	E
Sadleria cyatheoides Kaulf.	Ama'u	E
Sophora chrysophylla (Salisb.) Seem.	Māmane	E
Styphelia tameiameiae (Cham.) F. Muell.	Pūkiawe	E
Vaccinium reticulatum Sm.	'Ōhelo	E

An additional checklist of plants on the cliff face one half mile south of Waikau Cabin at an elevation of 6,670 ft. (2,223 m) was also made.

<u>At the cliff base on tallus slope</u>:

Dactylis glomerata L.	Cocksfoot, Orchard grass	X
Deschampsia australis f. *haleakalaensis* (Skottsb.) Skottsb.	---	E
Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	I
Fragaria chiloensis (L.) Duch.	'Ōhelo-papa	E
Holcus lanatus L.	Yorkshire fog	X
Hypochaeris radicata L.	Gosmore	X
Youngia japonica (L.) DC.	Oriental hawksbeard	X
Lysimachia cf. *remyi* Hbd.	Kolokolo kuahiwi	E
Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau	I
Rumex acatosella L.	Sheep sorrel	X
Styphelia tameiameiae (Cham.) F. Muell.	Pūkiawe	E
Vaccinium reticulatum Sm.	'Ōhelo	E

* E=Endemic, I=Indigenous, X=Exotic

On the cliff face:

Anthoxanthum odoratum L.	Sweet vernal grass	X*
Artemisia mauiensis (Gray) Skottsb.	Maui wormwood	E
Elaphoglossum hirtum var. *micans* (Mett.) C.Chr.	'Ēkaha	E
Hypochaeris radicata L.	Gosmore	X
Metrosideros collina (J. R. & G. Forst.) Gray	'Ōhi'a-lehua	E
Polypodium pellucidum Kaulf.	'Ae	E
Pteris cretica L.	'Ōwali	I
Sadleria cyatheioides Kaulf.	'Ama'u	E
Sophora chrysophylla (Salisb.) Seem	Māmane	E
Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	E

* E=Endemic, I=Indigenous, X=Exotic

Study Area #8

Map reference: N 20° 46' 08"
W 156° 43' 03"

Location:

Upper Ko'olau Gap--area at base of cliff east of Hosmer's Grove, locally known as Āina-hou. See Figs. 2 and 4 (pp. 7,9). The area is at the end of the horse trail that descends along the western side of the Ko'olau Gap beginning soon after the Waikau Trail leaves the Hale-mau'u Trail.

Elevation: 5,560 ft. (1,853 m)

Aspect: Northfacing but sheltered by the cliff to the south and west of the area.

General description:

A mesic *Metrosideros* ('Ōhi'a) forest along the western edge of the Ko'olau Gap. The study area is relatively flat and is crossed by a two-to four-foot-deep, steep-banked intermittent stream.

Soil type:

Hydrandepts-Tropaquods Association. Well-drained to poorly drained soils on uplands (USDA Soil Survey 1972). The soil in the area studied was predominantly tropaquod-type though close to the stream bed the area was well drained. The area at the base of the cliff was scree rubble covered by shrub vegetation.

Surrounding area:

The area is bordered to the north and east by an ecosystem similar to the study area. To the south and west there are

cliffs. The westerly cliff is high and precipitous which lies an area which is close to the first two areas studied. The southerly cliff has a more gentle slope leading up to the Haleakala Crater. The slope is characterized by a *Metrosideros* ('Ōhi'a) forest which gets shorter and thinner with increasing elevation.

Climate:

This area is frequently covered by but not necessarily immersed in trade-wind-blown clouds billowing up the Ko'olau Gap. There is little evidence of cloud forest vegetation. The rainfall averages about 75 inches per year. The particular topography of the area probably accounts for the clouds passing over the area.

Rationale for studying this area:

'Āina-hou lies immediately outside the Park in the Ko'olau Gap. It is an area containing much alluvium from lava flows higher up the Gap within the Park. The general region supports a climax mesic *Metrosideros* ('Ōhi'a) forest. As such the area could represent the climax community for the lava flows higher up as they undergo succession. A study of this area will be helpful in evaluating the adjacent regions of the Park.

Number of specimens collected:

Flowering plants	15
Ferns	12
Mosses and Liverworts	45
Lichens	36

Vegetation of Study Area #8

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G.Forst.) Gray	'Ōhi'a-lehua	40	40 ft. (13m)	E	Some flower flowering.
2	*Cheirodendron trigynum* (Gaud.) Heller	'Ōlapa	10	20 ft. (7m)	E	
	Ilex anomala H. & A.	Kāwa'u	1	20 ft. (7m)	E	
3	*Perrotetia sandwichensis* Gray	Wai-mea	5	12 ft. (4m)	E	Flowering
	Rubus hawaiiensis Gray	'Ākala	5	10 ft. (3m)	E	In fruit
	Coprosma montana Hbd.	Pilo	1	10 ft. (3m)	E	
	Broussaisia arguta Gaud.	Kanawao	1	10 ft. (3m)	E	Flowering
	Vaccinium dentatum Sm. var. *dentatum*	'Ōhelo	1	10 ft. (3m)	E	
4	*Dryopteris carvifolia* (Kuntz.) C.Chr.		75	3 ft. (1m)		
	Sadleria cyatheoides Kaulf.	'Ama'u	1	4 ft. (1.3m)	E	
	Pteris cretica L.	'Ōwali	15	5 ft. (1.6m)	I	

Athyrium microphyllum (Sw.) Alston	'Akōlea	1	5 ft. (1.6m)	E	Two species difficult to
Athyrium sandwichianum (Presl.)	Hō'i'o			E	distinguish in the field.
Polystichum haleakalense Brack.	Ka'upu	1	4 ft. (1.3m)	E	

Epiphytes Though many of the trees have both lichen and moss epiphytes on them, there are no species which predominate. *Homaliodendron flabellatum* is a very common moss. Lichen genera which are frequent are *Stricta, Menegazzia* and some as yet unidentified species.

Location: Western side of Ko'olau Gap at 5,560 ft.

Description: 'Ōhi'a forest with open areas of fern or grassland.

Date studied: 17 June 1975.

Total vegetation cover: 100 percent.

* E = Endemic, I = Indigenous, X = Exotic

General comments:

The area is well known as an accessible site for *Hillebrandia hawaiiensis* Oliver (Pua-maka-nui). It was in this area that the second known collection of the endemic moss *Thamnobryum speciosum* was made. These two items attest to the interest that Ainahou engenders for botanists. It should be noted, however, that *T. speciosum* is common at Pali-kū also.

Unfortunately, the area is badly disturbed by pigs. There is much evidence of uprooting and large areas have been converted to grassland. There is no evidence of goats in the area.

Besides the *Thamnobryum*, considerable quantities of the moss, *Daltonia* (Fam. Hookeriaceae), are present in very sheltered localities. Members of this genus, at least locally, are restricted to protected upper-elevation rain-forest-type areas. Disturbance in the area is attested to by presence of *Funaria subintegra* and *Pogonatrum tahitense*, which were absent from Area #6; (although much shaded mud was there, it was covered by taxa as *Hookeria, Plagiothecium, Fissidens*, etc.).

Study Area #9

Map reference: N 20° 45' 20"
W 156° 43' 01"

Location: Base of Hale-mau'u Trail. See Figs. 2 and 4 (pp. 7,9).

Elevation: 6,700 ft. (2,233 m)

Aspect:

Protected on north and west by Lele-iwi Pali and to the south and east it faces into the Ko'olau Gap.

General description:

A flat grassland area with scattered low (less than 1-2 m) lava outcrops.

Soil type:

Though the general area is described as very rocky the soil in this area is a fine alluvium carried down from the surrounding Lele-iwi Cliffs. The soil has a definite profile with a dark brown upper layer covered by a thin layer of humus.

Surrounding area:

To the north and west lie the Hale-mau'u Trail and Lele-iwi Pali. The lava fields of the Ko'olau Gap to the south and east border the area on the eastern side of the Hale-mau'u-Hōlua Trail. All the surrounding areas except some lower portions of the Lele-iwi Pali are covered by scrub vegetation. The area is therefore an isolated pocket of grassland.

Climate:

The area is frequently immersed in cloud particularly during the late morning and most of the afternoon. Since the area is leeward of the prevailing winds it is doubtful that much rain interception occurs in the area. The average annual rainfall is 50 inches, with much of it coming from a few storms.

Rationale for studying this area:

The collecting site is on alluvial soil at the base of the cliff on the western side of the Ko'olau Gap. The Hale-mau'u

Vegetation of Study Area #9

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
Grassland:						
Ground	*Anthoxanthum odoratum* L.	Sweet vernal grass	50	1 ft. (0.3m)	X	Flowering.
	Dactylis glomerata L.	Cocksfoot	35	3 ft. (1m)	X	Flowering.
	Holcus lanatus L.	Yorkshire fog	15	1 ft. (0.3m)	X	Flowering.
Rocky outcrops:						
1	*Vaccinium reticulatum* Sm.	'Ōhelo	15	4 ft. (1.3m)	E	Flowering.
	Styphelia tameiameiae (Cham.) F. Muell.	Pūkiawe	30	5 ft. (1.7m)	E	
Ground	*Coprosma montana* Hbd.	Pilo	1	6 in. (0.1m)	E	
	Holcus lanatus L.	Yorkshire fog	1	1 ft. (0.3m)	X	
Epiphytes	*Pseudocyphellaria* and *Macromitrium* but very infrequent.					

Location:	Hale-mau'u Trail at base of Lele-iwi Pali.
Description:	Cocksfoot grassland with occasional rocky outcrops.
Date studied:	18 June 1975.
Total vegetation cover:	95 percent in grassland; 45 percent on rocky outcrops.

* E = Endemic, I = Indigenous, X = Exotic

Trail also runs through the area. This site will be compared with similar sites at the eastern side of the Ko'olau Gap close to Waikau Cabin, the Pali-kū grasslands, and grasslands found in the center of 'Ō'ili-pu'u and Ka-lua-nui. The areas will be compared in terms of the differences in disturbance and edaphic factors prevalent.

Number of specimens collected:

Flowering Plants	10
Ferns	2
Mosses and Liverworts	22
Lichens	9

General comments:

The area is disturbed with numerous tracks criss-crossing the area. The origin of the tracks is not known since they could be the result of pigs and/or goats and/or straying hikers. However, there is no evidence of uprooting by pigs or heavy grazing by goats. All the tussocks are well-formed and the fertile stalks are complete. Pigs inhabit the area during the wetter months of the year. Goats have been observed occasionally in the area in the past.

Few mosses are found besides the usual high elevation xeric taxa such as *Grimmia, Racomitrium* and *Ceratodon,* which are on exposed rock or soil. However, *Leucobryum* which was collected in the area is a tropical rainforest moss. The spores were probably blown in from lower down the Ko'olau Gap and became established in very protected niches. Where there is any depth of soil there is little vegetation other than grass.

Study Area #10

Map reference: N 20° 45' 21"
W 156° 12' 57"

Location:

The southerly aspect of the lower 500 ft. of the Hale-mau'u Trail. See Figs. 2 and 4 (pp. 7,9).

Elevation: 6,700-7,200 ft. (2,233-2,400 m)

Aspect:

The cliff faces south. It is protected by a ridge from the prevailing winds blowing up the Ko'olau Gap.

General description:

A steep cliff of about 70° with small areas of 100° slope and other more prevalent areas with a slope of not less than 60°. The area drains into a flat grassland at the base of the cliff described in Study Area #9.

Soil type:

Rock outcrops, where the bed rock is at the surface in about 90% (USDA Soil Survey 1972) of the area. The flatter areas have a loose scree "soil" much of which is held in position by the vegetation.

Surrounding area:

At the base of the cliff and to the south lies the grassland described in Study Area #9. To the west the area is of a similar nature to the area under description. Above (to the north and over the ridge) and on the right (to the east) the area grades into a north-facing area with a distinctly lusher vegetation described as Study Area #11.

Vegetation of Study Area #10

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Sadleria cyatheoides* Kaulf	'Ama'u	20	3 ft. (1m)	E	
	Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	20	3 ft. (1m)	E	
Ground	*Vaccinium reticulatum* Sm.	'Ōhelo	20	2 ft. (0.6m)	E	
	Coprosma montana Hbd.	Kūkae-nēnē	15	6 in. (0.15m)	E	In fruit.
	Deschampsia australis Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		5	1 ft. (0.3m)	E	
	Stereocaulon		1	3 in. (0.07m)	I	
Epiphytes	Not common.					

Location:	The lower, south-facing cliff of Lele-iwi Pali, traversed by the Hale-mau'u Trail.
Description:	Open, mixed 'Ōhelo, Pūkiawe, 'Ama'u scrub.
Date studied:	18 June 1975.
Total vegetation cover:	60 percent.

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* E = Endemic, I = Indigenous, X = Exotic

Climate:

The area is often immersed in cloud during the daytime but since it is to the lee of the prevailing wind it is doubtful if there is much rain interception by the vegetation. The average annual rainfall is 50 inches much of which comes during a few major storms.

Rationale for studying this area:

This site and the next are convenient sample sites of the Lele-iwi Cliffs in the Gap because the Hale-mau'u Trail traverses the region. The cliffs are between the outer slope sampled in Study Areas #1, 2 and 3 and the Ko'olau Gap sampled in Areas #7, 9 and 12. The cliffs can also be compared with some observations made on the cliffs above Waikau.

Number of specimens collected:

Flowering plants	12	
Ferns	4	
Mosses and Liverworts	3	(but 7 total seen)
Lichens	13	

General comments:

Due to its steep slope, the area is very difficult to traverse except along the trail. There is no evidence of damage by pigs, but goats are known to infest the region. There are occasional signs of disturbance by people and horses along the trail but the damage is confined to a small and relatively insignificant area of the trailside. The weeds *Hypochaeris radicata* L. (Gosmore) and *Oenothera*

(Evening Primrose) occur along the trailside. They are obviously associated with the trailside disturbed areas and were introduced by horses and hikers.

Artemisia mauiensis (Gray) Skottsb. (Maui wormwood) occurs on some nearby steep sheer cliff in cracks in the rock face. They are protected from goats and man by the inaccessibility of the cliff face.

All bryophytes are rock and soil forms which are normally found at high elevations. The most outstanding discovery in this area was the presence of *Polytrichum*. On Maui this species is known only from the Kau-pō Gap. Since it is confined to trailside localities, it almost certainly was introduced and transported by horses or man.

Study Area #11

Map reference: N 20° 45' 19"
W 156° 12' 53"

Location:

The northern aspect of the lower slopes of the Hale-mau'u Trail. See Figs. 2 and 4 (pp. 7,9).

Elevation: 6,900-7,200 ft. (2,300-2,400 m)

Aspect:

The cliff faces north and is continuously exposed to the prevailing winds blowing up the Ko'olau Gap.

General description:

A very steep cliff with a general slope of approximately 80°. There are large areas which are almost sheer (90°) but many

of these are covered with vegetation. It is only where the area approaches a ridge that the slope becomes less steep (about 50°).

Soil type:

Rock outcrops. A region where the bedrock is at the surface in about 90% of the area (USDA Soil Survey 1972). The soil is very thin and is only held in place by the thick vegetation. There is a substantial humus layer which is held in place by the vegetation.

Surrounding area:

Downslope to the north and on the west is an area of a similar nature to the area described. At the base of the cliff (6,560 ft. [2,187 m]) lies the upper Ko'olau Forest Reserve at ʻĀina-hou (Study Area #8). To the south and over the ridge as well as to the east the area grades into the drier south-facing cliffs described in Area #10.

Climate:

The study area is frequently immersed in cloud. Since it is directly exposed to the prevailing trade wind there is considerable fog interception. The annual average rainfall is 50 inches but this figure does not include fog interception.

Rationale for studying this area:

See comments on Study Area #10 (p. 38).

Number of specimens collected:

Flowering plants	2*
Ferns	1
Mosses and Liverworts	18
Lichens	12

*Very few specimens were collected since they were a repetition of the previous area.

General comments:

This area when compared with Study Area #10 has a higher vegetation cover even though the slope is much steeper. This phenomenon is probably the result of the high frequency of fog interception. In fact, a day without cloud being driven onto this cliff during the day is unusual.

Pigs are known to enter the area occasionally. However, it is unlikely that they will do much damage because the area is so steep. There is no evidence of goats in the area and we are not sure why they are absent.

The higher total of specimens seen reflects a greater diversity as well as a greater biomass of species. The trailside flora is different from the surrounding area, with the weeds *Sporobolus indicus* (L.) R.Br. (West Indian dropseed), *Anthoxanthum odoratum* L. (Sweet vernal grass), *Holcus lanatus* L. (Yorkshire fog), and *Hypochaeris radicata* L. (Hairy cat's ear) predominant. The weeds are introduced and maintained by the constant disturbance and the apparently slow rate of recovery of the native vegetation.

Vegetation of Study Area #11

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Styphelia tameiameiae* (Cham.) F.Muell.	Pūkiawe	20	4 ft. (1.2m)	E	
2	*Vaccinium berberifolium* (Gray) Skottsb.	'Ōhelo	30	2 ft. (0.6m)	E	
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	30	2 ft. (0.6m)	I	
	Sadleria cyatheioides Kaulf.	'Ama'u	10	2 ft. (0.6m)	E	
Ground	*Anthoxanthum odoratum* L.	Sweet vernal grass	5	6 in. (0.15m)	X	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
Epiphytes	*Pseudocyphellaria*, *Usnea* and *Parmelia* are common on the lower protected branches of *Styphelia* and *Vaccinium*. A *Macromitrium* sp. was present.					

Location:	Hale-mau'u Trail, north-facing slopes of Lele-iwi Pali.
Description:	Closed Pūkiawe-'Ōhelo-Kīlau scrub.
Date studied:	18 June 1975.
Total vegetation cover:	95 percent.

* E = Endemic, I = Indigenous, X = Exotic

Study Area #12

Map reference: N 20° 45' 08"
W 156° 11' 30"

Location:

Grassland on east side of stream about one-eighth of a mile south of Waikau Cabin.

Elevation: 6,650 ft. (2,217 m)

Aspect:

The area is protected from the prevailing weather blowing up the Ko'olau Gap by its proximity to the Waikau Cliffs.

General description:

A flat grassland area with a very gentle slope (not more than 10°).

Soil type:

Very stony land. Fifty to 90% of the surface is covered with stones and boulders (USDA Soil Survey 1972). Though the surrounding area fits the soil type description well there is a 50-meter wide area of alluvial deposit that runs alongside the Waikau Cliff. The ecosystem described is on this alluvial soil. There is an indication of stratification in the soil which is covered by a thin but distinct layer of humus.

Surrounding area:

To the north (upslope) and south (downslope) lies a similar type of ecosystem which is dominated by *Holcus lanatus* L. (Yorkshire fog). To the east are the cliffs of the Waikau side of the Ko'olau Gap and to the west the pāhoehoe lava

flows described in Study Area #8. To the south and upslope is a heterogenous area of grassland and outcrops of lava covered with a scrub vegetation.

Climate:

The area is frequently immersed in cloud particularly during the late morning and most of the afternoon. However, there is little fog interception because the area is protected from the prevailing wind by the cliffs. The average annual rainfall is 50 inches. Much of the rain comes from a few storms in the region.

Rationale for studying this area:

This grassland in a protected area is for comparison with Study Area #9. The differences in the vegetation in the two areas may be attributable to differences in climate or soil-type, or it may reflect the degree of disturbance.

Number of specimens collected:

Flowering plants	3
Ferns	1
Mosses and Liverworts	9
Lichens	7

General comments:

This isolated patch of *Deschampsia* grassland is interesting for several reasons. It probably represents the pristine grassland successional stage on this type of substratum. Its low elevation as compared with the normal altitude for such ecosystems today is remarkable particularly in such a disturbed area. Finally, it is very interesting to

Vegetation of Study Area #12

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
Ground	*Deschampsia australis* Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		90	2 ft. (0.6m)	E	
	Holcus lanatus L.	Yorkshire fog	10	1 ft. (0.3m)	X	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
	Rumex acetosella L.	Sheep sorrel	1	6 in. (0.15m)	X	
Epiphytes	None					

Location: Waikau Cabin

Description: *Deschampsia* grassland

Date studied: 18 June 1975

Total vegetation cover: 95 percent

* E = Endemic, I = Indigenous, X = Exotic

note that this grassland has withstood the invasion of the general area by *Holcus lanatus* L. (Yorkshire fog). This latter fact may indicate that *Deschampsia australis* Nees ex. Stend. is capable of withstanding the dislodgement by *H. lanatus* when grazing and trampling are absent or low. This observation does not necessarily suggest that *Deschampsia* will be able to replace *H. lanatus* if grazing and trampling are minimized or stopped completely.

The paucity of bryophytes and lichens is due to nearly complete cover by tussock grasses; the few that were seen were scattered principally between the bunches and in the few open areas.

Study Area #13

Map reference: N 20° 43' 50"
W 156° 08' 38"

Location:

Area behind the Ranger's Cabin at Pali-kū and along both sides of the stream. See Figs. 2 and 5 (pp. 7,10).

Elevation: 6,400 ft. (2,133 m)

Aspect: The area faces directly south down the Kau-pō Gap.

General description:

An area covered by a heterogenous open woodland with a dense scrub beneath. A stream with deeply eroded banks passes through the area. The surrounding land has a slope of approximately 30-40° which becomes steeper, up to 70°, closer to the Pali-kū Cliffs behind.

Soil type:

Cinderland (USDA Soil Survey 1972). The soil is deep with an indication of stratification. There is a substantial layer of humus on top of the soil.

Surrounding area:

Below (to the south) lie grassland meadows some of which are enclosed. To the north and east are the cliffs of Pali-kū. To the west is a transition zone giving way to a *Styphelia-Vaccinium* grassland on old lava flows.

Climate:

The area is subjected to a very variable climatic regime. The rainfall is 40 inches (1016 mm) per year according to Tagliaferro (1959). This figure is almost certainly on the low side. Rangers familiar with the area indicate that the average is probably double that figure. Yocum (1967) cites figures of 150-200 inches. Again the majority of this rain comes from several major storms.

Rationale for studying this area:

This area is either a degenerate form of the cliff vegetation or a transition zone between the cliff and crater floor vegetation. However, the area falls within the transect following the eastern cliff of the Kau-pō Gap up to the top of the Kalapawili Ridge.

Number of specimens collected:

Flowering plants	6
Ferns	6
Mosses and Liverworts	39
Lichens	109

Vegetation of Study Area #13

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G. Forst.) Gray	'Ōhi'a-lehua	20	30 ft. (10m)	E	
	Myrsine lessertiana A.DC.	Kōlea-lau-nui	5	30 ft. (10m)	E	
	Sophora chrysophylla (Salisb.) Seem	Māmane	5	20 ft. (6m)	E	
	Dodonaea viscosa Jacq.	A'ali'i	5	20 ft. (6m)	E	
	Coprosma montana Hbd.	Pilo	1	20 ft. (6m)	E	
2	*Rubus hawaiiensis* Gray	'Ākala	30	4 ft. (1.2m)	E	
	Sadleria cyatheoides Kaulf.	'Ama'u	20	3 ft. (1m)	E	
	Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	10	3 ft. (1m)	I	
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	10	3 ft. (1m)	I	
Ground	*Holcus lanatus* L.	Yorkshire fog	20	1 ft. (0.3m)	X	
	Prunella vulgaris L.	Self-heal	5	1 ft. (0.3m)	X	

Epiphytes Lichens: *Pseudocyphellaria, Usnea,* Collemaceae and Stictaceae.

Mosses: Meteoriaceae, *Daltonia, Frullania, Holomitrium.*

Location: Behind Pali-kū Cabin.

Description: Disturbed 'Ōhi'a forest grading into dryland forest.

Date studied: 19 June 1975.

Total vegetation cover: 100 percent.

* E = Endemic, I = Indigenous, X = Exotic

General comments:

This area is unusual. The vegetation shows all the signs of release from a heavy grazing pressure; mature and dying trees with no regeneration and a dense undergrowth of *Rubus*, an aggressive endemic colonizer of disturbed areas. Yet, within this general area there occur many rare and interesting species of insects. If herbivores continue to be excluded from the area the ecosystem should revert to its original form.

The stream area is very rich in bryophytes and lichens due to the high humidity and protected nature of the site. Cover is nearly complete except on stream bottom; bryophytes are abundant on rocks, (esp. *Brachythecium*) mud and rocky banks (many thalloids, *Fissidens*), *Thamnobryum* on rocks under the foot bridge. Trees support many as yet unidentified Orthotrichaceous-Pottiaceous taxa while *Daltonia* is found on *Rubus* twigs. The area behind the cabin toward the cliff is considerably drier with drought-tolerant forms as *Dicranum speirophyllum* var. *breviflagellare*. Only six bryophytes were collected here. The number of lichen species collected seems to be the same in both areas illustrating their higher tolerance to dessication.

Study Area #14

Map reference: N 20° 43' 11"
W 156° 08' 25"

Location:

The gully along the trail between Pali-kū and Kuiki passes. See Figs. 2 and 5 (pp. 7, 10).

Elevation: 6,400 ft. (2,133 m)

Aspect:

The gully faces west in Haleakala Crater across the grassland at Pali-kū.

General description:

A quickly narrowing gully reaching from the grassland at the base of the cliff to the ridge top. The gully is heavily forested but because of the steep slope (from 50-90°) there are occasional areas of exposed rock.

Soil type:

Rock outcrop. Bedrock covering 90% of the surface (USDA Soil Survey 1972). However, because of the high rainfall and lush vegetation in the area there are local pockets of scree and washed-down soil which has a high humus content.

Surrounding area:

Below the gully lies a grassland meadow close to the Pali-kū Ranger's Cabin. On either side of the gully are areas of cliff similar to the study area separated from the gully by rocky outcrops. The Kī-pahulu side of the ridge is covered with a dense scrub *Metrosideros* community.

Vegetation of Study Area #14

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G.Forst.) Gray	'Ōhi'a-lehua	40	20 ft. (7m)	E	Predominantly on cliff face and ridges
2	*Pteridium aquilinum* (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	5	3 ft. (1m)	I	In isolated pockets
	Sadleria cyatheoides Kaulf.	'Ama'u	30	3 ft. (1m)	E	
	Vaccinium berberifolium (Gray) Skottsb.	'Ōhelo	40	3 ft. (1m)	E	
	Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	1	3 ft. (1m)	E	
	Coprosma montana Hbd.	Pilo	1	3 ft. (1m)	E	
Ground	*Deschampsia australis* Nees ex. Steud. f. *haleakalaensis* Skottsb.		10	1 ft. (0.3m)	E	

Epiphytes *Parmelia, Anaptychia,* and *Pseudocyphellaria* are abundant. There are deep gullies in which one finds the following: *Broussaisia, Pelea, Myrsine, Smilax,* and *Ilex anomala.* Scattered along the cliffs are occasional isolated trees of *Cheirodendron trigynum* (Ōlapa). At the base of the cliff is a large scree area where an almost impenetrable thicket of *Rubus hawaiiensis* (Ākala) is found.

Location:	Gully en route from Pali-kū to Kuiki.
Description:	'Ōhi'a forest.
Date studied:	21 June 1975.
Total vegetation cover:	90 percent.

* E = Endemic, I = Indigenous, X = Exotic

Climate:

Annual rainfall approximately 40 inches (1016 mm) per year. The weather in this area is extremely variable. Strong winds and heavy rainstorms are common. Clouds from Kī-pahulu Valley frequently spill over the ridge into the gully. Yocum (1967) cites figures of 150-200 inches of rain each year. Much of the rain comes in heavy storms.

Rationale for studying this area:

The cliffs at Pali-kū were one of the sites identified for study by the Haleakala National Park Administration. The area has been protected from human and probably goat disturbance for a long time. The area is probably a refugium and is representative of the previous general vegetation at the base of the cliff.

Number of specimens collected:

Flowering plants	20
Ferns	21
Mosses and Liverworts	26
Lichens	52

General comments:

The area has a rich flora but most of it is hidden in deep steep-walled gullies covered by *Metrosideros*. Within these gullies many species were found in surprising abundance. The general flora of the cliff face is not very different from other forested areas at around 6,000 feet (2,000 m). The cliffs at Pali-kū are in a wetter region as evidenced by the abundant epiphytes but the dominance of lichen epiphytes shows

that the region is subjected to extensive periods of drought.

There is little evidence of pig or goat damage in the area although the trail up to the ridgetop is supposedly an old goat trail. There is heavy soil erosion in some areas, probably due not to animal damage, but to the low sheer strength of this friable soil on steep slopes. In contrast to the area behind Pali-kū Cabin the vegetation in this area appears to be stable and maintaining itself. Young trees and seedlings are evident and the vegetation is strong and vigorous.

In the grassland below there is a potential threat to the whole area as a recreation facility. *Rubus penetrans* (Blackberry) is established near the base of the cliffs and if not eradicated soon the area will lose its camping and recreational value. (See our recommendations section for potential solutions to the problem. It should be noted that *R. penetrans* is well established in Wai-ho'i Valley and the Hāna Rain Forest Reserve and the control program at Pali-kū will require continuous updating.)

Along with the Makawao Forest Reserve and Pali-kū stream-bed, this area is one of the three best areas for bryophytes investigated this summer. Together with collections made on June 25, 1975, a total of 65 collections were made. The impression is of lushness. Many "rare" taxa (e.g. *Thamnobryum, Glossadelphus chrysobasilaris, G. irroratus, Ulota cervina*) are abundant. The area is relatively undisturbed and is a good example of a high elevation rainforest

type of bryophyte. Some items are:

G. chrysobasilaris	*Soiaromium tricostatum*
Trachypodopsis auriculata	*Dicranodontium* sp.
Dicranum speirophyllum	*Glossadelphus irroratus*
Zygodon reinwardtii	*Daltonia* sp.
Thuidium plicatum	*Syrrhopodon hawaiicus*

All are examples of upper elevation rainforest taxa.

Study Area #15

Map reference: N 20° 42' 06"
W 156° 08' 32"

Location: Base of eastern cliff of Kau-pō Gap. See Figs. 2 and 5 (pp. 7, 10).

Elevation: 5,000 ft. (1,667 m).

Aspect:

The area faces south down the Kau-pō Gap and is protected on the eastern side by the Kau-pō Gap cliffs.

General description:

An open parkland along both sides of a deep gully with steep (60°-90° slope) banks.

Soil type:

Very stony land. Fifty to 90% of the ground covered with stones and boulders (USDA Soil Survey 1972). Though this description is applicable in certain areas of the study site, other areas are too steep to retain any but the largest stones and boulders. Those areas lacking stones are covered by a grass-covered soil. Trampling by goats has cut into this

soil quite severely and erosion is a problem of some consequence.

Surrounding area:

On all but the eastern flank this area is surrounded by a *Dodon Vaccinium-Myrsine* community on old lava flows. The eastern flank is a grassland covering the eastern wall of the Kau-pō Gap.

Climate: The average annual rainfall is approximately 40 in.

Rationale for studying this area:

This is a very accessible part of the Kau-pō Gap. It is also the highest point at which koa grows in the Gap. This is the lowest segment of the Kau-pō Gap-Kalapawili Ridge transect studied.

Number of specimens collected:

Flowering plants	8
Ferns	5
Mosses and Liverworts	22
Lichens	34

General comments:

The area studied is a small pocket of koa parkland forest, probably a remnant of a former extensive koa forest on the eastern cliffs of the Kau-pō Gap. Unfortunately, there is no sign of any regeneration even by suckers from roots. Also all branches within one meter of the ground are stripped of their foliage. All these are signs of heavy browsing by goats. The cliffs above the area are rarely silent. The almost continuous bleating of kids attests to a very large

Vegetation of Study Area #15

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Acacia koa* Gray	Koa	15	40 ft. (13m)	E	No regeneration due to goat browsing.
2	*Dodonaea sandwicensis* Sherff.	A'ali'i	10	15 ft. (5m)	E	
	Sophora chrysophylla (Salisb.) Seem.	Māmane	5	15 ft. (5m)	E	
3	*Eupatorium adenophorum* Spreng.	Maui pa'makani	30	3 ft. (1m)	X	Common along trail and stream bed in thick patches.
	Rubus hawaiiensis Gray	'Ākala	5	3 ft. (1m)	E	
	Sadleria cyatheioides Kaulf.	'Ama'u	1	3 ft. (1m)	E	
	Dryopteris sp.		1	3 ft. (1m)	I or E	
Ground	*Pteridium aquilinum* (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	5	1 ft. (0.3m)	I	Along trail and scattered in koa parkland.
	Holcus lanatus L.	Yorkshire fog	50	1 ft. (0.3m)	X	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	5	6 in. (0.15m)	X	

Epiphytes *Parmelia* and *Frullania* are abundant, *Usnea* is common, *Ramalina* frequent, and *Macromitrium* occasional.

Location: Base of eastern cliff of Kau-pō Gap at 5,000 ft.

Description: Koa parkland.

Date studied: 22 June 1976.

Total vegetation cover: 90 percent.

• E = Endemic, I = Indigenous, X = Exotic

goat population in the area. At lower elevations it becomes evident from observing the increasing incidence of koa particularly on the cliffs that koa may be a major feature of the cliff vegetation on the eastern side of the Gap.

Some common high elevation xeric forms of mosses are found both on the *Acacia koa* and rocks. *Grimmia, Polytrichum,* and *Brachythecium* were common on rock. This is not an unusual flora. Some *Fissidens* was seen in very protected pockets. The ground was mostly covered by grasses precluding soil bryophytes.

This koa parkland would be an excellent location to set up a goat exclosure. Two features would probably be evident within a year: first, *Eupatorium adenophorum* Spreng. (Maui pamakani) would form a thicket along the stream; second, numerous koa saplings would shoot up from the root system of the established koa trees. It is not known whether a koa forest would reoccupy this terrain. Koa seedlings need high light intensities to grow. The high cover by *Holcus lanatus* may prevent seedling germination. However, a fire in the grassland might promote the reestablishment of a koa forest (Vogl, 1969).

Lobelia grayanum was found growing on the side of the cliff in an area inaccessible to goats.

Study Area #16

Map reference: N 20° 42' 21"
W 156° 08' 40"

Location:

At 5,800 ft. on the western side of the Kau-pō Trail. See Figs. 2 and 5 (pp. 7 and 10).

Elevation: 5,800 ft. (1,933 m).

Aspect:

The area is a southerly facing region but is close to the eastern cliffs of the Kau-pō Gap.

General description:

A closed *Dodonaea* scrub forest on general flat land with steep banks and rocky outcrops. There are no apparent drainage channels.

Soil type:

Very stony land. Fifty to 90% of the ground covered with boulders and rocks (USDA Soil Survey 1972). There is little soil in this area though there is humus in some pockets in between the rocks.

Surrounding area:

A similar community surrounds the whole area except along its eastern flank where it is bordered by a grassland traversed by the Kau-pō Gap Trail.

Climate: The average annual rainfall is 40 in. (1016 mm).

Rationale for studying this area:

This area is part of an altitudinal transect along the eastern edge of the Kau-pō Gap.

Vegetation of Study Area #16

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Dodonaea sandwicensis* Sherff.	A'ali'i	75	12 ft. (4m)	E	
2	*Eupatorium adenophorum* Spreng.	Maui pa'makani	40	3 ft. (1m)	X	
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	10	2 ft. (0.6m)	E	
	Dryopteris paleacea (Sw.) C.Chr.	Lau-kāhi	5	2 ft. (0.6m)	I	
	Rubus hawaiiensis Gray	'Ākala	5	4 ft. (1.2m)	E	
	Sadleria cyatheioides Kaulf.	'Ama'u	1	4 ft. (1.2m)	E	
Ground	*Holcus lanatus* L.	Yorkshire fog	15	1 ft. (0.3m)	X	
Epiphytes	*Pseudocyphellaria* and species of *Collema* were abundant.					

Location:	Eastern side of Kau-pō Gap close to trail at 5,800 ft.
Description:	*Dodonaea* (A'ali'i) scrub.
Date studied:	22 June 1975.
Total vegetation cover:	100 percent.

* E = Endemic, I = Indigenous, X = Exotic

Number of specimens collected:

Flowering plants	13	
Ferns	0	
Mosses and Liverworts	0	(many seen and listed below)
Lichens	31	

General comments:

An area with a large number of *Dodonaea* trees growing on rock. The area is apparently undisturbed and self-sustaining. The area contains a vegetation fairly typical of a Hawaiian dry forest. However, along the trailside and invading this forest were a large number of exotic weeds including *Cirsium vulgare* (Sar.) Tenore (Bull thistle), *Physalis peruviana* L. (Pohā), *Plantago virginica* L. (Dwarf plantain), *Sonchus olera oleraceus* L. (Pua-lele), *Verbena litoralis* HBK.

The bryophytes were scattered, never abundant, and very typical in this general area. They were not collected at this site. A list follows:

Rocks:

Thuidium plicatum

Sematophyllum

Palamocladium

Grimmia haleakalae

Pseudosymblepharis

Macromitrium intricatum

Thuidium crenulatum

Racomitrium lanuginosum var. *pruinosum*

Soil:

Campylopus

Taxithelium

Trees:

Macromitrium intricatum

Frullania apiculata

Palamocladium

Orthotrichum hawaiicum

Sematophyllum

Study Area #17

Map reference: N 20° 43' 17"
W 156° 09' 33"

Location: 'Ō'ili-pu'u. See Figs. 2 and 5 (pp. 7 and 10).

Elevation: 6,600 ft. (2,200 m).

Aspect:

We studied the eastern face of 'Ō'ili-pu'u, the floor of the cone and the breach area.

General description:

An open, short, scrub *Styphelia-Vaccinium* vegetation on the side of a volcanic cone with a breach facing Pali-kū (i.e. due west). The slope of the cone is from 40-70°. There is no sign of water erosion.

Soil type:

Cinderland. Loose bedded magmatic-ejecta (USDA Soil Survey 1972). No sign of soil formation and no humus layer. A very porous substratum, with much fine ash.

Surrounding area:

Ō'ili-pu'u is surrounded on all sides by a similar community although there are occasional areas of lava flows or pockets where large quantities of ash have collected and formed a primitive soil.

Climate:

The area is dry. The average annual rainfall is 30 inches. Most of this rain comes from a few storms. The area is occasionally covered by cloud.

Rationale for studying this area:

'Ō'ili-pu'u is the most westerly cinder cone in the crater. The vegetation can be directly compared with that at Pali-kū which will reflect the effect of the difference in rainfall. Later work in the central crater region will also use this study as part of a transect from Pali-kū to the observatory. This transect will be useful in measuring the development of cinderland under various climatic conditions. Studies in these sites can then be compared directly with similar studies on lava flows close by to evaluate the effects of rainfall, substratum, etc.

Number of specimens collected:

Flowering plants	16
Ferns	2
Mosses and Liverworts	11
Lichens	18

General comments:

There is a considerable amount of disturbance on and around 'Ō'ili-pu'u. Numerous paths lead over and around the whole area. These tracks plus the obvious stunted appearance of some of the vegetation indicates that goats visit the area quite frequently.

The area is dry and exposed, and supports an impoverished flora. The presence of several fairly large *Metrosideros* trees on the cone indicate that the area is probably capable of supporting an open, mesic forest. However, what factors have prevented more trees growing in the area can be only

hypothesized. Browsing by goats may have removed all the young seedlings so that all that is left is the mature remnant of the potential vegetation. On the other hand, the establishment of the seedlings may require more mesic conditions than currently prevail in the 'Ō'ili-pu'u region. It should be noted that in the 'Ō'ili-pu'u crater margin there are no seedling māmane, a'ali'i or pūkiawe shrubs. Again we can only suspect the cause of the lack of regeneration. Our unsubstantiated opinion is that the grazing pressure by goats is responsible but the high cover of pūkiawe on the cinder cone tends to refute this opinion.

The vent area is filled with a grassland of *Holcus lanatus* L. The area immediately surrounding this grassland supports trees about 6-9 feet high including:

Dodonea sandwichensis Sherff. (A'ali'i)

Styphelia tameiameiae (Cham.) F. Muell. (Pūkiawe)

Sophora chrysophylla (Salisb.) Seem. (Māmane)

Among the mosses *Ceratodon purpureus* is common on ash. *Grimmia haleakalae* is not common and *Racomitrium lanuginosum* is rare, both occuring on rocks. *Bartramia, Bryum, Campylopus* are found rarely on dry soil.

Vegetation of Study Area #17

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Metrosideros collina* (J.R.&G.Forst.) Gray	'Ōhi'a-lehua	<1	10 ft. (3m)	E	Not regenerating.
2	*Styphelia tameiameiae* (Cham.) F.Muell.	Pūkiawe	40	2-3 ft. (1m)	E	
	Vaccinium reticulatum Sm.	'Ōhelo	35	2-3 ft. (1m)	E	
	Dodonaea sandwicensis Sherff.	A'ali'i	1	2-3 ft. (1m)	E	
Ground	*Holcus lanatus* L.	Yorkshire fog	10	6 in. (0.15m)	X	
	Machaerina gahniaeformis (Gaud.) Kern	'Uki	5	1 ft. (0.3m)	E	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
	Pellaea ternifolia (Cav.) Link	Kalamoho	1	6 in. (0.15m)	I	Growing in shade of rock crevices and plants; very few in open situations.

Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	1	1 ft. (0.3m)	I
Deschampsia australis Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		1	1 ft. (0.3m)	E

Epiphytes No foliose lichen species, a few crustose species but not abundant. The most abundant moss, *Macromitrium intricatum*, is present but quite rare.

Location: Ōili-pu'u.

Description: Open Pūkiawe, 'Ōhelo scrub.

Date studied: 23 June 1975.

Total vegetation cover: 65 percent

* E = Endemic, I = Indigenous, X = Exotic

Study Area #18

Map reference: N 20° 43' 17"
W 156° 09' 04"

Location:

Area about half-way between Ōili-pu'u and Pali-kū. See Figs. 2 and 5 (pp. 7 and 10).

Elevation: 6,400 ft. (2,133 m).

Aspect:

The area is flat but exposed directly to winds from the Kau-pō Gap or to cloud welling over from Kī-pahulu Valley.

General description:

An open *Styphelia-Coprosma* scrub community on a flat pahoehoe lava flow. There are no obvious drainage channels in the area.

Soil type:

Very stony land. Fifty to 90% of the ground is covered by rocks and boulders (USDA Soil Survey 1972). In this area 90% of the surface is pāhoehoe lava. The plants are established in the crevices between the lava. There is a small amount of litter over the surface particularly in shaded areas.

Surrounding area:

The area is surrounded on all sides by a similar ecosystem although the amount of vegetation may vary from area to area.

Climate:

This area is dry with an average annual rainfall of 30 inches. Most of the rain comes from a few storms. The area is occasionally immersed in clouds.

Rationale for studying this area:

This site will fulfill two requirements:

1. An elevational transect up the Kau-pō Gap.
2. A transect into the crater from Pali-kū to the central crater region.

Number of specimens collected:

Flowering plants	0*
Ferns	0
Mosses and Liverworts	1
Lichens	16

*Area similar to previous site so observations only recorded.

General comments:

The species composition of the vegetation in the area is not that different from that at 'Ō'ili-pu'u, even though the substratum is different. However, the total plant cover is higher and the plants are growing more vigorously. It is somewhat surprising that the plant cover on the pāhoehoe in this area is higher than on the cinder cone at 'Ō'ili-pu'u This contrast is also seen when comparing the height of the plants in both areas. The difference will probably be correlated with the rainfall and drainage patterns in the two areas.

The area is depauperate in species of all groups collected. The area is remarkable in that *Cladonia leiodeia* H. Magn. is so conspicuous and abundant yet *Stereocaulon* is neither obvious nor abundant. In other areas such as the Koʻolau Gap the two genera are frequently associated in almost

Vegetation of Study Area #18

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Styphelia tameiameiae* (Cham.) F. Muell.	Pūkiawe	20	3 ft. (1m)	E	
	Coprosma montana Hbd.	Pilo	1	3 ft. (1m)	E	
2	*Vaccinium reticulatum* Sm.	'Ōhelo	40	1.5 ft. (0.5m)	E	
3	*Pteridium aquilinum* (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	1	1 ft. (0.3m)	I	
	Holcus lanatus L.	Yorkshire fog	5	1 ft. (0.3m)	X	
	Deschampsia australis Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		1	1 ft. (0.3m)	E	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
Epiphytes	*Pseudocyphellaria* present occasionally.					

Location:	Halfway between ʻŌ'ili-pu'u and Pali-kū Cabin.
Description:	Pūkiawe-'Ōhelo scrub.
Date studied:	23 June 1975.
Total vegetation cover:	80 percent.

* E = Endemic, I = Indigenous, X = Exotic

equal numbers.

The area is poor for bryophytes. *Bartramia, Ceratodon, Macromitrium intricatum* and *Frullania apiculata* are rare but very typical for this type of habitat.

Study Area #19

Map reference: N 20° 43' 06"
W 156° 08' 40"

Location:

Area at the head of the Kau-pō Trail directly below the large paddock at Pali-kū. See Figs. 2 and 5 (pp. 7 and 10).

Elevation: 6,250 ft. (2,083 m).

Aspect:

The area is essentially protected on all sides except to the west, which faces into Haleakala Crater across the head of the Kau-pō Gap.

General description:

A *Deschampsia-Holcus* tussock grassland on gently sloping (5-20°) ground. There are occasional depressions probably due to subsidence.

Soil type:

Cinderland. Loose-bedded magmatic ejecta (USDA Soil Survey 1972). However, this cinder has been covered by a finer-particle soil carried or blown down from the surrounding cliffs. There is evidence of stratification in this area. The soil is covered by a definite layer of humus.

Surrounding area:

North and south of the area are similar grasslands. The grassland in the paddock above is grazed by horses and is almost all *Holcus lanatus* L. To the east of the area are the *Metrosideros* forested cliffs of Pali-kū. To the west the area is bordered by a *Styphelia-Vaccinium* community similar to that described in Study Area #18. An eroded occasional stream runs between the grassland and lava flow.

Climate:

The area is subjected to a very variable climate. The annual average rainfall is 40 inches.

Rationale for studying this area:

This site was studied for comparison with Areas #9 (base of Hale-mau'u Trail) and #12 (grassland upstream from Waikau).

Number of specimens collected:

Flowering plants	3
Ferns	0
Mosses and Liverworts	7
Lichens	0

General comments:

This grassland is in an area which has been occasionally grazed by horses and goats. We are unaware of the past history of the area and can only guess that the *Deschampsia* and *Holcus* are in balance.

Grasslands usually have no, or only a few, bryophytes and lichens. This area is no exception. The *Holcus lanatus* L. present in the area excluded lichens around the breaches.

Vegetation of Study Area #19

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
Ground	*Deschampsia australis* Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		40	3 ft. (1m)	E	Forming pure stands in places.
	Holcus lanatus L.	Yorkshire fog	60	2 ft. (0.6m)	X	
	Rumex acetosella L.	Sheep sorrel	5	2 ft. (0.6m)	X	Between *Deschampsia* tussocks.
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	1 ft. (0.3m)	X	Between *Deschampsia* tussocks.
	Carex macloviana D'Urv.	St. Malo's sedge	1	1 ft. (0.3m)	I	
	Pteridium aquilinum is encroaching on the area particularly from the base of the cliff.				E	
Epiphytes	None					

Location: 100 yards south of Pali-kū.

Description: *Holcus-Deschampsia* meadow.

Date studied: 23 June 1975.

Total vegetation cover: 100 percent.

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* E = Endemic, I = Indigenous, X = Exotic

Species such as *Peltigera polydactyla* were frequently found around the edges of the *Deschampsia*.

Study Area #20

Map reference: N 20° 44' 12"
W 156° 09' 09"

Location:

North facing slope of Kalapawili Ridge at top of Lau-'ulu Trail. See Figs. 2 and 5 (pp. 7 and 10).

Elevation: 8,200 ft. (2,733 m).

Aspect: North facing slope.

General description:

A *Styphelia-Vaccinium* scrub on rough terrain. The general slope of the area is approximately 45° but there are erosion gullies which are deep (up to 12 ft. [4 m]) and fairly steep-sided (slope 70°).

Soil type:

Rough mountainous land. Very steep terrain broken by numerous drainage channels. Not stony but with only a thin soil mantle (USDA Soil Survey 1972). The ridge line is very rocky with exposed boulders covering about 70% of the surface.

Surrounding area:

Below (to the north) and to the east and west the area is covered by a similar ecosystem. To the south and over the Kalapawili Ridge the ecosystem is similar but with some small differences. For example, there are apparently more weeds such as *Holcus lanatus* L. (Yorkshire fog). Also, the area appears

to have about 10-15% less cover and shorter plants. The region is apparently drier because the clouds are not driven into the area by the prevailing winds.

Climate:

The average annual rainfall is 40 inches. There is probably a considerable amount of cloud interception from clouds billowing up the north face of the mountain.

Rationale for studying this area:

This area is the highest point on the transect which continues up from the Kau-pō Gap.

Number of specimens collected:

Flowering plants	8
Ferns	1
Mosses and Liverworts	29
Lichens	22

General comments:

Three trails meet in the area. On the ridgeline there is some effect from human disturbance. There is some considerable pig damage along and off the trail to Wai-'ānapānapa. Goats are known to browse in the area, though there are no signs of severe cropping of plants. The presence of *Holcus* and *Hypochaeris* are probably the result of years of use of the trail by hunters with their horses.

The bryophyte flora is typical of the high elevation. There is a fairly large number of species in the area but they are present in small numbers.

Vegetation of Study Area #20

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Vaccinium reticulatum* Sm. *Vaccinium berberifolium* (Gray) Skottsb.	'Ōhelo	30	5 ft. (1.5m)	E	Two species present, difficult to separate except on close examination.
	Styphelia tameiameiae (Cham.) F. Muell	Pūkiawe	20	5 ft. (1.5m)	E	
2	*Deschampsia australis* Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		40	2 ft. (0.6m)	E	
	Pteridium aquilinum (L.) Kuhn var. *decompositum* (Gaud.) Tryon	Kīlau, Bracken fern	5	2 ft. (0.6m)	I	Pig damage--rooting for rhizomes.
Ground	*Hypochaeris radicata* L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
	Holcus lanatus L.	Yorkshire fog	1	6 in. (0.15m)	X	
Epiphytes	*Pseudocyphellaria* and *Parmelia* occasional; *Orthotrichum* and *Ulota* rare.					

Location:	North-facing slope of Kalapawili Ridge at top of Lau-'ulu Trail.
Description:	Open 'Ōhelo-Pūkiawe scrub.
Date studied:	24 June 1975.
Total vegetation cover:	90 percent.

* E = Endemic, I = Indigenous, X = Exotic

Study Area #21

Map reference: N 20° 43' 55"
W 156° 08' 53"

Location: Ka-lua-nui Crater. See Figs. 2 and 5 (pp. 7, 10).

Elevation: 7,000 ft. (2,333 m).

Aspect: The area is a sheltered depression facing south.

General description:

A tussock *Deschampsia* grassland with a gentle slope (5-10°) toward an off-center depression where water accumulates during periods of high rainfall.

Soil type:

Cinderland. Compact, bedded, magmatic ejecta (USDA Soil Survey 1972). Stratification is evident with a thick layer of humus on top of the soil.

Surrounding areas:

The small crater is surrounded on all sides by a *Vaccinium-Styphelia* scrub vegetation. On the northern side of the crater the area is protected by the cliffs of the Kalapawili Ridge.

Climate:

A protected area at the base of the cliff and leeward of the prevailing winds. The average annual rainfall is 40 inches and there is little cloud interception.

Rationale for studying this area:

The grassland will be compared with Area #9 (base of Hale-mau'u Trail); Area #12 (grassland south of Waikau); and Area #19 (grassland below paddock at Pali-kū). This area, along with Area #22, is an integral part of the transect from the Kau-pō

Gap to the top of the Kalapawili Ridge.

Number of specimens collected:

Flowering plants	0
Ferns	0
Mosses and Liverworts	2
Lichens	3

General comments:

This isolated grassland in the crater seems to be typical of similar situations elsewhere, e.g., 'Ō'ili-pu'u.

Study Area #22

Map reference: N 20° 43' 54"
W 156° 08' 50"

Location: Ka-lua-nui Crater Rim. See Figs. 2 and 5 (pp. 7,10).

Elevation: 7,080 ft. (2,360 m).

Aspect: Same as Area #21 but not as sheltered.

General description:

A low *Vaccinium-Styphelia* scrub community with little ground cover on a gently sloping (10-25°) area.

Soil type:

Cinderland. Loose, bedded, magmatic-ejecta (USDA Soil Survey 1972). This area is quite rocky with about 50% of the surface covered by stones and rocks. Much of the rock is friable.

Surrounding area:

On all sides except the north the area is surrounded by a similar vegetation. To the north the area falls off within 25 m. toward the crater and the *Deschampsia* grassland

Vegetation of Study Area #21

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
Ground	*Deschampsia australis* Nees ex Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		50	3 ft. (1m)	E	
	Poa pratensis L.	Kentucky blue grass	50	2 ft. (0.6m)	X	
	Rumex acetosella L.	Sheep sorrel	1	2 ft. (0.6m)	X	Growing in scattered areas particularly in wetter regions of the crater floor.
Epiphytes	None					

Location: Ka-lua-nui Crater floor.

Description: *Deschampsia-Poa* grassland.

Date studied: 24 June 1975.

Total vegetation cover: 95 percent.

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* E = Endemic, I = Indigenous, X = Exotic

Vegetation of Study Area #22

STRATUM	SPECIES	COMMON NAME	PERCENT COVER	HEIGHT	STATUS*	COMMENTS
1	*Vaccinium reticulatum* Sm.	'Ōhelo	40	3 ft. (1m)	E	
	Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	10	3 ft. (1m)	E	
	Coprosma montana Hbd.	Pilo	1	3 ft. (1m)	E	
2	*Deschampsia australis* Nees ex. Steud. f. *haleakalaensis* (Skottsb.) Skottsb.		10	1.5 ft. (0.5m)	E	
	Holcus lanatus L.	Yorkshire fog	5	1.5 ft. (0.5m)	X	
Ground	*Rumex acetosella* L.	Sheep sorrel	1	6 in. (0.15m)	X	
	Coprosma ernodeoides Gray	Kukae-nene	1	6 in. (0.15m)	E	
	Luzula hawaiiensis Buch.		1	6 in. (0.15m)	E	
	Hypochaeris radicata L.	Hairy cat's ear, Gosmore	1	6 in. (0.15m)	X	
Epiphytes	None					

Location: Ka-lua-nui Crater Rim.

Description: 'Ōhelo scrubland with some Pūkiawe.

Date studied: 24 June 1975.

Total vegetation cover: 70 percent.

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* E = Endemic, I = Indigenous, X = Exotic

described in Area #21.

Climate: (Same as Area #21.)

Rationale for studying this area:

This area is part of the transect from the Kau-pō Gap to the top of the Kalapawili Ridge.

Number of specimens collected:

Flowering plants	16	
Ferns	1	
Mosses and Liverworts	3	(7 species seen)
Lichens	12	

General comments:

Though the vegetation of the area is quite typical of scrubland in the crater, in this region it is quite open. The scrub is short and there is very little herbaceous cover of the clinker-like cinder. There is no evidence of undue disturbance by humans or animals.

This is another area in which moss species which were common throughout the crater were not collected. The mosses present were: *Bryum argenteum, Ceratodon purpureum, Macromitrium intricatum, M. piliferum, Racomitrium lanuginosum, Ulota cervinum, Anoectangium.*

General Comments on the Lichen Flora of Haleakala National Park

There is a modest flora of lichens within the summit area of Haleakala. There are several species which are particularly conspicuous as a consequence of their size and abundance. *Pseudocyphellaria crocata, Alectoria smithii, Stereocaulon vulcani, and Cladonia leiodeia* are among these species. The fruticose forms are particularly evident but it is interesting to note that the genus *Cladonia* is not, apart from *C. leiodeia*, a significant feature of the fruticose flora. Among the foliose forms, members of the Stictaceae are quite common whereas the Parmeliaceae are not as well represented as might have been expected. The crustose species are not common. The corticolous species are few in number and not at all frequent or conspicuous. Some saxicolous species are very common but they blend in so well with the rocks that they are not very conspicuous.

Pseudocyphellaria crocata (L.) Vain.

This species is the most abundant lichen in the Haleakala National Park excluding Kipahulu Valley. It is a brown foliose species with conspicuous bright yellow spots on both the upper and lower surfaces. It is overlooked frequently because of its color which blends in with the shadows within the bush. It is normally found growing on the main trunks or stems of *Styphelia tameiameiae* and *Vaccinium* spp. particularly in shaded positions. The species rarely grows

in open, exposed situations except in areas which are frequently immersed in clouds.

Specimens are nearly always fertile. However, above 8,000 ft. the frequency of fertile specimens within the population is considerably reduced.

The species was found growing in an atypical environment on two occasions. In both instances, the plant was growing over humus between tussocks of *Deschampsia australis*. Above the plants there was a dense cover of dead leaves which obviously cut down the light quite considerably. It is interesting to note that in a similar environment but under *Holcus lanatus* L. (Yorkshire fog) no lichens were present. The major difference between the leaves of the two species is the leaves of *H. lanatus* are broad whereas those of *D. australis* are rolled in on themselves longitudinally forming a narrow, round, needle-shaped leaf. The probable explanation is that leaf for leaf the *H. lanatus* leaves occlude much more light than the *D. australis* leaves. Though *Pseudocyphellaria* is capable of growing in this situation it survives only marginally. It does not reproduce sexually whereas in higher light intensities it does so prolifically. Asexual reproduction is also reduced if not completely stopped. The yellow soralia normally seen on the upper surface of actively growing species are rare or absent on specimens growing between the *Deschampsia* tussocks.

Alectoria smithii DR.

This black, fruticose lichen looks very much like a tangle of black hair. It is normally found among the uppermost and dead branches of *Styphelia tameiameiae* and *Vaccinium* spp. where it is exposed to full sunlight. However, the species is not always confined to the epiphytic habit. It is occasionally found growing with mosses over rocks.

Though fertile specimens of the species have been collected in the islands, for example on Mauna Loa (Jacobsen, 1972), none of the specimens collected in the Haleakala Crater region were fertile.

Another species of *Alectoria, A. lanestris* (Ach.) Gyeln., has been collected by Dr. Peter Bowler (#1645) in the Hosmer Grove area. This collection is a new record for the Hawaiian Islands. No specimens of this species were collected in the current Resources Basic Inventory Study.

Stereocaulon vulcani (Bory) Ach.

This gray, fruticose lichen is the principle lichen pioneer of lava flows. It grows in dense tufts of infrequently branched upright stalks (pseudopodetia). At the tip of many stalks there is a small, rounded, black apothecium. The stalks are generally covered by a whitish-gray crumbly structure.

The lichen is common within the crater on the more recent lava flows and older flows which have not been changed by weathering. This species is very important in the ecology of lava flows in that it probably constitutes part of the first

seral stage in the colonization of lava flows. The species is known to change the underlying lava chemically (Jackson, 1971). This chemical decomposition of the lava rock is a significant factor in the initial formation of soil on lava flows. *Stereocaulon vulcani* contributes further to soil formation by contributing significant quantities of organic matter to the developing soil. This organic matter improves the soil by increasing the retention of water which will provide other plants a better chance of survival.

Cladonia leiodea Magn.

The three species of *Cladonia* subgenus *Cladina* found in Hawaii are endemic to the islands. *C. leiodeia* is a pale yellow much-branded lichen found growing over humus and sometimes over rocks.

This species is abundant in the National Park. It is found in all areas frequently inundated in clouds. It is an early colonizer of lava flows but it is also found in *Metrosideros* cloud forest. On recent lava flows, the species is normally found in depressions where litter accumulates. The accumulation of litter is accelerated by the net-like growth of the lichen. Indeed, it is rare to find the lichen without many dead leaves entangled in the thallus. In areas, such as the Koʻolau Gap, where there is not much shading and yet considerable cloud cover, this lichen can cover up to ten percent of an area. During later stages of succession ferns and shrubs frequently become established in the underlying humus of this lichen.

Ramalina sp.

This white fruticose species is found throughout the crater between 5,500 - 8,000 ft. (1,833 - 2,667 m). It is extremely flaccid and delicate. It grows on rocks in heavily shaded, cool, moist situations. It even occurs in the lava flows of the upper Ko'olau Gap but deep in the many small caves. In these situations it is very often overlooked. The species has not been found in the fertile condition but it does produce a moderate number of asexual propagules.

The status of the species is not known but it is thought to be a new species. However, it could be a variety of another as yet unidentified species found on the undersurface of *Acacia koa* Gray branches at 5,000 ft. in the Kau'po Gap. This latter species is flaccid and white but produces abundant sexual reproductive bodies. The fact that there is a radical shift in reproductive strategy and substrate preference is not untoward. Species which are approaching their ecological limits frequently undergo such abrupt changes in behavior.

Usnea sp.

There are at least two species of the genus *Usnea* found in most areas of the National Park. Both species are yellowish-green. Both species of the pendulous fruticose genus are highly branched.

The genus occurs sporadically throughout the National Park. It is particularly abundant in areas inundated for long periods in clouds and has a similar distribution to

Alectoria smithii. However, the above species do not occur with any frequency in areas of high rainfall. The two commonly occurring species are found on most shrubs and trees but are particularly abundant on māmane (*Sophora chrysophylla* (Salisb.) Seem.). Another species smothers branches of *Acacia koa* Gray (koa) in the Kaupō Gap.

INSECTS

Location: Hosmer Grove

Light trap:

Large numbers of noctuid moths of about 10 species, 6 of which are endemic. The rest of the catch consisted of small numbers of pyralid, geometrid and pterophorid moths.

Pitfall traps:

Large numbers of sowbugs, a few collembola and carabid beetles, and 3 millipedes.

Malaise trap:

Set near campground in scrub forest. The catch was large in both number of insects and species. Almost all were flying insects with the greatest numbers in the active day-flying groups such as hymenoptera, diptera and microlepidoptera. Also found to be common were the diptera: Tephritidae--mostly one species, Pipunculidae--2 or 3 species, Syrphidae, Tachinidae, Muscidae, and blue and green blow flies. Common hymenoptera were bees of the genus *Nesoprosopis*, and wasps of the genus *Odynerus*. Several groups of parasitic hymenoptera were common with the genus *Aphidius* (parasites of aphids) being abundant.

Under rocks:

Bees of the genus *Nesoprosopis* were abundant, nesting in soil under rocks. Three species were present, one of which is parasitic on others of its own genus. Sowbugs were very abundant while ants were represented by the Argentine ant,

Iridomyrmex humilis, an introduced pest which appears to be confined to this area. There were a few carabids.

Stream pools:

The water strider *Microvelia vagans* was common in water pools in the stream beds. Large numbers of dead insects were present near these isolated pools. Millipedes and sowbugs were present in large numbers feeding on the insect remains. In this stream bed area crane flies were common under over-hanging cliffs. Large numbers of collembola were present in the wet leaf litter near the stream.

Vegetation:

Mirid bugs of the genus *Orthotylus* were abundant on *Coprosma montana* and *Sophora*. Mirids of the genus *Psallus* were common in association with *Sophora* and *Dodonaea*. Seed-feeding bugs of the genus *Nysius* (Lygaeidae) were often collected on *Metrosideros, Dodonaea, and Sophora*.

General observations:

Several *Megalotica holombra*, a black geometrid day-flying moth, were seen in scrub forest near Hosmer Grove campground.

Location: Hale-mau'u Trail Head

Light trap:

The catch was very similar to that taken in Hosmer Grove. Almost all were noctuid moths.

Pitfall traps:

Five traps were set in the area of the light trap and caught 1 small carabid beetle, some moths, several sowbugs and 1 noctuid larva.

Malaise trap:

Similar to the Hosmer Grove catch. Mostly active day-flying insects. Several of the stream-lined endemic cerambycid beetles of the genus *Plagithmysus* were caught here. The catch also included several of the solitary black wasps *Ectemnius* and *Odynerus*. Large numbers of the solitary black bee *Nesoprosopis* were caught in the area. Several specimens of the endemic day-flying geometrid moths, *Eupethecia scoroides*, were taken at this locality. This species was also common in the Hosmer Grove area. Larvae of Hawaiian species of *Eupithecia* are predaceous on flies and other small insects (Beardsley).

Under rocks:

A great amount of effort was spent in checking under rocks where the elytra of large numbers of carabids were found, but no intact specimen of this species was recovered. A few smaller carabids were found along with a few spiders, millipedes, centipedes and many sowbugs.

Vegetation:

The major plant types were checked. Lygaeids of the genus *Nysius* were common; an apparently new species of this genus was found associated with *Styphelia* at this locality. During August, adults of several species of endemic planthoppers (*Nesosydne* spp.) and leafhoppers (*Nesophrosyne* spp.) were found associated with native shrubs in this area. These were not present as adults during June (Beardsley).

Location: Kala-haku Overlook

Light trap:

The catch was fairly large but not as big as at lower elevations. Most of the material in the trap was noctuid moths.

Pitfall traps:

The five traps set in the area yielded 2 large carabids (*Barypristus rupicola*), 1 small carabid, 1 noctuid larva and several sowbugs.

Under rocks:

Collecting from this habitat produced an endemic wolf spider, more large carabids and sowbugs.

Vegetation:

An endemic predaceous bug (*Nabis* sp.) was collected from *Deschampsia* but most specimens were immature.

General obervations:

Two specimens of the flightless moth *Hodegia apatella* were collected. Insect diversity was low in the area which reflected the small number of plant species present.

Location: Observatory and Summit Area

Under rocks:

From here was collected an endemic wolf spider, the large carabid *Barypristus rupicola*, and sowbugs.

Vegetation:

Nysius spp. were common on *Raillardia* and *Vaccinium*. The *Vaccinium* was infested with large numbers of aphids. In association with these aphids were larvae and adult brown lacewings, coccinellid beetle larvae and parasitic wasps. One large cerambycid beetle was collected from *Raillardia*. In August adults of two native mirid bugs, *Cyrtopeltus hawaiiensis* and *Sarona* n. sp. were taken on *Raillardia* as were large numbers of *Nysius* spp., mostly *N. coenosulus*, *N. delectulus* and *N. nemorivagus* (Beardsley).

General observations:

Blow flies and honey bees were commonly observed flying about the area. Very few insect species were present and this is a reflection of the small number of host plant species.

Location: Maka-wao Forest Reserve

Malaise trap:

The malaise was set up near where the pasture and the rain forest merge. The malaise catch was large and varied consisting of mostly hymenoptera, diptera and microlepidoptera. Syrphid flies were extremely abundant in this area. Included in the parasitic species were the hymenoptera *Coccigomimus*, *Apanteles*, *Aphraerta* (only place in the crater) and *Euderus metalicus*. There were some ichneumonids, but groups such as *Odynerus*, *Nesoprosopis* and *Ectemnius* were not as abundant as at higher elevations. Flies of the groups Calliphoridae (blow flies), Pipunculidae, Mucsidae, and Tachinidae were caught in moderate to large numbers. Other groups which were common in the malaise catch were *Orthotylus* (Miridae), brown lacewings (very abundant), psocids, psyllids and microlepidoptera.

Litter:

The litter supported a large fauna. Collembola, millipedes, centipedes, sowbugs and carabid beetles were most frequently found.

Vegetation:

Collecting from specific plants produced many insects not found in the malaise. The grass had very large numbers of

aphids and these attracted lacewings, coccinellids, syrphids and parasitic wasps. Nitidulids were commonly collected on *Vaccinium, Coprosma montana, Morinda, Mysine,* and *Metrosideros. Neseis mauiensis* (Lygaeidae) were collected in numbers from *Vaccinium, C. montana,* and *Morinda.* Delphacidae and Cicadellidae of several species were collected from many of the angiosperm plants and certain groups appear to be confined to certain plant types. Psocids and psyllids were very common on most of the angiosperm plants.

General observations:

One of only two crickets collected on the trip was found here. Crane flies were abundant along stream beds. Overall this area produced a great diversity of insect species.

Location: Waikau Cabin

Malaise trap:

The catch here was not much different from other areas. *Nesoprosopis* bees comprised the bulk of the catch. The spider wasps (pompilidae) were more common in this area than others.

Pitfall traps:

These were not very productive, producing primarily sowbugs.

Vegetation:

Night sweeping was tried and found to give good results with several species collected that were not collected at other times, the most unusual of which was a flightless dolichopodid fly collected from *Rubus hawaiiensis.* Also collected from *R. hawaiiensis* at night were endemic drosophilids (one of

which was of the large picture-wing type), collembola, brown lacewings and microlepidoptera. Sweeping *Deschampsia* grassland produced many of the predaceous bug *Nabis* (Nabidae), leafhoppers, brown lacewings and aphids. Fuller's rose beetle (Curculionidae) was found on endemic sedge. Crane flies were abundant on cliff faces in damp areas.

Lava tube:

A side trip into a lava tube resulted in the discovery of several cave-adapted cixiids and one cave-adapted centipede. At 6400 feet this is one of the highest elevations at which cave-adapted organisms have been found in the Hawaiian Islands (Howarth).

Location: Ko'olau Gap--'Āina-hou

General observations:

The insect fauna was very similar to that found in the Makawao Forest Reserve, especially in the lower elevations of the Gap which were dense rain forest. *Aphidius*, a hymenopterous parasite of aphids, was very abundant in the Gap. Damselfly nymphs (*Megalagrion* sp.) were found between the leaf sheaths of a large sedge.

Location: Halemau'u Trail Base

Under rocks:

This habitat produced much the same type of material at this end of the crater as elsewhere. This included sowbugs, carabids and solitary bees in the genus *Nesoprosopis*. An insect collected here which was at higher densities than elsewhere was the predaceous bug *Oechalia pacifica* (Pentatomidae).

Vegetation:

Aphids and lacewings were abundant in grasslands. Evening primrose had heavy aphid infestations. The introduced Fuller's rose beetle (Curculionidae) was found on sedge. General sweeping of vegetation produced several *Oliarus similis* (?) (Clixiidae).

Location: Paliku Area

Overview:

The locality had the most species and greatest overall number of insects of any area surveyed. This was probably due to the many varied habitats which intersected here. Almost all insects collected elsewhere in the park were present here with the exception of a few species which were found only near the summit (i.e., flightless moth, large carabid) and lower elevation rain forests (i.e., giant lacewing).

Location: Paliku--Scrub woodland behind Cabin

Malaise trap:

This site produced the greatest number of species and individuals of any site sampled. The major amount of the material was active day-flying insects from the orders hymenoptera, diptera and microlepidoptera. The most outstanding material in the catch were the large number of drosophilids and several cerambycids. The hymenoptera included: *Odynerus* (Eumenidae), *Ectemnius* (Crabronidae), *Pompilus* (Pompilidae), *Coccygomimus* and *Gambrus* and *Diadegma blackburni* (Ichneumonidae), *Nesoprosopis* (Prosopididae), *Apanteles* and *Aphidius* (Braconidae), *Euderus metalicus* (Eulophidae) and paper wasps (Vespidae). The diptera were the same major families as in other areas with the exception of a large catch of drosophilidae.

General observations:

Blow flies were extremely abundant at Paliku especially near the cabins. This is primarily from the flies breeding on discarded goat carcasses.

Location: *Styphelia-Coprosma* scrub community on flatland between Oili Pu'u and Paliku

Malaise trap:

Even though this area was only about one-half mile from the Paliku Cabin site it differed considerably. The catch had much larger numbers of *Nesoprosopis* (about 4/5ths of the material) and much fewer species of the other groups caught near the cabin.

Pitfall traps:

At the end of a week the traps had collected 6 carabids, 1 millipede, several collembola, 1 noctuid larva and several *Geocoris pallens* (Lygaeidae) which were not collected elsewhere. This predaceous immigrant lygaeid bug is associated with grasses.

Under rocks:

The introduced paper wasp, *Polistes fucataus aurifer*, was common in this area and two nests were found on the underside of a rock. One nest was about five inches across and was vacated. The other nest was three inches in diameter and had 7 wasps on it. They aggressively defended the nest when it was disturbed but were otherwise docile.

Vegetation:

The bushes in this area had large numbers of microlepidoptera particularly on *Dodonaea*. Many of these appear to be a single species.

Location: Gully at Paliku containing trail to Kuiki

Malaise trap:

The catch here was very good in terms of numbers of species and individuals but no one group was strongly dominant. Microlepidoptera were the most common group. Midges were present in very large numbers, and several dozen crane flies made these groups more abundant than elsewhere in the crater. Two species of the day-flying moth *Megalotica* were caught: several *M. holombra* and two *M. aphoristis*. These were the

only *M. aphoristis* caught in the crater.

Litter:

Tearing apart moss and ground litter on a white sheet produced little except collembola. Many large long collembola (Entomobryidae) were found in a decaying log.

Plunge pools:

Several predaceous diving beetles (Dytiscidae) were collected from a small pool. Both adults and larvae were present but larvae were much more common.

Vegetation:

Sweeping over moss-covered cliffs above the plunge pools produced many midges and crane flies. Much time was spent collecting from the lily *Astelia*. Midges and drosophilidae were present in large numbers about the flowers. Between the leaf sheaths were many damselfly nymphs. An unusual carabid with peculiar raised veins on the elytra (*Mecylothorax*, new species) was found between the leaf sheaths. Also about this area were snails, slugs, collembola, green flat bugs and leafhoppers. Giant plantain (*Rumex*) was checked. Most of the seed capsules had holes in them and beetle larvae were found in a few. Also found were larvae in the hollow flower stems of this plantain. Representatives of most of the angiosperm plants were checked. Many hemiptera and homoptera appeared to be limited to only certain plant species and groups. The insect fauna was similar to that studied in the rain forests of Makawao Forest Reserve and Koolau Gap. The leaves of *Broussaisia* were heavily galled

by what was probably mite damage (Beardsley). Thrips were found in new leaf buds.

Location: The ridge above Paliku gully at 7000 feet to Kuiki at 7500 feet

Under rocks:

Several carabids were found of at least three species. Ants (*Hypoponera opaciceps* [Mayr]) were found under one rock but otherwise were not collected in other areas of the crater which were studied. Sowbugs were common here. Several small centipedes were found. Carabid larvae were discovered under rocks in association with larvae of *Nesoprosopis* which may serve as prey for the larvae of the carabids.

General observations:

Day-flying moths of the genus *Megalotica* were common (dozen seen at one time) where it was often attracted to *Metrosideros* even when not in bloom. Adult damselflies, (*Megalagrion* spp.) which probably live as nymphs in such habitats as *Astelia* leaf sheaths, were moderately common. Noted but not caught were one monarch butterfly, a few painted lady butterflies and several large dragonflies (*Anax*).

Location: Kaupo Gap, 6,400 feet to 5,000 feet

Malaise trap:

The trap was set at three locations in the gap:

(1) 6100 ft. beneath a large *Metrosideros* in a meadow at the base of a gully;

(2) 5200 ft. in *Dodonaea-Metrosideros* scrub forest;

(3) 5000 ft. in a dry stream bed in an area of scattered large Koa.

The catch at these sites was comprised of material much the same as in other malaise catches. Active day-flying insects composed most of the catch. As in other sites most of the material was in the orders diptera, hymenoptera and micro-lepidoptera. A much larger percentage of the malaise material was small parasitic wasps as compared to other sites sampled. This greater percentage of parasitic wasps was especially true at the 6100 ft. location where such parasites as *Aphidius, Bracon, Coccygomimus, Diplazon, Gambrus, Apanteles* and *Euderus metalicus* (an introduced species) were as common as, or more so than, elsewhere in the crater. The diptera were well represented in the malaise. Drosophilidae were in numbers matched only by the Paliku area. Other common to abundant flies caught in the malaise were Calliphoridae, Syrphidae, Tachinidae, Muscidae, Tephritidae, and Pipunculidae. Because the 6100 ft. malaise was in a meadow it collected more grass-inhabiting insects than the other sites in the gap. These included aphids and their natural enemies, i.e., parasitic wasps, coccinellids,

lacewings and syrphids (all introduced species). The grass also had leafhoppers which were hosts for pipunculid flies present in the meadow. The Malaise at 5200 ft. produced cerambycid beetles not collected elsewhere in the Gap. *Psylla uncatoides* (Psyllidae), an introduced pest species, was very abundant in the malaise at 5000 ft. where they were in great numbers on Koa, the principal host of *P. uncatoides* in Hawaii. Throughout the Gap, coccinellid beetles were present in greater numbers of species and individuals than at other sites. This may be due to large populations of aphids and psyllids in the Gap.

Vegetation:

Maui Pamakani (*Eupatorium adenophorum*) thrived along much of the Kaupo Gap trail and the banks of the stream bed. These plants had almost no galls. Several species of parasitic wasps were attracted to *E. adenophorum*, especially *Bracon* at 5000 ft. The flowers of *Metrosideros* attracted large numbers of insects. The most common of these by far was the bee *Nesoprosopis*. Also very common on *Metrosideros* and *Dodonaea* was the endemic butterfly *Vaga blackburni* (Lycaenidae). Insects found on *Sophora* were: large numbers of *Orthotylus perkinsi*; several predaceous *Nabis*; *Psallus* sp. (common); *Neseis ochriasis baldwini* (Lygaeidae); *Euderus metalicus* (Eulophidae); *Oliarus similis* (Cixiidae); and psocidae. An endemic mealy bug, *Chlorococcus chloris* (Beardsley), was found on *Sophora* in this area. *Dodonaea* was another plant in the Gap which had many insects associated with it. Tephritid flies showed

a high degree of preference for this plant. Psocids and several parasitic hymenoptera were often collected from *Dodonaea*. The only staphylinid (a family of predaceous beetles) was taken in the Gap at 5000 ft. on *E. adenophorum*.

General observations:

Overall the Kaupo Gap had a higher percentage of introduced insects which appear to be correlated to the greater percentage of introduced vegetation. The malaise trap got large volumes of insect material even though it was up for only a short time in each area. As one walks down the Gap insects become far more noticeable than in any other place in the crater. This may be due to the fact that plants such as *Eupatorium adenophorum*, *Dodonaea*, and *Metrosideros* tend to concentrate the insects where they become easily visible since these plants serve as a food source. However, in a rain forest environment the nectar-feeding insects are not nearly so obvious because the feeding activity is in the upper reaches of the trees or hidden by thick foliage.

SUMMARY OF BIRD SPECIES AND RELATIVE ABUNDANCE

H. Eddie Smith

Through the period of May 1 through June 10, 1975, I confined my activities to two general study areas in preparation for the oncoming summer bird census of the Haleakala National Park Resources Basic Inventory.

The areas mentioned are: (1) Haleakala Ranch land and grazing pasture at 6,000 ft. elevation (Map Reference-- N 20° 47' 00", E 156° 14' 20"), which has been established as the hunting territory of a pair of Pueo mentioned in my recent manuscript (Smith, 1975); and (2) the Maka-wao Forest Reserve (Study Area #6, p. 31), which I have explored superficially in hopes of including this region in this summer's bird census.

Area #1

This region is primarily grazing pasture and encompasses an area of some three miles square which is disected by numerous gullies. In these gullies native 'Ōhi'a, Māmane, and some Lobelias are found in sufficient quantity to support food and nesting sites for several native and introduced passerpine bird species. The following is a check-list of the bird species and their relative abundance:

Short-Eared Owl (*Asio flammeus*) "Pueo"

At least one owl was seen to hunt this range nearly every day, and on one occasion two owls were observed.

Ring-Necked Pheasant (*Phasianus colchicus torquatus*)

Well-represented and breeding. One nest was discovered with twelve eggs apparently destroyed by either rats or mongooses.

American Golden Plover (*Pluvialis dominica*)

While this species was well-represented in early April, it was totally absent in the latter part of April, May and June, due to its annual migration.

Spotted Dove (*Streptopelia chinensis chinensis*)

While several observations of this species were recorded, this dove should be considered uncommon in this area.

Barred Dove (*Geopelia striata striata*)

Not seen nor heard to call.

Skylark (*Alauda arvensis arvensis*)

Well-represented and by far the most obvious species in the area.

Red-Billed Leiothrix (*Leiothrix lutea*)

Was not seen nor heard to call.

Mockingbird (*Mimus polyglottos*)

An estimation of four breeding pairs of mockingbirds was determined by sight and by locating territories.

White-eye (*Zosterops japonica japonica*)

Well-represented throughout the entire area and is considered to be the most abundant passerine bird species. One active nest was located on April 30, 1975, situated in the fork of a low pūkiawe bush approximately four feet above the ground. When I approached the nest to investigate its content four nestlings abandoned the nest and fluttered to the ground.

Myna *(Acridotheres tristis)*

Several scattered sightings of the myna were recorded.

Amakihi *(Loxops virens)*

While not found in large numbers, the Amakihi was well represented and primary song was spaced according to nest site availability. I found what could possibly have been an abandoned Amakihi nest situated in the top of a Māmane tree aprroximately 4 ft. above the ground.

Maui Creeper *(Loxops maculata newtoni)*

Was not seen nor heard to call.

Apapane *(Himatione sanguinea)*

Present, but in limited numbers--obviously restricted by the limited abundance of flowering trees as a food source. Six Apapane in juvenile plumage were observed.

I'iwi *(Vestiaria coccinea)*

Was not seen nor heard to call.

American Cardinal *(Cardinalis cardinalis)*

Was not seen nor heard to call.

House finch *(Carpodacus mexicanus frontalis)*

Several separate flocks of 10-15 birds were observed within the study area.

Area #2

This study area is within the Makawao Forest Reserve at an elevation of 5,700 ft. and is adjacent to Study Area #1. At the time of this writing I had made only five exploratory visits, and these only barely penetrating the dense 'Ōhi'a

Forest. Consequently the following list of bird species can only be used as a preliminary check-list.

Melodious Laughing Thrush *(Garrulax canorus)*

One bird was observed singing in a low-hanging *Coprosma* tree, and on two other occasions the thrush was heard to sing but was not observed. This species is considered to be uncommon in this area.

Red-billed Leiothrix

Very abundant and singing the primary song continuously throughout the day.

White-eye

Well established, but found to be in less abundance than the native creeper and Apapane. One nest was found and photographed approximately 5 ft. above the ground in the fork of a *Gouldia* tree. The nest contained three eggs, and the frantic activity of two adult white-eyes in a nearby tree indicated that this nest was active.

Amakihi

Well represented by less than half as many as the Maui Creeper.

Maui Creeper

This species is considered to be the second most abundant bird species in the forest, and is present in large numbers.

Apapane

Considered to be the most common species of bird in the forest. It is of interest that during the month of May, I found that juvenile Apapane outnumbered the adults by no less than a

ratio of 2:1. One nest discovered on May 8, 1975, was situated approximately 30 ft. above the ground in the terminal crown of a flowering 'Ōhi'a tree. After one hour of observation with field glasses the nest was found to contain three, and possibly four, Apapane nestlings which were fully feathered and appeared to be nearly ready to fledge. The adult Apapane only fed the young once during the one hour of observation.

I'iwi

Since the I'iwi is more territorial than the three preceding bird species, it was difficult to ascertain the relative abundance of the small region of forest covered in this investigation. However, I consider the I'iwi to be well established and the eight juveniles observed indicate a successful breeding cycle.

House Finch

Four house finches were seen preening in the crown of a dead Koa tree, well inside the forest.

STATUS OF BIRDS DURING HALEAKALA RBI

During the Resources Basic Inventory Expedition I made a census of the birds in the various regions studied. The counts were made by observing and listening to the birds for 15 minute intervals, and were recorded in Table 1. These observations were made after the general expedition had quit the area for at least one week. Some general observations follow.

I. Endemic and Indigenous Birds

The northwest outer slope:

Along the outer slopes of Haleakala, from the Park boundaries to the summit, there are two areas considered to be strongholds for two species of Hawaii's native Honeycreepers, the Apapane (*Himatione sanguinea*) and the Amakihi (*Loxops virens*). The first area is Hosmer's Grove, an exotic pine and *Eucalyptus* grove at an elevation of 6,800 ft. (2,267m). This region affords shade, shelter and is bordered by a sufficient amount of native vegetation to offer a food source to a substantial population of native birds. Limited numbers of the I'iwi (*Vestiaria coccinea*) and the Maui Creeper (*Loxops maculata newtoni*) have been sighted on several occasions as well as a stable population of Apapane and Amakihi. The staple food source in this area appears to be the flowering Māmane (*Sophora chrysophylla* [Salisb.] Seem.) and 'Ōhi'a (*Metrosideros collina* [J.R.&G.Forst.] Gray) trees.

The second location along the outer slopes is a stand of *Eucalyptus* trees at the 8,500 ft. (2,833m) elevation mark. In this area the Maui Creeper and I'iwi are not present, but the Apapane and Amakihi are seen to thrive in relatively good numbers. They seem to subsist chiefly upon the flowering Māmane in the surrounding area. In July, 1975, several juvenile Apapane and two fledgling Amakihi were observed in this location substantiating the fact that the birds are breeding successfully as well as subsisting in the area. In addition to these two areas, stream beds, gullies and other

locations that afford sufficient native vegetation for food and shelter support populations of Amakihi and Apapane up to the tree line at 9,000 ft. elevation. The summit area is a nesting site for the rare and endemic dark-rumped Petrel (*Pterodroma phaeopygin sandwicensis*). Several Pueo (*Asio flammeus*) have been observed hunting from Hosmer's Grove to the summit.

Inside Haleakala Crater:

Although much of the Crater appears barren, there are some locations within the crater which support several species of Hawaii's native birds. The Nene (*Branta sandvicensis*) has been observed throughout the crater, and the White-tailed tropic bird (*Phaethon lepturus*) may be seen soaring high above the crater. The Paliku area, with its lush native vegetation, supports a relatively large population of Amakihi and Apapane. Several Maui Creeper were observed there feeding in the Olapa (*Cheirodendron trigynum* [Gaud.] Heller) trees. Down the Kaupo Gap within the National Park area there is an abundance of Apapane and Amakihi plus several I'iwi. Other areas within the crater that support the Apapane and Amakihi were: the Halemau'u Trail from the top to the bottom of Ko'olau Gap, the grassland by Crystal Cave, Waikau hunter's cabin, and Waianapanapa--where the very beautiful Crested Honeycreeper (*Palmeria dolei*) may be observed.

II. Introduced Birds

The following is a list of the introduced avifauna, most of which may be seen both within and outside the crater:

Common Name	Scientific Name
Chukar	*Alectoris chukar*
Ring-necked Pheasant	*Phasianus colchicus torquatus*
Skylark	*Alauda arvensis arvensis*
Red-billed Leiothrix	*Leiothrix lutea*
Mockingbird	*Mimus polyglottos*
Japanese White-eye	*Zosterops japonica japonica*
Common Myna	*Acridotheres tristis*
Ricebird	*Lonchura punctulata*
House Sparrow	*Passer domesticus*
Cardinal	*Cardinalis cardinalis*
House Finch	*Carpodacus mexicanus frontalis*

TABLE 1. BIRDS OF HALEAKALA CRATER AND ADJACENT AREAS OF HALEAKALA NATIONAL PARK, JULY 1975

COMMON NAME	SCIENTIFIC NAME	STATUS*	LOCALITIES (Key Below)
Dark Rumped Petrel	*Pterodroma phaeopygia sandwichensis*	E	4 (5 burrows, 2 active)
Nene	*Branta sandvicensis*	E	7,8
Chukar	*Alectoris chukar*	X	2,3,5,6,9
Pheasant	*Phasianus colchicus torquatus*	X	1,2,3,5,6,7,8,9,10,11
Spotted Dove	*Streptopelia chinensis chinensis*	X	None
Barred Dove	*Geopelia striata striata*	X	None
Pueo	*Asio flammeus sandwichensis*	E	7,8,10,11
Skylark	*Alauda arvensis arvensis*	X	1,2,3,5,11
Red-billed Leiothrix	*Leiothrix lutea*	X	1,8,10,12
Mockingbird	*Mimus polyglottos*	X	2,5,9,11
White-eye	*Zosterops japonica japonica*	X	1,2,5,6,7,8,9,10,11,12
Common Myna	*Acridotheres tristis tristis*	X	11
House sparrow	*Passer domesticus*	X	None
Amakihi	*Loxops virens wilsoni*	E	1,2,6,7,8,9,10,11,12
Maui Creeper	*Loxops maculata newtoni*	E	7,12
Apapane	*Himatione sanguinea*	E	1,2,6,7,8,9,10,11,12

I'iwi	*Vestiaria coccinea*	E	10,12
House Finch	*Carpodacus mexicanus frontalis*	X	1,2,5,6,7,8,10,11,12
Rice Bird or Spotted Munia	*Lonchura punctulata*	X	1,12
Cardinal	*Cardinalis cardinalis*	X	1,10,11

KEY to LOCALITIES:

1. On top of and inside deep gully (Areas #1 and 2, pp.126,128), at 6,700 ft., June 11, 1975, 9:30 a.m., cloudy-rain.
2. Hale-mau'u Trailhead, at 7,700 ft., June 13, 1975, 9:00 a.m., clear and sunny.
3. Kala-haku Overlook, at 9,000 ft., June 13, 1975, 1:00 p.m., clear and sunny.
4. Haleakala Summit, at 9,600 ft., June 14, 1975, 10:15 a.m., clear.
5. Grassland by Hōlua, 6,960 ft., June 18, 1975, 12:40 p.m., clear.
6. Waikau Cabin, 6,450 ft., June 19, 1975, 5:50 a.m., clear and frost.
7. Kuiki Slopes, 6,000-7,000 ft., July 8, 1975, 7-12 a.m., clear.
8. Slope behind Pali-kū Cabin, 6,000 ft., July 9, 1975, 7 a.m.-12:30 p.m., partly cloudy.
9. Pine grove, 8,550 ft., July 12, 1975, 10:00 a.m., overcast.
10. Ravine by tower, 6,400 ft., July 13, 1975, 7:00 a.m. - 12:00 a.m., clear.
11. Gulch behind Pu'u-nianiau, 6,750 ft., July 14, 1975, 9:30 a.m.-12:30 p.m., clear.
12. "Geranium Arboretum" behind Hosmer Grove, 6,600 ft., July 29, 1975, 9 a.m., clear.

* X = Exotic, E = Endemic

RECOMMENDATIONS

Three major management problems are identified. Some recommendations are made to eradicate the offensive organism or provide further information that would help to establish whether the problem is serious or not. These problems are the most serious from our point of view. There are other areas which are probably management problems. We have not come to any consensus on many of these for lack of information. For example, there appears to be a proliferation of new trails within the crater. Have these been specifically identified as needed or are they an indication of general abuse by users of the National Park?

Pigs

Several areas of the Haleakala National Park Crater and Crater Rim show incontestable damage by feral pigs. Most areas affected are covered by forests. It is in these areas and the bordering shrub communities that most of the damage is occurring. However, in the Kalapawili Ridge and Kuiki *Deschampsia* grassland areas there is evidence of considerable pig damage resulting in soil erosion.

The pigs in searching for food dig up the ground cover which is generally killed by such treatment. The plants apparently have little regenerative capability. Exotic weeds invade the exposed areas, particularly *Holcus lanatus* (Yorkshire fog), *Hypochoeris radicata* (Hairy cat's ear, Gosmore) and *Rumex acetosella* (Sheep sorrel). They then compete with

germinating endemic and native species which they soon overgrow. At the same time, other changes occur in the soil further suppressing the reestablishment of the indigenous flora (Forehand, 1970).

The invasion of the open scrub mesic forest by such exotics is occurring all the time. However, we believe that the large patches of grassland that are appearing in these ecosystems is the result of an accelerated invasion due to pig disturbance.

The pig problem is of some real concern. Though the Hawaiians had pigs in pre-Cook times there is some question as to whether or not the pigs were really wild. Though undoubtedly not under rigid control and living off the land, animals that escaped were probably hunted during periods of famine.

Tomich (1969) has noted that the pig during Hawaiian times is presumed to have been a small animal. Ellis commented on the small size of the animals in 1823. The small size was probably the result of several factors. Only animals suitable for long canoe voyages were brought in. Small animals require less food, space, etc. The small initial population was inbred severely and probably the race demonstrated loss of vigor as a consequence. However, subsequent to the establishment of the large cattle breeding and feeding ranches the larger varieties of domestic pigs were introduced to upgrade the feral natives. Apart from increasing the size of the animal, the crossbreeding of the varieties would have

produced more vigorous offspring due to heterosis (hybrid vigor). Therefore, the modern feral pig is a different beast from the native Hawaiian variety. It is larger and more aggressive.

It is best to think of the pig problem as a relatively new situation which will need a fresh appraisal. We cannot rely on past information or practices.

It is suggested that a monitoring program be set up to get some information on pig activity which may later be used to establish a full-scale research program. The monitoring should include:

(2) A log of all sightings of pigs including the number, age and sex if possible;

(2) A log of all sightings of pig damage;

(3) A photographic study of recovery from pig damage;

(4) Some exclosures within pig-infested areas should be established to compare and contrast pig damage with undamaged situations.

The logs should include information from sites not frequently visited. The casual observations from trails may be misleading. There is evidence that suggests that pigs shun areas frequented by humans.

The Blackberry at Pali-kū

Rubus penetrans Bailey (Blackberry) was introduced into Hawaii in 1894 (Neal, 1965). It was not recognized as a serious pest until the 1930's by which time it had become well established in Kauai, East Maui and Hawaii. The plant is considered a noxious weed (Hosaka and Thistle, 1954).

The noxious feature of the blackberry is that it forms thickets which are difficult to traverse. The problem is compounded by the sharp-pointed thorns which readily penetrate all but the sturdiest clothing.

The plant spreads rapidly from the point of its original establishment by virtue of the fact that any part of a stem that touches the ground has the ability to root and form new shoots. Since the growth habit of the plant is a rambler, the thin spindly shoots cannot support themselves very well. Thus without support from some other plant the tip of the shoot generally arches down to the ground. This tip will root and a new plant is formed. The rate of shoot growth is such that these plants could form several new plants each year under suitable growth conditions. The mild climate and high rainfall in many areas of Hawaii are ideal.

Though it is extremely unlikely that the blackberry could become established in the crater proper it could become well established in the Pali-kū region. If so it could have a negative impact on the camping grounds in that area.

Possible control measures:

1. The plants could be removed by hand two or three times a year. This is a time-consuming chore and with limited manpower resources may not be practicable.

The major advantage to this scheme is that no herbicides are used.

The disadvantage is the manpower requirement particularly since the exercise must be repeated at regular intervals. After the first two or three eradication attempts the area will still have to be patrolled. The plant can regenerate rapidly from subterranean portions of the shoot.

It should be possible to eradicate the blackberry plant from the Pali-kū meadows within two or three years.

2. The plants could be sprayed with chemical herbicides.

The advantage is that this is a cheap, fast and generally effective method.

The disadvantages are that there are few chemical herbicides which are considered to be without undesirable side effects. One should use a herbicide that will affect only the blackberry. However, there is no herbicide specific for the blackberry. The normal treatment is to use a mixture of 2,4-D (2,4-Dichlorophenoxyacetic acid) and silvex (2,4,5-TP [2,4,5-trichlorophenoxypropionic acid]). This mixture is a general herbicide for broad-leaved plants. Grasses, therefore, would not be affected.

2,4-D does not leave an appreciable or long-lasting residue. 2,4,5-TP does leave a residue which is estimated to have

a half life of 9-10 months in an area like Pali-kū. Since the chemical is most effective as a foliar spray this treatment would need to be repeated every four months for a couple of years. This level of residue loading in the soil is almost certainly unacceptable to the Park management.

3. The State Department of Agriculture has a program whereby they will eradicate officially declared noxious weeds which are just recently established in an area. However, they will probably use the most economically effective method which in this case would be herbicide. Also it is not known whether or not they would agree to operate on Federal property.

Goats

Goats are found in all areas of the Haleakala National Park excluding the rain and cloud forest in Kipahulu Valley. By all accounts their effect on the native vegetation is devastating (Brian, 1948; Kobayashi, 1973; Yocum, 1967). We, however, are not sufficiently conversant with the goat problem in Haleakala National Park to make any overall recommendation.

However, the large populations of goats in certain areas, e.g. Kau-pō Gap, indicate that plant material that would normally be part of the standing crop in the Park is being consumed by these animals. Their impact on the native ecosystem is not a general grazing of all plants. Rather they have dietary preferences, and the high pressure on these plant species will disturb the balance between the various plant

species in the community.

Grazing pressure is not their only detrimental effect in the National Park. As Kobayashi (1973) has pointed out, the trampling of roots and general disturbance of the substratum is probably of greater significance in their destructive effects on the silversword than browsing *per se*.

Acacia koa Gray is found in the lower Kau-pō Gap area of the National Park. In our Study Area #15 at 5,000 feet there is a stand of mature trees. Though the trees produce copious quantities of seeds there are no seedlings in the surrounding area. There are also no suckers formed on the exposed roots of the trees. Normally, such exposed roots would produce suckers.

Our observations of this area and the surrounding cliff lead us to believe that previously this area had supported a koa forest. However, all regeneration has apparently ceased. It is our opinion that this lack of regeneration is the result of intensive goat browsing. H. Eddie Smith recalls that many hunters have noted that the goats migrate up the cliff face during the day. At dusk, the gravid and nursing females in particular return to the gully with their kids to spend the night in relative protection. At daybreak, they commence foraging again and probably consume any koa seedling or sapling they may see. Koa is apparently a preferred dietary plant.

In this area, we would recommend that a goat exclosure be built and the regeneration of koa be monitored.

We recommend that goat exclosures be constructed in

several areas. One has already been suggested in the comments on Study Area #15 at 5,000 feet along the Kau-pō Gap Trail. Other areas might include areas in the general vicinity of the Kala-haku Overlook, Crystal Cave, Ka-palaoa Cabin, Hōlua Cabin and perhaps Kuiki. If these exclosures are constructed we would suggest that they be very carefully monitored prior to their establishment and consequently by a team of ecologists.

Though we did question the present control methods used by the Haleakala National Park administration, we realize that budgetary, personnel and logistic problems related to goat control in the Park make the current practice of shooting goats on sight the most practicable. We still feel that the fly problem so created may be a potential health hazard in the area. With increasing numbers of people visiting the Park and particularly hiking through the crater the abuse of the facilities provided is bound to increase. What worries us is that Maui County already has a disproportionately high number of salmonella and shigella cases every year. With an increasing number of visitors and a large population of flies the possibility of an intestinal disease outbreak originating in the crater increases. This could arise from the flies contaminating food or the water supply.

For several reasons, therefore, we recommend the establishment of a major goat control program as a very high priority item in the Haleakala National Park program.

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