

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

DEPARTMENT OF BOTANY

UNIVERSITY OF HAWAII AT MANOA

HONOLULU, HAWAII 96822

(808) 948-8218

TECHNICAL REPORT #15

PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

PLANT SURVEY

NATIONAL PARK SERVICE

CONTRACT NO. CX 8000 6 0031

Contribution Number CPSU UH 002/5

(Final Report)

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 (CPSU UH) on March 16, 1973. The CPSU UH 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 Heiau National Historic Site. Through the Unit Director, projects are undertaken in areas identified by park management. These studies provide information for resource management programs. The involvement of University faculty and students in the resource management of the National Parks in Hawaii leads to a greater awareness of the problems and needs of the National Park Service. At the same time, research not directly or immediately applicable to management is also encouraged through the CPSU UH.

Contribution numbers are assigned as follows. CPSU UH identifies the Cooperative National Park Resources Studies Unit of the University of Hawaii. This is followed by a three-digit number assigned in sequence to each new project of this CPSU. The fourth digit indicates the report number for that particular project.

Puukohola Heiau National Historic Site  
Plant Survey

February 1977

James D. Macneil and Don E. Hemmes  
Biology Department  
University of Hawaii at Hilo  
Hilo, Hawaii 96720

## ABSTRACT

A checklist of all plant species located within the Puukohola Heiau National Historic Site was compiled for the dry season during May 1975, and for the wet season in March 1976. A total of 50 species from 21 Angiosperm families were recorded along with 2 ferns and 1 Basidiomycete. Of the total number of species collected, 38 were introductions, 10 were indigenous, and 5 were endemic. Among the species present are *Ophioglossum concinnum*, a fern proposed for rare and endangered status, and an unknown species of *Atriplex*, provisionally identified as *A. johnstonii*. Four distinct communities were recognized: a xerophytic scrub savannah, a closed kiawe forest, a halophytic scrub, and a disturbed roadside community. Recommendations are made concerning a potential fire hazard, the control of two noxious weeds, and the preservation of the rare fern.

## TABLE OF CONTENTS

ABSTRACT	i
INTRODUCTION	1
Geographical Location and Climate	1
Soil	4
History	4
METHODS	5
RESULTS	8
Species Inventory	8
Vegetation Communities	8
1. Scrub-grassland community	10
2. Closed kiawe forest	10
Coastal closed forest	11
Fluvial closed forest	11
3. Halophytic community	11
4. Roadside community	13
Noteworthy species	13
1. 'Āheahea ( <i>Chenopodium oahuense</i> )	13
2. Saltbush ( <i>Atriplex</i> sp.)	13
3. Pā'ū-o-Hi'iaka ( <i>Jacquemontia sandwicensis</i> var. <i>tomentosa</i> f. <i>hosakae</i> )	14
4. Blue-seeded portulaca ( <i>Portulaca cyanosperma</i> )	14
5. 'Iwa'iwa ( <i>Doryopteris decora</i> )	15
6. Pololei ( <i>Ophioglossum concinnum</i> )	15
DISCUSSION	15
RECOMMENDATIONS	16
LITERATURE CITED	17
ACKNOWLEDGEMENTS	18
APPENDIX 1	30
APPENDIX 2	35

## LIST OF FIGURES

Figure 1.	Location of Puukohola Heiau National Historic Site	3
Figure 2.	Diagram showing transects	7
Figure 3.	Vegetation map	9

## LIST OF TABLES

Table 1.	Physico-chemical analysis of soil	19
Table 2.	Species checklist	20
Table 3.	Plants present in the five community types	25

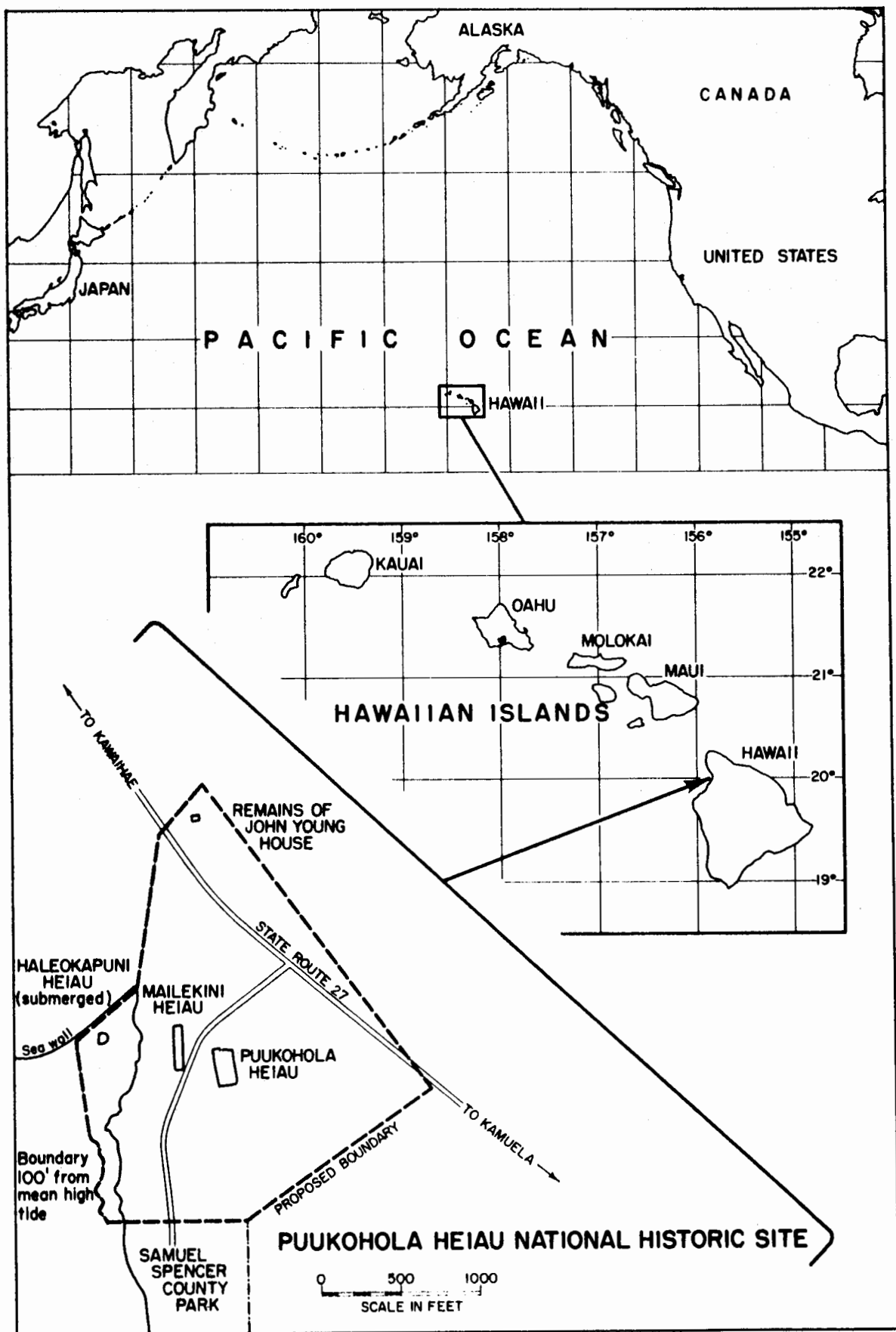
## INTRODUCTION

### Geographical Location and Climate

Puukohola Heiau National Historic Site is located approximately one mile south of Kawaihae at the base of the western slope of Kohala Mountain on the leeward side of the island of Hawai'i (Fig. 1). The 77-acre (31-hectare) site consists of a gently undulating landscape with a maximum elevation of 135 feet (41 m) descending to sea level. The area is bordered on the west by ocean and to the south by the Samuel M. Spencer County Beach Park and undeveloped savannah. The eastern boundary runs approximately parallel to Hawaii State Highway 27. This arid coastal zone boasts the lowest per annum precipitation (7.45 inches [189 mm]/year) in the state of Hawai'i, due to the rain shadow produced by Kohala Mountain which rises 5,500 feet (1675 m) above sea level to the north and northeast, blocking the predominant trade winds. Mauna Kea (13,796 feet [4205 m]) and Hualālai (8,271 feet [2521 m]) are situated to the southeast and south, respectively, and also play a role in producing the arid environment. There is a definite fluctuation in rainfall between the summer and winter months. The majority of the rainfall occurs during the months of January and February, when cyclonic cold fronts (Kona storms) from the south converge over the hot land mass on the leeward slopes (Blumenstock and Price 1972). During the rest of the year when the tradewinds predominate, the rainfall is light, very infrequent, and sufficient only to settle the dust.

Figure 1. Map showing the location of Puukohola Heiau National Historic Site, its environs, and the three heiau. The Site has an area of approximately 77 acres (31 hectares), and is situated one mile south of Kawaihae. A small section of ocean extending about 100 feet (30.5 m) from the 700 yards (630 m) of shoreline was originally proposed as being part of the Site.





The mean annual temperature of Pu'ukoholā is 76°F (24°C) with the highest temperatures recorded during September. The annual variations in photoperiod and altitude of the sun above the horizon are slight, thus producing a relatively constant insolation which fluctuates by only a third from its maximum to minimum intensity each year. This slight fluctuation is in part responsible for the small variation in the area's temperature (Blumenstock and Price 1972).

### Soil

The soil at the Pu'ukoholā Site is a red desert laterite soil and falls into the Kawaihae soil family. This soil type has been most aptly described as follows: "the A<sub>1</sub> horizon is very weak, thin, and reddish brown, probably formed from the weathering of a thin deposition of volcanic ash or cinders. This overlies unweathered rocks coated with CaCO<sub>3</sub> leached from the A<sub>1</sub> horizon" (Sherman 1972). A soil analysis of Pu'ukoholā is presented in Table 1. The soil permeability is classified as moderate and the moisture storage capacity relatively low (1.5 inch/foot soil).

### History

Historical analyses of the pre-contact flora by Rock (1913) and Carlquist (1970) describe the arid coastal vegetation zone as consisting predominately of the following species: pā'ū-o-Hi'iaka (*Jacquemontia sandwicensis*),

pili (*Heteropogon contortus*), 'ilima (*Sida fallax*), and kākōnakōna (*Panicum torridum*).

With the onset of contact with western civilization great changes in the native flora began to occur. In 1793, Capt. George Vancouver left cattle, sheep, and goats on the island of Hawai'i. Kamehameha I imposed a kapu on their slaughter and the change in native vegetation began (Handy and Handy 1972).

The sandalwood trade (St. John 1947) and the immigration of missionaries in the first quarter of the 19th century, combined with the increasing use of Kawaihae Harbor as a port of entry, facilitated the introduction of many species. These new introductions rapidly invaded their new environment and soon produced a new vegetation community.

#### METHODS

Numerous search and collection expeditions were carried out throughout the site in May 1975, the dry season, and in March 1976, a month after several heavy rain storms of 1-2 inches (25-50 mm) each. To aid in a complete coverage of the 77 acres (31 hectares), four arbitrary sections were designated and surveyed systematically. Representative plants were collected and pressed for identification. All specimens after identification were sent to Dr. Derral Herbst, Lyon Arboretum, University of Hawaii, Honolulu, for verification. Herbarium sheets of a representative collection of all the plants collected will be deposited at Puukohola Heiau National

Historic Site. To avoid unnecessary confusion, the nomenclature used in this report follows St. John (1973). Though we do not necessarily agree with some of the nomenclature, this work is the most complete list of Hawaiian plant names to date. The rare and endangered species lists also use this nomenclature. There is one exception to this usage. St. John recognizes *Pennisetum setosum* and *Cenchrus ciliaris*, which are probably the same taxon. To avoid confusion, we have used the name *Pennisetum ciliare* following the suggestion of Fosberg (see Appendix 2).

Nineteen 15-meter transects were spaced at 100-meter intervals along State Highway 27 and Spencer Beach Park County Road to monitor roadside introductions. Transect #1 was situated at a position one meter to the north of the entrance to the Site's headquarters and ran perpendicular to State Highway 27 in an easterly direction. The remaining 18 transects fall in an alternate pattern whereby each successive transect runs perpendicular to the roadway, but on the opposite side of the road from the previous one.

The relative abundance of the existing flora along each transect was determined by placing one-meter-square quadrats on alternate sides at every two-meter interval along each transect line (Fig. 2). Quadrat #1 was always placed on the northern side of the line, thus situating quadrat #3\* on the southern side, quadrat #5 on the northern side, etc. Each quadrat was divided into 100 points to give the relative percentage of encountered species.

---

\*Quadrat #3 is the second quadrat, #5 is the third, etc. Their numbers correspond to their distance in meters from the road.

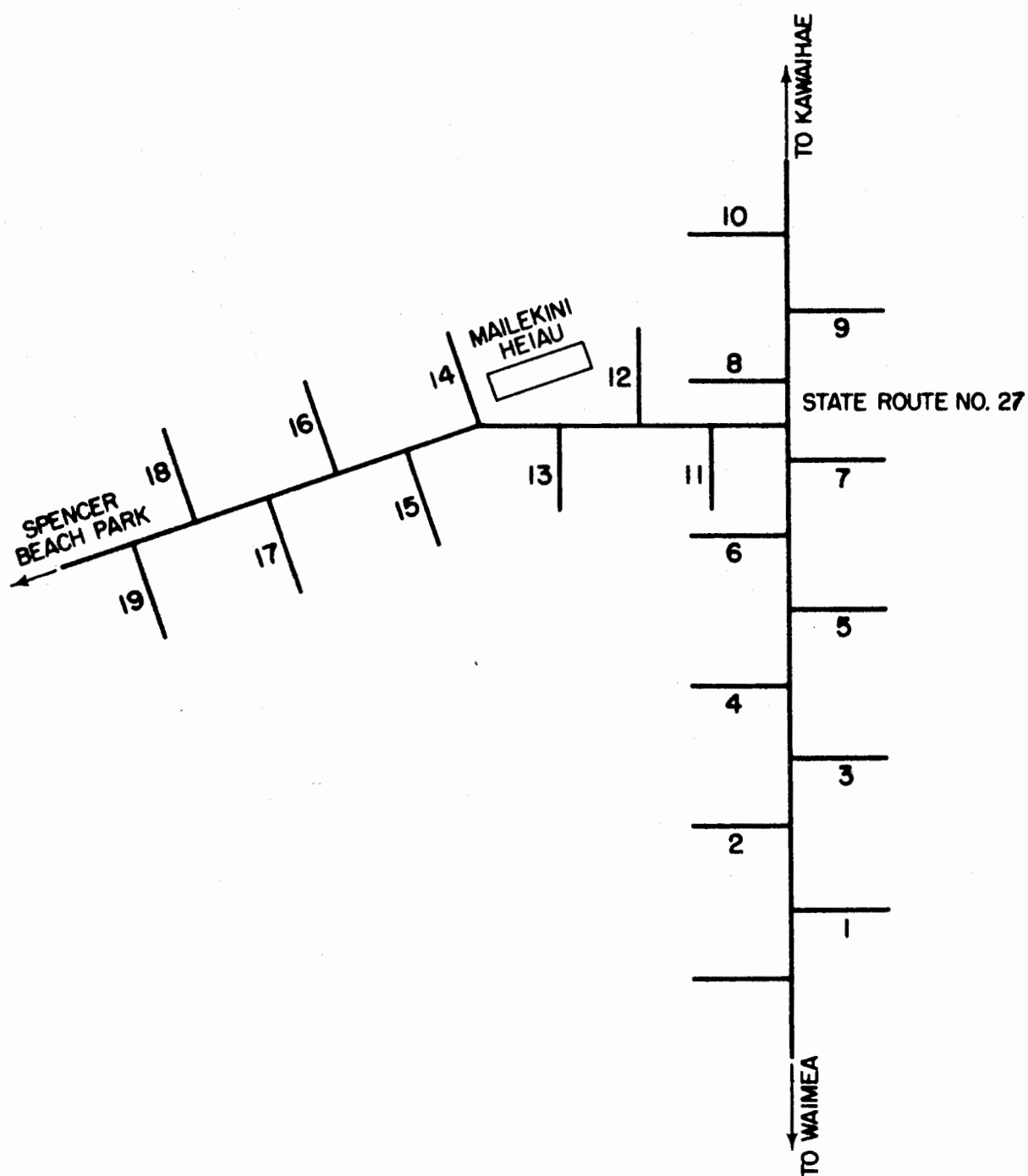


Figure 2. Diagram showing the position of 19 transects at right angles to the roadways at Puukohola Heiau National Historic Site, which were sampled to determine the effect of the roadways on the adjacent vegetation.

## RESULTS

### Species Inventory

A checklist of all plant species recorded within the confines of Puukohola Heiau National Historic Site during the dry season, May 1975, and the wet season, March 1976, is presented in Table 2. Species observed only during the wet season are indicated by an asterisk (\*). A total of 50 species representing 21 Angiosperm families were found along with 2 ferns and a Lycoperdales (puff-ball). After each species the status—i.e., whether introduced, indigenous, or endemic (according to St. John [1973])—is recorded, along with its relative abundance and distribution at the Historic Site. Of the total number of species collected, 37 are introductions, 10 are indigenous, 5 are endemic, and 1 is yet to be positively identified, but it is probably an introduction.

### Vegetation Communities

Four distinct plant communities can be recognized within the boundaries of Puukohola Heiau National Historic Site. The vegetation map (Fig. 3) shows the sharp demarcation between the open xeric grassland surrounding Pu'ukoholā Heiau and the lower elevation coastal forest. To the north, this forest forms a protective canopy over the third community: a brackish water pond and extensive salt marsh which extends several hundred yards inland from the back

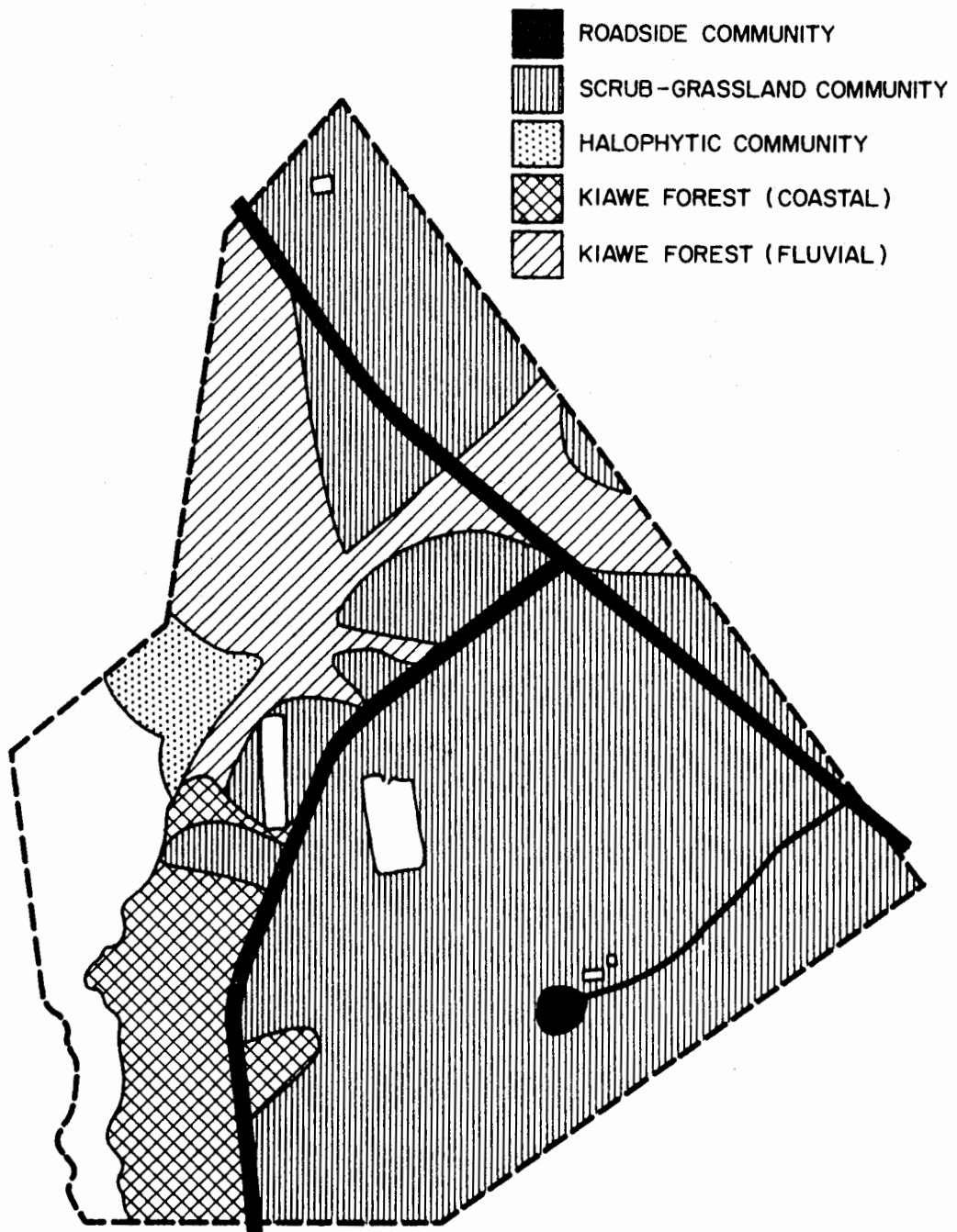


Figure 3. Vegetation map of the major plant communities at Puukohola Heiau National Historic Site.

SCALE: 1 inch = 500 feet

berm of the sand beach. The disturbed roadside community was recognized as a fourth vegetation community type.

### 1. Scrub-grassland community

The xeric, open scrub-grassland environment is the predominant community type (Table 3). It is dominated by the grass feathery pennisetum (*Pennisetum ciliare*), and by scattered low stature shrubs of kiawe (*Prosopis pallida*). Within this community scattered low density populations of slender mimosa (*Desmanthus virgatus*), fountaingrass (*Pennisetum setaceum*), koa-haole (*Leucaena leucocephala*), 'ilima (*Sida fallax*), morning glory (*Ipomoea congesta*), and hairy merremia (*Merremia aegyptia*) are found. The habit and cover of these species fluctuates greatly according to the time of the year. During the summer, vegetative die-back is extensive as this area dries out, but during the few months of the "wet" winter season a dramatic "greening" and burst of vegetative growth occurs. Though encountered rarely, the xerophytic Basidiomycete *Battarrea phalloides* and the endemic pā'ū-o-Hi'iaka (*Jacquemontia sandwicensis*) were collected in this community type.

### 2. Closed kiawe forest

This forest community is found in areas where groundwater provides a relatively constant soil moisture content throughout the year. The community contains a diverse flora (Table 3) and can be subdivided into two types, coastal and fluvial.



Coastal closed forest. This closed forest of tall kiawe (*Prosopis pallida*) borders the ocean from the south end of the beach below Hale o Kapuni Heiau to Spencer Beach Park. Because of its thick canopy, only sparse populations of feathery pennisetum (*Pennisetum ciliare*), 'ilima (*Sida fallax*), and hairy abutilon (*Abutilon grandifolium*) occur under the trees.

Fluvial closed forest. This community borders Makeāhua Gulch and extends through the northern portions of the Site. It also consists of a forest of tall kiawe (*Prosopis pallida*) intermixed with vigorously growing specimens of natal redtop (*Rhynchelytrum repens*), bristly foxtail (*Setaria verticillata*) guinea grass (*Panicum maximum*), nohu (*Tribulus cistoides*), puncture vine (*Tribulus terrestris*), wild spurge (*Euphorbia geniculata*), coat buttons (*Tridax procumbens*), and pua-lele or sow thistle (*Sonchus oleraceus*).

### 3. Halophytic community

This community of salt-tolerant plants (Table 3) is located around the brackish pond, within the marsh and beach area at the northwestern end of the Site. This area is of fluvial origin and cannot be more than 10 to 15 feet (3 to 5 m) above sea level at its highest point. It extends in a narrow strip for nearly 200 yards (180 m) inland from the small sand beach. The community merges with the closed forest zone. The beach has a scattered population of Australian saltbush (*Atriplex semibaccata*) and another saltbush (*Atriplex muelleri*) of relatively

low habit. Scattered seedlings of kiawe (*Prosopis pallida*) and milo (*Thespesia populnea*) grow not more than 25 feet (7.5 m) from the sea on the beach during the winter months. Toward the berm of the beach, stands of beach morning glory (*Ipomoea brasiliensis*) and naupaka-kahakai (*Scaevola taccada*) appear. These immediately give way to marsh bordered on the south by a closed forest of well-established kiawe (*Prosopis pallida*) interspersed with tall representatives of coconut (*Cocos nucifera*) and tree heliotrope (*Messerschmidia argentea*). The understory vegetation is comprised of scattered passion flower (*Passiflora foetida*), wild portulaca (*Portulaca oleracea*), and feathery pennisetum (*Pennisetum ciliare*). Numerous young specimens of kiawe (*Prosopis pallida*) may also be observed, yet most of the ground cover is shaded and devoid of vegetation. The marsh area, between the pond and the beach, contains large populations of sea purslane or 'ākulikuli (*Sesuvium portulacastrum*) and saltwort (*Batis maritima*), as well as scattered representatives of nena (*Heliotropium curassavicum*), hairy spurge (*Euphorbia hirta*), and pakai (*Amaranthus dubius*). Near the brackish pond young Canary Island date palm (*Phoenix canariensis*) as well as 'āheahea (*Chenopodium oahuense*) are located. Vigorously growing populations of Australian saltbush (*Atriplex semibaccata*) and another saltbush (*Atriplex muelleri*) are found around the periphery of the pond and are much more robust than those populations encountered on the beach.

#### 4. Roadside community

A strip of land about five meters wide bordering all roads was considered a separate community. This community is heavily disturbed from road-building activities and continues to be affected by both vehicular and pedestrian traffic. Though much of the community would be a scrub-grassland under natural conditions, the disturbance has produced a community with a very depleted complement of species (Table 3). There are only twelve species present and none are unique to this habitat (Appendix 1). Further from the road, that is, beyond five meters, the number of species present begins to increase, indicating that the effects of disturbance are decreasing.

#### Noteworthy Species

Several plants located within the Puukohola Heiau National Historic Site require further mention.

##### 1. 'Āheahea (*Chenopodium oahuense*)

This endemic species was encountered within the halophytic community and is represented by two shrubs approximately 7 feet (2 m) tall. 'Āheahea is quite common throughout the islands. No protective measures are called for.

##### 2. Saltbush (*Atriplex* sp.)

This species of *Atriplex* is represented by several small shrubs on the sand beach. Its habit and fruit structure are unlike any of the four *Atriplex* species described from the Hawaiian Islands (i.e., *A. muelleri*, *A. rosea*, *A. semibaccata*, and *A. lentiformis*). This species is a dioecious herb, with

alternate canescent leaves. It differs basically from the other *Atriplex* species described from Hawai'i in that the dehiscent pericarp becomes woody at maturity. Herbarium specimens have been sent to Dr. F. R. Fosberg, Smithsonian Institution, Washington, D.C., who has provisionally identified it as *A. johnstonii* Wolf. It should be considered as an exotic species. No management activity is proposed to maintain or to eradicate this species.

3. Pā'ū-o-Hi'iaka (*Jacquemontia sandwicensis* var. *tomentosa* f. *hosakae*)

Pā'ū-o-Hi'iaka occurs around the Historic Site Headquarters. It is not common; however, it is not a rare or endangered plant, and no measures are needed to protect or propagate this endemic plant. St. John (1976) has recently discussed the taxonomy of this species. He has suggested that the forma *hosakae* not be considered as a distinctive form.

4. Blue-seeded portulaca (*Portulaca cyanosperma*)

The blue-seeded portulaca is common along the county roadside between State Highway 27 and Spencer Beach Park. The taxonomy of this species is in a state of some confusion. Geesink (1969) has synonymized this taxon with *P. pilosa*, a cosmopolitan weed. Some botanists with local experience (Leith et al. 1975) are not inclined to accept Geesink's position. However, *P. cyanosperma* was first described from the islands around Ni'ihau and later Kaua'i during the thirties. It has since spread very rapidly and can now be found in abundance around the island of Hawai'i. This behavior is very unusual for an endemic species though not impossible.

5. 'Iwa'iwa (*Doryopteris decora*)

'Iwa'iwa is a common endemic fern in lowland xeric shrub and grassland. No special precautions should be taken to protect this plant.

6. Pololei (*Ophioglossum concinnum*)

Pololei is a rare endemic fern that has been proposed for inclusion in the federal listing of rare and endangered plants (Fosberg and Herbst 1975; Herat and Herat 1976; U.S. Fish and Wildlife Service 1976). It is a perennial plant which grows only during the rainy season. A small colony was found on the makai side of State Highway 27 about 100 meters Kawaihae of the road to the Historic Site Headquarters. The plants were 10 meters away from the highway. Every effort should be made to preserve the area in as natural a condition as possible.

#### DISCUSSION

The vegetation in the arid coastal vegetation zone has undergone considerable alteration since 1788. Rock (1974) and Carlquist (1970) list 'ilima, pili, kākonakona, and pā'ū-o-Hi'iaka as the dominant elements of the flora. To this list we can probably add the indigenous and endemic plants that are there today, i.e., 'āheahea, alena, 'ākulikuli, 'ihi, nohu, milo, hi'a-loa, pōhuehue, koali-'awahia nena, and naupaka-kahakai. Most of these plants would have been concentrated around the shoreline and the streambed of Makeāhua Gulch. Two grasses from the above list, pili and kākonakona, are no longer present in the Historic Site. They

have probably been displaced by the two species of *Pennisetum* which now predominate.

#### RECOMMENDATIONS

1. There is a potential fire hazard from dead fountain grasses (*Pennisetum* spp.) in the scrub-grassland area. The amount of fuel will increase after each season's growth because the dry stems have little chance of rotting. All important structures should be protected by firebreaks. Also, the public should be made aware of the fire hazard or smoking should be prohibited.
2. There are two potentially noxious weeds in the Historic Site, koa-haole (*Leucaena leucocephala*) and the castor bean (*Ricinus communis*). Both should be sought out and cut back periodically. Both have the potential to form thickets around and within the archaeological sites, which would probably be destroyed if these weeds became established.
3. Within the grounds of the Historic Site, the pololei fern was discovered. This species has been proposed as a rare and endangered species (U.S. Fish and Wildlife Service 1976). The fern (*Ophioglossum concinnum*), a member of the adder's tongue ferns, is ephemeral and only found during the rainy season. Every effort should be made to maintain the area and keep it undisturbed from trampling, grazing, or damage by fire.

## LITERATURE CITED

- Blumenstock, D.I., and S. Price. 1972. Climates of the states: Hawaii. Pages 155-204 in E.A. Kay, ed. A natural history of the Hawaiian Islands: selected readings. University Press of Hawaii, Honolulu.
- Carlquist, S. 1970. Hawaii: a natural history. The Natural History Press, Garden City, N.Y. 463 pp.
- Fosberg, F.R., and D. Herbst. 1975. Rare and endangered species of Hawaiian vascular plants. *Allertonia* 1:1-72.
- Geesink, R. 1969. An account of the genus *Portulaca* in Indo-Australia and the Pacific (Portulacaceae). *Blumea* 17:275-301.
- Handy, E.S.C., and E.G. Handy. 1972. Native planters in old Hawaii: their life, lore, environment. B.P. Bishop Museum Bull. 233. B.P. Bishop Museum Press, Honolulu. 641 pp.
- Herat, T.R., and R.M. Herat. 1976. A checklist and status report of the ferns and fern allies in Hawaii Volcanoes National Park. CPSU UH Tech. Rep. 8. (Univ. Hawaii, Bot. Dept.) 58 pp.
- Leith, H., J.H. Leith, and A. Leith. 1975. *Portulaca pilosa* ssp. *villosa*; ecotype of *P. pilosa* of great variability and adaptability. Newsletter, Haw. Bot. Soc. 14(2):23-25.
- Rock, J.F. 1974. The indigenous trees of the Hawaiian Islands. Pacific Tropical Botanical Garden, Lawai, Kauai. Charles E. Tuttle Co., Tokyo. xx + 548 pp. [First published in 1913.]

- Sherman, G.D. 1972. Tropical soils of the Hawaiian Islands. Pages 205-252 in E.A. Kay, ed. A natural history of the Hawaiian Islands: selected readings. University Press of Hawaii, Honolulu.
- St. John, H. 1947. The history, present distribution, and abundance of sandalwood on Oahu, Hawaiian Islands. Hawaiian Plant Studies 14. Pacific Science 1:5-20.
- St. John, H. 1973. List and summary of the flowering plants in the Hawaiian Islands. Pacific Tropical Botanical Garden, Memoir 1, Lawai, Kauai, Hawaii. 519 pp.
- St. John, H. 1976. The status of *Jacquemontia sandwicensis* (Convolvulaceae). Phytologia 33:423-428.
- U.S. Fish and Wildlife Service. 1976. Endangered and threatened species. Federal Register 41(117): 24524-24572.

#### ACKNOWLEDGEMENTS

The authors would like to thank Ms. Deborah Weiner for typing and for her editorial assistance. They also gratefully acknowledge the aid of Dr. C. W. Smith in preparing and editing this report; Dr. C. H. Lamoureux and Ms. Lani Stemmermann for their critical reviews and helpful suggestions; Dr. Derral Herbst, University of Hawaii Lyon Arboretum, for assisting in the plant identification; and Mr. Y. N. Tamimi, University of Hawaii Beaumont Agricultural Research Center, Hilo, for the soil chemical analysis.



TABLE 1  
PHYSICO-CHEMICAL ANALYSIS OF SOIL FROM  
PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

---

Percent water	10.4
Paste pH	7.82
Ca	3360.0 ppm
Mg	930.0 ppm
K	1300.0 ppm
P	19.1 ppm

---

SOURCE: Beaumont Agricultural Research  
Center, Hilo, Hawaii. Laboratory  
sample #142-2-76.

TABLE 2  
SPECIES CHECKLIST FOR PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

Scientific Name	Common Name	Status	Abundance
PTERIDOPHYTES (Ferns)			
OPHIOGLOSSACEAE			
<i>*Ophioglossum concinnum</i> Brack.	Pololei, pololoi, adder's tongue	E	Rare
ADIANTACEAE			
<i>*Doryopteris decora</i> Brack.	'Iwa'iwa, kumu-niu, manawahua	E	Rare
ANGIOSPERMS (Flowering Plants)			
GRAMINEAE (POACEAE)	GRASS FAMILY		
<i>Aristida adscensionis</i> L.	Sixweeks threeawn	X	Infrequent
<i>Chloris inflata</i> Link	Swollen fingergrass, mau'u lei	X	Infrequent
<i>*Chloris virgata</i> Sw.	Feather fingergrass	X	Infrequent
<i>*Eragrostis cilianensis</i> (All.) Vignolo-Lutati	Stinkgrass	X	Rare
<i>Panicum maximum</i> Jacq.	Guinea grass	X	Rare
<i>Pennisetum setaceum</i> (Forsk.) Chiov.	Fountaingrass	X	Common
<i>Pennisetum ciliare</i> (L.) Link	Feathery pennisetum, buffelgrass	X	Abundant

NOTE:

STATUS

E = Endemic (native, found only in Hawaii)  
I = Indigenous (native, but not unique to Hawaii)  
X = Exotic (introduced)

ABUNDANCE

Rare = only occasional plants found in area  
Infrequent = few plants, generally in localized areas  
Common = plants frequently found in most areas  
Abundant = very numerous

\*Found only in wet season.

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
GRAMINEAE (POACEAE)	GRASS FAMILY		
<i>Rhynchelytrum repens</i> (Willd.) C.E. Hubb.	Natal redtop	X	Infrequent
<i>Setaria verticillata</i> (L.) Beauv.	Bristly foxtail	X	Rare
PALMAE (ARECACEAE)	PALM FAMILY		
<i>Cocos nucifera</i> L.	Coconut, niu	X	Rare
<i>Phoenix canariensis</i> Hort. ex Chabaud	Canary Is. date palm	X	Rare
CHENOPODIACEAE	GOOSEFOOT FAMILY		
* <i>Atriplex ? johnstonii</i> Wolf	Saltbush	X	Rare
* <i>Atriplex muelleri</i> Benth.	Saltbush	X	Infrequent
<i>Atriplex semibaccata</i> R.Br.	Australian saltbush	X	Infrequent
<i>Chenopodium murale</i> L.	Nettle-leaved goosefoot	X	Infrequent
<i>Chenopodium oahuense</i> (Meyen) Aellen	'Āheahea	E	Rare
AMARANTHACEAE	AMARANTH FAMILY		
<i>Amaranthus dubius</i> Mart.	Pakai, spleen amaranth	X	Infrequent
NYCTAGINACEAE	FOUR O'CLOCK FAMILY		
* <i>Boerhavia diffusa</i> L.	Alena	I	Rare

\*Found only in wet season.

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
BATIDACEAE	BATIS FAMILY		
<i>Batis maritima</i> L.	Saltwort, 'ākulikuli-kai	X	Rare
AIZOACEAE	CARPETWEED FAMILY		
<i>Sesuvium portulacastrum</i> (L.) L.	Sea purslane, 'ākulikuli	I	Rare
PORTULACACEAE	PURSLANE FAMILY		
<i>Portulaca cyanosperma</i> Egler	'Ihi, blue-seeded portulaca	E	Infrequent
* <i>Portulaca oleracea</i> L.	Wild portulaca, pigweed	X	Rare
CAPPARACEAE	CAPER FAMILY		
<i>Gynandropsis gynandra</i> (L.) Briq.	African spiderflower, honohina	X	Rare
LEGUMINOSAE (FABACEAE)	PEA FAMILY		
<i>Desmanthus virgatus</i> (L.) Willd.	Slender mimosa	X	Infrequent
<i>Leucaena leucocephala</i> (Lam.) de Wit	Koa-haole	X	Infrequent
<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) HBK.	Kiawe	X	Common
ZYGOPHYLLACEAE	TRIBULUS FAMILY		
* <i>Tribulus cistoides</i> L.	Nohu, large-flowered caltrop	I	Rare
* <i>Tribulus terrestris</i> L.	Puncture vine	X	Infrequent

\*Found only in wet season.

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
<b>EUPHORBIACEAE</b>	<b>SPURGE FAMILY</b>		
* <i>Euphorbia geniculata</i> Ortega	Wild spurge, kaliko	X	Infrequent
<i>Euphorbia hirta</i> L.	Hairy spurge, koko-kahiki	X	Infrequent
<i>Ricinus communis</i> L.	Castor bean, kolī	X	Infrequent
<b>MALVACEAE</b>	<b>MALLOW FAMILY</b>		
<i>Abutilon grandifolium</i> (Willd.) Sweet	Hairy abutilon, ma'o	X	Infrequent
<i>Sida fallax</i> Walp.	'Ilima	I	Infrequent
<i>Thespesia populnea</i> (L.) Soland. ex Correa	Milo	I	Rare
<b>STERCULIACEAE</b>	<b>COCOA FAMILY</b>		
<i>Waltheria americana</i> L.	Hi'a-loa, 'uha-loa	I	Common
<b>PASSIFLORACEAE</b>	<b>PASSION FLOWER FAMILY</b>		
<i>Passiflora foetida</i> L.	Scarlet-fruited passionflower, pohāpohā	X	Rare
<b>CONVOLVULACEAE</b>	<b>MORNING-GLORY FAMILY</b>		
<i>Ipomoea brasiliensis</i> (L.) Sweet (more commonly known as <i>I. pes-caprae</i> )	Beach morning-glory, pōhuehue	I	Rare
<i>Ipomoea congesta</i> R.Br.	Morning-glory, koali-'awahia	I	Rare
<i>Jacquemontia sandwicensis</i> var. <i>tomentosa</i> f. <i>hosakae</i> Deg. & Deg.	Pā'ū-o-Hi'iaka	E	Rare
<i>Merremia aegyptia</i> (L.) Urban	Hairy merremia, koali-kua-hulu	X	Infrequent

\*Found only in wet season.

TABLE 2--Continued

Scientific Name	Common Name	Status	Abundance
BORAGINACEAE		HELIOTROPE FAMILY	
<i>Heliotropium curassavicum</i> L.	Nena, kīpūkai, seaside heliotrope	I	Rare
<i>Messerschmidia argentea</i> (L. f.) Johnston	Tree heliotrope, velvet leaf	X	Rare
SOLANACEAE		NIGHTSHADE FAMILY	
<i>Lycopersicon pimpinellifolium</i> Mill.	Currant tomato, 'ōhi'a-ma-kanahēle	X	Rare
CUCURBITACEAE		GOURD or SQUASH FAMILY	
<i>Citrullus</i> sp.	ipu	X	Rare
GOODENIACEAE		NAUPAKA FAMILY	
<i>Scaevola taccada</i> (Gaertn.) Roxb.	Naupaka-kahakai	I	Rare
COMPOSITAE (ASTERACEAE)		SUNFLOWER FAMILY	
<i>Bidens cynapiifolia</i> HBK.	West Indian beggar's tick	X	Infrequent
<i>Emilia sonchifolia</i> (L.) DC.	Lilac pua-lele	X	Rare
<i>Graphalium peregrinum</i> Fern.		X	Rare
<i>Sonchus oleraceus</i> L.	Sow thistle, pua-lele	X	Rare
<i>Tridax procumbens</i> L.	Coat buttons	X	Rare
FUNGI			
LYCOPERDALES		PUFF-BALLS	
<i>Battarrea phalloides</i> (Dicks.) Pers.	Xerophytic fungus	X	Rare

TABLE 3

## PLANTS PRESENT IN THE FIVE COMMUNITY TYPES AT PUUKOHOLA HEIAU NATIONAL HISTORIC SITE

Scientific Name	Scrub-grassland	Coastal Closed Forest	Fluvial Closed Forest	Halophytic	Roadside
PTERIDOPHYTES (Ferns)					
OPHIOGLOSSACEAE					
<i>Ophioglossum concinnum</i> Brack.	X				
ADIANTACEAE					
<i>Doryopteris decora</i> Brack.	X				
ANGIOSPERMS (Flowering Plants)					
GRAMINEAE (POACEAE)					
<i>Aristida adscensionis</i> L.	X				
<i>Chloris inflata</i> Link	X	X	X		X
<i>Chloris virgata</i> Sw.	X		X		X
<i>Eragrostis cilianensis</i> (All.) Vignolo-Lutati	X				
<i>Panicum maximum</i> Jacq.			X		
<i>Pennisetum setaceum</i> (Forsk.) Chiov.	X				
<i>Pennisetum ciliare</i> (L.) Link	X	X		X	X
<i>Rhynchelytrum repens</i> (Willd.) C.E. Hubb.			X		
<i>Setaria verticillata</i> (L.) Beauv.			X		

TABLE 3--Continued

Scientific Name	Scrub- grassland	Coastal Closed Forest	Fluvial Closed Forest	Halophytic	Roadside
<b>PALMAE (ARECACEAE)</b>					
<i>Cocos nucifera</i> L.				X	
<i>Phoenix canariensis</i> Hort. ex Chabaud				X	
<b>CHENOPODIACEAE</b>					
<i>Atriplex ? johnstonii</i> Wolf				X	
<i>Atriplex muelleri</i> Benth.				X	
<i>Atriplex semibaccata</i> R.Br.				X	
<i>Chenopodium murale</i> L.		X	X	X	
<i>Chenopodium oahuense</i> (Meyen) Aellen				X	
<b>AMARANTHACEAE</b>					
<i>Amaranthus dubius</i> Mart.				X	X
<b>NYCTAGINACEAE</b>					
<i>Boerhavia diffusa</i> L.	X				
<b>BATIDACEAE</b>					
<i>Batis maritima</i> L.				X	
<b>AIZOACEAE</b>					
<i>Sesuvium portulacastrum</i> (L.) L.				X	



TABLE 3--Continued

Scientific Name	Scrub-grassland	Coastal Closed Forest	Fluvial Closed Forest	Halophytic	Roadside
<b>PORTULACACEAE</b>					
<i>Portulaca cyanosperma</i> Egler					X
<i>Portulaca oleracea</i> L.				X	
<b>CAPPARACEAE</b>					
<i>Gynandropsis gynandra</i> (L.) Briq.	X				
<b>LEGUMINOSAE (FABACEAE)</b>					
<i>Desmanthus virgatus</i> (L.) Willd.	X				
<i>Leucaena leucocephala</i> (Lam.) de Wit	X				X
<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) HBK.	X	X	X	X	X
<b>ZYGOPHYLLACEAE</b>					
<i>Tribulus cistoides</i> L.			X		
<i>Tribulus terrestris</i> L.			X		
<b>EUPHORBIACEAE</b>					
<i>Euphorbia geniculata</i> Ortega			X		
<i>Euphorbia hirta</i> L.				X	
<i>Ricinus communis</i> L.	X	X	X		
<b>MALVACEAE</b>					
<i>Abutilon grandifolium</i> (Willd.) Sweet		X			X

TABLE 3-- Continued

Scientific Name	Scrub- grassland	Coastal Closed Forest	Fluvial Closed Forest	Halophytic	Roadside
<b>MALVACEAE</b>					
<i>Sida fallax</i> Walp.	X	X			X
<i>Thespesia populnea</i> (L.) Soland. ex Correa				X	
<b>STERCULIACEAE</b>					
<i>Waltheria americana</i> L.	X				X
<b>PASSIFLORACEAE</b>					
<i>Passiflora foetida</i> L.				X	
<b>CONVOLVULACEAE</b>					
<i>Ipomoea brasiliensis</i> (L.) Sweet (more commonly known as <i>I. pes-caprae</i> )				X	
<i>Ipomoea congesta</i> R.Br.	X				
<i>Jacquemontia sandwicensis</i> var. <i>tomentosa</i> f. <i>hosakae</i> Deg. & Deg.	X				
<i>Merremia aegyptia</i> (L.) Urban	X				
<b>BORAGINACEAE</b>					
<i>Heliotropium curassavicum</i> L.				X	
<i>Messerschmidia argentea</i> (L. f.) Johnston				X	

TABLE 3--Continued

Scientific Name	Scrub- grassland	Coastal Closed Forest	Fluvial Closed Forest	Halophytic	Roadside
<b>SOLANACEAE</b>					
<i>Lycopersicon pimpinellifolium</i> Mill.		X			
<b>CUCURBITACEAE</b>					
<i>Citrullus</i> sp.		X			
<b>GOODENIACEAE</b>					
<i>Scaevola taccada</i> (Gaertn.) Roxb.				X	
<b>COMPOSITAE (ASTERACEAE)</b>					
<i>Bidens cynapiifolia</i> HBK.	X	X	X		X
<i>Emilia sonchifolia</i> (L.) DC.	X		X		X
<i>Gnaphalium peregrinum</i> Fern.	X				
<i>Sonchus oleraceus</i> L.			X		
<i>Tridax procumbens</i> L.			X		
<b>FUNGI</b>					
<b>LYCOPERDALES</b>					
<i>Battarrea phalloides</i> (Dicks.) Pers.	X				

APPENDIX 1

Percentage cover of individual species along the roadside transects  
at Puukohola Heiau National Historic Site

Transect	Species	<u>Quadrat Number</u>							
		1	3	5	7	9	11	13	15
#1	<i>Pennisetum ciliare</i> Feathery pennisetum	100	100	100	100	60	100	100	100
	<i>Prosopis pallida</i> Kiawe					40			
#2	<i>Pennisetum ciliare</i> Feathery pennisetum	100	100	100	100	100	100	100	100
#3	<i>Prosopis pallida</i> Kiawe	95							
	<i>Sida fallax</i> 'Ilima	5							
	<i>Pennisetum ciliare</i> Feathery pennisetum		100	100	95	50	94	100	50
	<i>Euphorbia hirta</i> Hairy spurge				5				
	Bare ground					50	6		50

APPENDIX 1 (continued)

Transect	Species	Quadrat Number							
		1	3	5	7	9	11	13	15
#4	<i>Pennisetum ciliare</i> Feathery pennisetum	100	99	35	100	100	60	70	75
	<i>Sida fallax</i> 'Ilima		1					30	
	<i>Prosopis pallida</i> Kiawe						40		
	Bare ground			65					25
#5	<i>Pennisetum ciliare</i> Feathery pennisetum					25	70	35	60
	<i>Sesuvium portulacastrum</i> Sea purslane					2			
	<i>Merremia aegyptia</i> Hairy merremia					3	30	5	
	Bare ground	100	100	100	100	70		60	40
#6	<i>Pennisetum ciliare</i> Feathery pennisetum	95	50	25	75	25	95	75	90
	<i>Sida fallax</i> 'Ilima						5		
	Bare ground	5			25	75			10
	Rock		50	75				25	

APPENDIX 1 (continued)

Transect	Species	Quadrat Number							
		1	3	5	7	9	11	13	15
#7	<i>Pennisetum ciliare</i> Feathery pennisetum	96	30		20	50	80	5	
	<i>Leucaena leucocephala</i> Koa haole	4	2	100	60	10		10	
	Bare ground		68		20	40	19	85	
	Rock								100
	<i>Prosopis pallida</i> Kiawe						1		
#8	<i>Pennisetum ciliare</i> Feathery pennisetum						10	10	
	<i>Pennisetum setaceum</i> Fountaingrass						10		
	<i>Leucaena leucocephala</i> Koa haole						40		
	Rock					100	40	90	100
#9	<i>Pennisetum ciliare</i> Feathery pennisetum			90	30	10	25	50	50
	<i>Prosopis pallida</i> Kiawe					1		50	50
	Rock	100	100	10	70	89	75		

APPENDIX 1 (continued)

Transect	Species	Quadrat Number									
		1	3	5	7	9	11	13	15		
#10	<i>Pennisetum ciliare</i>		40	90	10	20	25				
	Feathery pennisetum		60	10	90		100				
	Bare ground										
	Rock	100				80	75			100	
#11	<i>Pennisetum ciliare</i>	90	90	90	90	50	70			90	
	Feathery pennisetum										
	Bare ground	10	10	10	10	50	30	100	100	10	
#12	<i>Pennisetum ciliare</i>	100	100								
	Feathery pennisetum										
	Concrete rubble			100	100	100	100	100	100	100	
#13	<i>Pennisetum ciliare</i>			80	100	80	20	20	20	60	
	Feathery pennisetum										
	Bare ground	100	100	20		20	80	80	80	40	
#14	<i>Pennisetum ciliare</i>									10	
	Feathery pennisetum										
#15	<i>Pennisetum ciliare</i>	80	30	40	75	95	80	95	95	95	
	Feathery pennisetum										
	Bare ground	20		60	25						
	Rock		70			5	20	5	5	5	

APPENDIX 1 (continued)

Transect	Species	Quadrat Number							
		1	3	5	7	9	11	13	15
#16	Transect #16 ran through entrance to service roadway of Mailekini Heiau.								
#17	<i>Pennisetum ciliare</i> Feathery pennisetum	85	80	10	50	90	5	30	40
	Bare ground	15	20	90	50	10	95	70	60
#18	<i>Pennisetum ciliare</i> Feathery pennisetum		30		40	30	10	10	
	<i>Prosopis pallida</i> Kiawe							80	100
	Rock	100	20			20		10	
	Bare ground		50	100	60	50	90		
#19	<i>Pennisetum ciliare</i> Feathery pennisetum	50	40	50	50	50	50	50	50
	<i>Prosopis pallida</i> Kiawe	50	40	50	50	50	50	50	50
	<i>Leucaena leucocephala</i> Koa haole		20						
Control	<i>Pennisetum ciliare</i> Feathery pennisetum	10	30	100	100	100	100	100	100
	Bare ground	90	70						





## APPENDIX 2

*National Museum of Natural History - Smithsonian Institution*

WASHINGTON, D.C. 20560 • TEL. 202-

December 1, 1976

Prof. Don E. Hemmes  
 Sciences Division  
 University of Hawaii  
 P.O. Box 1357  
 Hilo, Hawaii 96720

Dear Dr. Hemmes:

I am sorry to be so slow in replying to your letter of October 14. It came when I was overseas and I am just getting to the various identification jobs that piled up while I was away.

The two plants you sent are both interesting. Unfortunately Mr. Macneil did not number his collections, so it is hard to talk about them. Also he gives very little information. It would be good to know, for example, if the Atriplex is a shrub or an herb, what its habit and appearance are.

The grass is what has up to now usually been called Pennisetum setosum or Pennisetum polystachion. Rotar gives it under both Cenchrus ciliaris and Pennisetum setosum, with very different-looking drawings, neither looking much like it. My opinion now is that it belongs to the taxon known generally as Pennisetum ciliare (L.) Link, but which in the most recent work on Cenchrus has been called Cenchrus ciliaris L. Your question has made me look rather carefully at this group from other areas. The trouble is that it belongs at the place in the genus Pennisetum from which Cenchrus arose and it makes little difference in which genus you place it. They run together. I personally prefer, until I get better evidence, to call it Pennisetum ciliare (L.) Link, because of its obvious close relationship to P. polystachion (P. setosum), but no one can be very critical if one calls it Cenchrus ciliaris, following DeLisle's revision. I would not call it P. setosum as most people in Hawaii have.

The Atriplex is also difficult, but in a different way. The specimens are very scrappy and there is no information as to whether we are dealing with a bush or an herb, what its growth habit is--erect, arching, or creeping. There are no lower leaves, and though there are both male flowers and fruits on the same sheets, it is not stated if the plants are individually predominantly of one sex, or if they are typically monoecious. Unfortunately these are the sort of characters used in most of the keys. I have tried to match it in the herbarium and it seems to come closest to Atriplex johnstonii Wolf, of Southern California, but the match is not very good. The leaves, especially, are wrong, both for A. johnstonii and for A. nummularia, which I

Prof. Don E. Hemmes

-2-

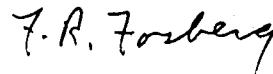
December 1, 1976

first thought it might be. For the time being I will call it Atriplex johnstonii Wolf.

I would appreciate it if you could collect a good series of specimens, showing more of the plant, noting if the leaves when fresh are green or gray and the habit of the plant. I would also like more information on the locality. I know the Park fairly well, but do not know the Puukohola Heiau. I presume it is along the coast, but where?

I may get to Hawaii next February or March, and will be visiting Juliette Wentworth if so. Please give Roger Baldwin my greetings, and Juliette, if you see her. I'll be happy to look at any of your plants if you have extra material.

Very sincerely,



F. R. Fosberg  
Senior Botanist

FRF:bd