Technical Report 105

Vascular Plants of Pu'uhonua O Hōnaunau National Historical Park

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VASCULAR PLANTS OF PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

VASCULAR PLANTS OF PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK

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ABSTRACT

The vegetation of Pu'uhonua o Hōnaunau National Historical Park was surveyed in 1992-93 as part of a monitoring study of plants, birds, mammals, and invertebrates of three Kona parks. One hundred thirty four vascular plant species were found in the Park, including six endemic species (4%), 17 (13%) indigenous species, 15 (11%) Polynesian introductions, and 96 (72%) alien or non-indigenous species introduced after 1778. Thirty-three species were additions to the known flora of the Park since the previous plant checklist (Smith et al. 1986).

Alien woody species were the dominant elements in the Park's vegetation. Ēkoa (Leucaena leucocephala) was the most abundant alien shrub species in the Park, occurring in 93% of vegetation plots often with >75% estimated cover. 'Opiuma (Pithecellobium dulce) was found in 70% of vegetation plots and had cover values ranging from <1% to 5-25%. Christmas berry (Schinus terebinthifolius), klu (Acacia farnesiana), and lantana (Lantana camara) were found in about half the plots with estimated cover of <1% to 1-5%. Kiawe (Prosopis pallida) occurred in only 10% of plots with estimated cover values from 5-25% to >75%. Guinea grass (Panicum maximum) grew in 33% of all vegetation plots, and had its greatest cover (>50%) south of Alahaka Pali. Natal redtop grass (Rhynchelytrum repens) occurred in 67% of plots, primarily north of Alahaka Pali. Redtop cover was variable and was highest near the 1871 trail. Six other herbaceous species were seen in many plots, but had low estimated cover.

All non-cultivated native plants and several naturalized Polynesian introductions were mapped along transects, trails, the coast, and near brackish pools. The most notable native plant was maiapilo (Capparis sandwichiana), a candidate endangered species; only one maiapilo shrub was found within the Park. Fourteen non-cultivated, indigenous species were located during this survey; eight of these were found along the coast or near brackish pools, and six others were on transects upslope. Pili (Heteropogon contortus) was among the indigenous plants found upslope in the Park, and the grass was also planted near the visitor center.

Vegetation types were similar to those mapped by Leishmann in 1986. Ēkoa shrubland was the most widespread vegetation type in the Park; in the northern part of the Park this shrubland has become more closed since 1986. Natal redtop grasslands also appear to have decreased in extent since 1986, probably through the invasion of ēkoa and other alien shrubs.

ACKNOWLEDGMENTS

We would like to thank Pu'uhonua o Hōnaunau Superintendent Jerry Shimoda and his staff, particularly Gordon Joyce and Charles Hua, for their assistance and cooperation during this study. We are especially grateful for the use of the Park dormitory during field data collection. Members of the research staff at Hawaii Volcanoes National Park and Kaloko-Honokōhau National Historical Park assisted us in the field and contributed to the botanical component of the monitoring project. Dr. Charles Stone planned this project and coordinated surveys at the three Kona Parks. Mark Aeder and Jason Texeira established transects for data collection. Michelle Fulton participated in the field survey and helped us with data entry and summarization. We would also like to thank Dr. Charles Lamoureux of Lyon Arboretum and Dr. George Staples of Bernice P. Bishop Museum for their useful comments on an earlier draft of this report and checklist.

INTRODUCTION

The pu'uhonua or place of refuge at Hōnaunau, along with associated cultural features, is one of the most important archaeological and historical sites in the Hawaiian Islands (Kirch 1985). In addition to the pu'uhonua enclosed by the 1,000-ft-long Great Wall, the Pu'uhonua o Hōnaunau area contains several significant heiau or temples, three hōlua (sled tracks) and numerous house sites, including a complex of ali'i or royal residences (National Park Service 1976). After the breakdown of the traditional Hawaiian religious and kapu system, structures at the Hale o Keawe Heiau within the Great Wall were destroyed in 1829, and the area came to be used for goats and later cattle (Emory 1986).

Vegetation of the area was historically open with groves of planted trees and patches of grass; sparse vegetation prevailed until after the 1920s (National Park Service 1976). By the 1950s, the area was covered by thorny introduced shrubs (Greenwell 1986), and was maintained as a County Park. The National Park Service acquired approximately 182 acres at Hōnaunau and established Pu'uhonua o Hōnaunau National Historical Park (first called City of Refuge NHP) in 1961 (National Park Service 1976).

After acquisition, the Park Service cleared approximately 80 acres of alien shrubs and planted a number of Polynesian and native plant species (National Park Service 1976). Today the Park maintains open conditions along the coast, along the 1871 trail, and near many significant archaeological and historic sites and the visitor center in the northwestern quarter of the Park. The remainder of the Park is covered by dense, largely alien vegetation and is little used by visitors.

The first published list of plants of Hōnaunau was made in 1957 (Greenwell 1986) as part of a study of the natural and cultural history of the area; this list included only native and Polynesian plants. A complete vascular plant checklist was produced in 1986, the result of a survey of the Park during wet and dry periods of three successive years

(Smith et al. 1986). In the same year, a vegetation map of the Park was drawn from ground surveys and aerial photograph interpretation (Leishmann 1986). The botanical survey presented here was part of a larger project designed to sample the plants, birds, mammals, and invertebrates of Pu'uhonua o Hōnaunau NHP, as well as those of Kaloko-Honokōhau National Historical Park and Pu'ukoholā Heiau National Historical Site. The results of plant surveys at the two other Kona Parks were presented in separate reports.

THE STUDY AREA

Pu'uhonua o Hōnaunau NHP is located on the western (leeward) coast of the island of Hawai'i in the South Kona District. The Park is approximately 26 km (16 mi) south of the city of Kailua-Kona and 4 km (2.4 mi) downslope and west of the Māmalahoa Highway. Stretching from Hōnaunau Bay to Ki'ilae Bay, the Park occupies the entire coastline of Kēōkea ahupua'a (land division) and portions of Hōnaunau and Ki'ilae ahupua'a (Fig. 1).

Climate - The Kona coast of Hawai'i has a distinct climatic regime drier and warmer than the windward side of the island. The Kona climate generally has its greatest rainfall in the summer and is characterized by pronounced daily wind patterns of land and sea breezes (Blumenstock and Price 1967). Mean annual rainfall at Hōnaunau is 659 mm (26 in). Highest monthly mean rainfall occurs in January and the summer months of June, August, and September (Giambelluca et al. 1986). Temperatures are warm in the coastal region of Kona; mean annual temperature is greater than 23.3°C (74°F). Warmer temperatures are experienced in the summer, but seasonal variation is not great. At Nāpō'opo'o, on the coast to the north, mean monthly maximum temperature ranges from 26.4°C (79.6°F) in January to 29.1°C (84.4°F) in August. Mean monthly minimum temperature follows the same pattern, ranging from 17.4°C (63.3°F) in February to 20.0°C (68.0°F) in August (Hawaii State Department of Land and Natural Resources 1970).

Geology and Soils - Pu'uhonua o Hōnaunau NHP is on the coastal plain of Mauna Loa, an active volcano that last erupted in 1984. Most of the western slope of Mauna Loa is covered by prehistoric flows of the Ka'ū Series that originated from the summit and southwest rift of the volcano (MacDonald and Abbott 1979). Most of the Park's substrate is composed of lava flows dated at 750 to 1,500 years before present (bp, before 1950). Flows of this age group cover approximately one quarter of Mauna Loa. Lava flows in the extreme southern part of the Park belong to an older group of flows dated at 1,500-4,000 years bp (Lockwood and Lipman 1987, Lockwood et al. 1988). Very little soil development has taken place on Park lava flows. Sato et al. (1973) classified most of the Park substrates as pāhoehoe lava with no soil covering and categorized the southern part of the Park as rough broken land, a miscellaneous land type of gulches and drainage channels with a variable soil cover. Bryan (1986) used an older

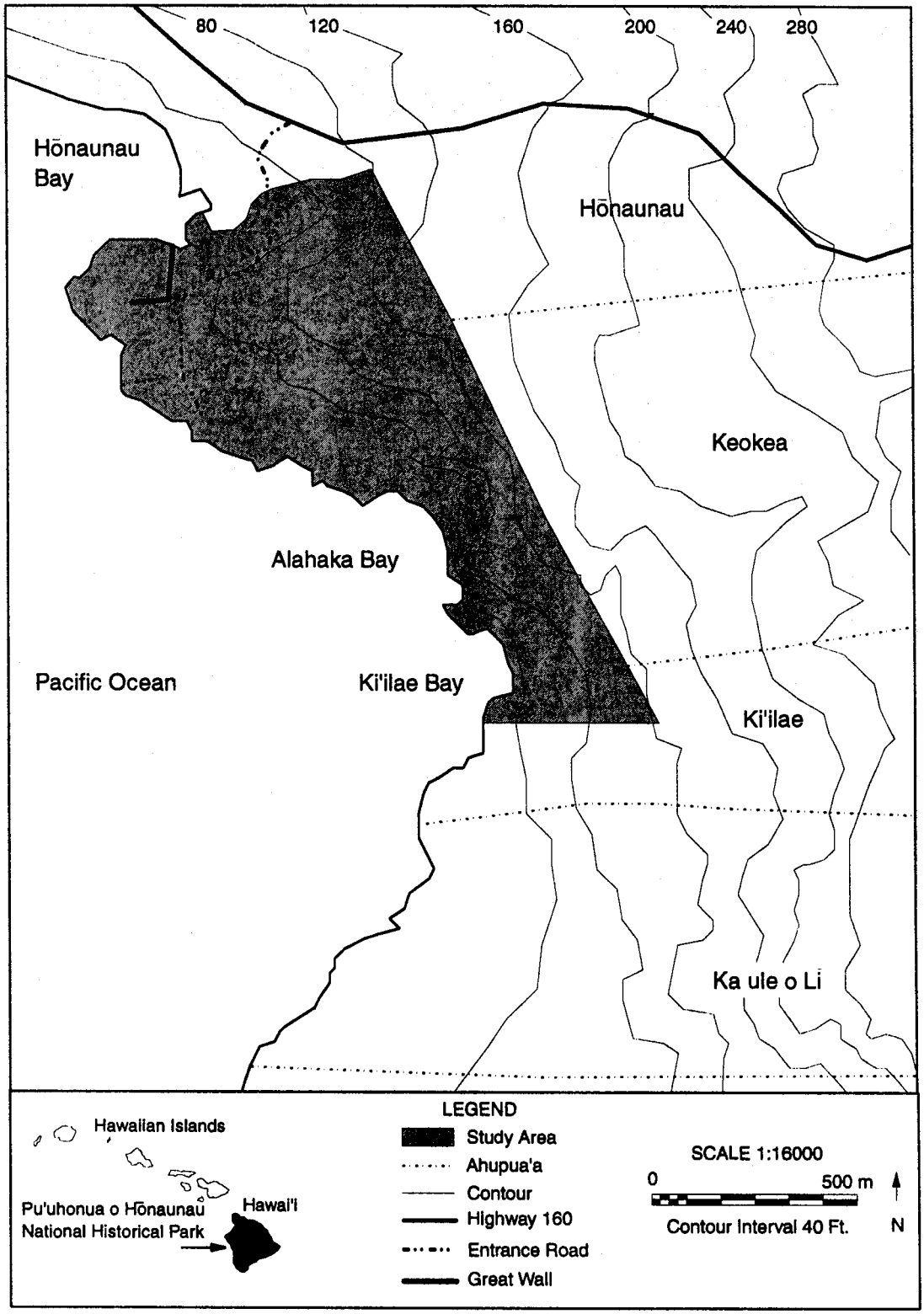

Figure 1. Pu'uhonua o Hōnaunau National Historical Park and surrounding land divisions, island of Hawai'i.

soil classification system that described the soils of the Park as rockland of pāhoehoe with very thin ash soil. In this older system, soils of the southern part of the Park were placed in the Wai'aha series of shallow ash soils over pāhoehoe.

Vegetation - The current vegetation of Pu'uhonua o Hōnaunau NHP is predominantly alien, except for the developed part of the Park, where coconut (Cocos nucifera) groves and plantings of Polynesian introductions are found. Leishmann (1986) mapped the Park's vegetation, using 26 different map units grouped into four basic vegetation types: alien shrubland, grassland, managed vegetation, and coastal strand. Most of the Park east of the 1871 trail was mapped as alien shrublands, with ēkoa or koa haole (Leucaena leucocephala) generally the dominant shrub. Several grassland types were recognized; the grass with the greatest cover was Natal redtop (Rhynchelytrum repens). Managed vegetation was dominated by coconut palms, and coastal strand was composed of native sedges, shrubs, and vines.

Alien shrublands have been prominent at Pu'uhonua o Hōnaunau for more than 40 years. Greenwell (1986), writing in 1957, described the vegetation of the future Park as a "tangle of exotics comprised mostly of kiawe, klu, 'opiuma, Lantana camara, pānini, ēkoa, 'uhaloa, Passiflora foetida, and monkeypod." Greenwell also reported that 50 years earlier (ca. 1907) the area above the beach was covered by pili (Heteropogon contortus). The vegetation of Pu'uhonua o Hōnaunau is thought to have been much more open during the time of Hawaiian habitation (National Park Service 1976). Vegetation prior to the arrival of Polynesians was probably a dry forest or shrubland of 'ōhi'a (Metrosideros polymorpha) with shrubs, grasses, and other native trees, such as wiliwili (Erythrina sandwicensis), naio (Myoporum sandwicense), and alahe'e (Canthium odoratum). Coastal and wetland vegetation may have been more extensive in pre-human times, and probably contained many species absent today.

METHODS

Data on plants (as well as on birds, mammals, and insects) were collected on a series of systematically placed transects crossing the Park from east to west. Transects started on the eastern boundary fenceline; the first began 50 m from a large corner post near the sewage station reached by the service road from the visitor center parking lot. The first five transects (00, 0 1, 2, and 3) were placed at intervals of 150 m along the fenceline; Transect 4 was 600 m from Transect 3 and 300 m north of the corner of the Park; and Transect 5 was the fenced southern Park boundary. Transects followed an azimuth of 250° true. The first four transects were approximately 500 m in length and ended at either the unpaved road to Park buildings and the picnic area or the coastal trail. Transect 3 was only 100 m long and ended on the edge of a cliff. Transects 4 and 5 were 200 and 280 m long, and both ended at the 1871 trail. Transects were marked at 10 m intervals.

The botanical survey was carried out between September and December 1992 with additional visits to the Park in September 1993. Vegetation was sampled in plots 10 m wide and 20 m long placed at 100-m intervals along transects, starting at 0. Thirty plots were established in the Park. The species composition of each plot was recorded. The percentage cover of each plant species within the plot was estimated using the Braun-Blanquet cover-abundance scale (Mueller-Dombois and Ellenberg 1974). The cover-abundance (determined from vegetation plots) of 16 alien plant species was mapped. Alien species mapped included eight of the most invasive shrub and grass species, two potentially invasive shrubs, and the six most common herbaceous species. The frequency of occurrence of each alien plant species was determined as the percentage of the total number of plots that contained each species.

The number of individuals of native plant species and Polynesian introductions was counted along transects in a belt 10 m wide. For mapping purposes, native plant numbers, by species, were summed over 100-m increments of the transects. Native plant densities (mean number per 10-m segment or 100 m^2) were calculated for the total length of transects in the Park and were extrapolated for reporting as number of plants/1,000 m^2. Only on-transect plants were included in this calculation. Native plants were also surveyed on the coast, along the 1871 trail, and along the base of the Alahaka Pali or cliff (also called Keanae'e Pali). Distances along trails and the coast were estimated by pacing, and native plants were mapped in 100-m increments. Trails in the developed part of the Park were walked and native plant localities were noted. Some species of native plants and Polynesian introductions (particularly sedges, grasses, sprawling herbs, dense shrubs, and palms) could not be individually counted; concentrations of these plants were mapped along transects and in other surveyed areas. Except for coconut palms and pili, which also occurred growing wild, no attempt was made to map species that were obviously planted.

A checklist was compiled of all vascular plant species seen within the Park (Appendix 1). Notes on species presence and distribution were made along transects, trails, roads, the coastline, and the developed part of the Park. Wagner et al. (1990) was used for the nomenclature of flowering plants, and an unpublished list by Wagner and Wagner (1995) was followed for the scientific names of ferns and fern allies. Common names of most flowering plants were derived from Wagner et al. (1990); for cultivated plants and ferns, Porter (1972) and St. John (1973) were consulted. Voucher specimens were made only when necessary for identification. A nearly comprehensive collection of specimens from the last botanical survey (Smith et al. 1986), deposited at the Hawaii Volcanoes National Park Herbarium, was consulted for this project.

RESULTS AND DISCUSSION

Plant Species Composition

One hundred thirty four vascular plant species were found in Pu'uhonua o Hōnaunau NHP during the 1992-93 survey, including six endemic or unique species (4%), 17 (13%) indigenous species, 15 (11%) Polynesian introductions, and 96 (72%) alien or non-indigenous species introduced after 1778. (See Appendix 1, Pu'uhonua o Hōnaunau NHP Vascular Plant Checklist). Only four species of ferns or fern allies were seen in the Park. Among the Park's flowering plants, most species (91) were dicotyledons. Forty-three different dicotyledonous families were represented in the Park's flora; members of the sunflower and pea families (Asteraceae and Fabaceae) were particularly numerous. Thirty-nine species of monocotyledons in 12 families occurred in the Park; more than half of these were grasses (Poaceae) and sedges (Cyperaceae).

Half of the endemic species found in the Park (3) appeared to be intentionally planted, but only four of the indigenous species were obviously cultivated. Most of the Polynesian introductions were represented in the Park by individuals planted in the developed areas; only three Polynesian species were completely naturalized and growing wild in the Park, and two others were probably both naturalized and planted. Of the 96 alien plant species in Pu'uhonua o Hōnaunau NHP, 19 were either intentionally planted or were persisting from old plantings; these species did not seem to be naturalized.

The number of vascular plant species in Pu'uhonua o Hōnaunau NHP has not changed greatly since the last botanical survey in 1984-86. Smith et al. (1986) found 126 vascular plant species within the Park; the proportions of species in the four different status groups were very similar for the two surveys. The percentage of alien species found in the Park decreased slightly between 1986 and 1993 (from 74% to 72%) and the percentage of Polynesian introductions increased (from 8% to 11%), undoubtedly due to plantings of culturally important species near the visitor center.

Additions to the Park's Flora - There were 33 additions to the Park's flora from the 1992-93 survey. Three native species were found that were not on the 1986 checklist. The fern 'iwa'iwa (Doryopteris decora) was seen only at the base of Alahaka (Keanae'e) Pali. The coastal sedge mau'u 'aki'aki (Fimbristylis cymosa) was not on the Smith et al. (1986) checklist, but there is a specimen of the sedge from the survey in the Hawaii Volcanoes National Park herbarium (Higashino and Stemmermann 10230). This species seems to have been inadvertently omitted from the 1986 checklist. One native species addition, 'a'ali'i (Dodonaea viscosa), was clearly planted near Park buildings. Fifteen other species, including four Polynesian introductions and 11 alien ornamentals, were probably planted in the Park since the 1986 survey. The remaining 15 additions to the flora were alien species apparently naturalized in the Park. Several of these alien species may have invaded the Park only recently; only one individual autograph tree (Clusia rosea), one hairy merremia (Merremia aegyptia) vine, and one Chinese banyan (Ficus

microcarpa) were noted during the 1992-93 survey. Other species, such as the fast-growing beggarweed shrubs (Desmodium cajanifolium and D. tortuosum), were found in only a few sites near the 1871 trail. Some of the alien species added during the current survey were annuals (Emilia fosbergii, Tridax procumbens) that appear seasonally.

Species Not Found Within the Park in 1992-93 - Twenty-three plant species listed from the Park in 1986 (Smith et al. 1986) were not seen during the 1992-93 survey. Among these were four plants listed from a previous survey that had apparently disappeared from the Park by 1986. Five of the plants not seen in 1992-93 were cultivated species in the developed portion of the Park; these may have died or been removed since 1986. This part of the Park was not exhaustively surveyed in 1992-93, as the primary objective was a systematic survey of the Park's undeveloped vegetation; species planted as just one individual may have been overlooked. Three other species not noted in 1992-93 were annuals and likely remain part of the Park's flora; these were purple cudweed (Gnaphalium purpureum), hedgehog or teasel gourd (Cucumis dipsaceus), and saltbush (Atriplex eardleyae, originally reported as A. semibaccata). The annual saltbush found in Pu'uhonua o Hōnaunau was documented by a voucher specimen in 1984 (Higashino et al. 10266, BISH); this was the first naturalized collection of the species in Hawai'i (Wagner et al. 1989).

Fountain grass was present in 1986 as a few individuals, but was not found in the Park in 1992-93; this invasive alien grass may have been eradicated from the Park as recommended by Smith et al. (1986). California grass (Brachiaria mutica) may also have been controlled, as it was listed by Smith et al. as a potential disturber of archaeological sites. Other alien species not resighted in 1992-93 were perennial plants listed as rare, uncommon, or occasional in 1986; their current status in the Park is uncertain.

Four native species listed in 1986 were not found during the 1992-93 survey. Ili'e'e (Plumbago zeylanica), a low-growing indigenous shrub, was noted as uncommon without locality information in 1986, and kīpūkai or nena (Heliotropium curassavicum) was rare along the coastal strand in the earlier survey. The coastline and adjacent shrublands of the Park were searched in 1992; future surveys should attempt to establish the status of these native plants in the Park. Another native species not relocated during the current survey was the indigenous swordfern or kupukupu (Nephrolepis exaltata). In 1992-93, the alien scaly swordfern (N. multiflora) was found to be relatively common in open, rocky areas, but the indigenous swordfern was not seen. If mixed with scaly swordfern, the native species might be easily overlooked. The fourth native species not found in 1992-93 was pōpolo or glossy nightshade, a questionably indigenous annual or short-lived herb. Pōpolo likely remains an ephemeral component of the Park's vegetation.

Alien Plant Species

Ninety-six alien plant species were found in Pu'uhonua o Hōnaunau NHP in 1992-93, but most of these were rated as uncommon to occasional in abundance. The one tree, five shrub, and two grass species discussed separately below were particularly abundant and widespread within the Park or were species capable of dominating lowland vegetation. These species, excluding kiawe (Prosopis pallida), have invaded much of the Park outside the developed area near the visitor center, park buildings, and cleared archaeological sites. Kiawe was not widespread, but is included here because of its ability to dominate lowland forests and shrublands elsewhere on the island. Five other alien shrub or tree species were rare in the Park in 1992-93, but have the potential to become more widespread and abundant. Six herbaceous alien species were distributed throughout much of the Park, but typically had low estimated cover in vegetation plots. These herbaceous aliens are not generally thought to be seriously disruptive species.

Ēkoa (Leucaena leucocephala) - A large shrub or small tree in the pea family, ēkoa or koa haole is native to tropical America but was an early introduction into the Hawaiian Islands. Ēkoa has been planted and spread throughout the Islands for use as cattle fodder, firewood, and erosion control, and the species is now naturalized in dry lowland regions on all the main Hawaiian Islands (Wagner et al. 1990).

Ēkoa was the most abundant woody plant in Pu'uhonua o Hōnaunau. The shrub was almost ubiquitous along the seven transects, and was found in 93% of the systematically-placed vegetation plots. Estimated percentage cover of ēkoa in plots was very high; approximately half of plots had >75% cover of the shrub (Fig. 2). Ēkoa cover was greatest in the eastern, upslope part of the Park; cover of the shrub was generally lower near the coast. Ēkoa was a co-dominant of vegetation at the base of Alahaka Pali. The shrub was very rare in the developed part of the Park.

Christmas berry (Schinus terebinthifolius) - A shrub in the mango family, Christmas berry is native to Brazil. The species was introduced to Hawaii as an ornamental, and its bright red berries are still used in leis and Christmas decorations (Neal 1965). Christmas berry is now naturalized in moist lowland areas on all the main Hawaiian Islands except Ni'ihau and Kaho'olawe (Wagner et al. 1990). Capable of forming dense thickets, Christmas berry may shade out other plants and produce inhibiting (allelopathic) substances (Smith 1985).

Christmas berry was distributed throughout the northern half of the Park, but was rare south of Alahaka Pali, where it was seen only at the base of the cliff. The shrub occurred in 47% of vegetation plots along transects. While widespread, Christmas berry had little estimated cover in plots; percentage cover was typically 1-5% on the eastern side of the Park and <1% near the 1871 trail and the coast (Fig. 3). Very little Christmas berry was present in the developed part of the Park.

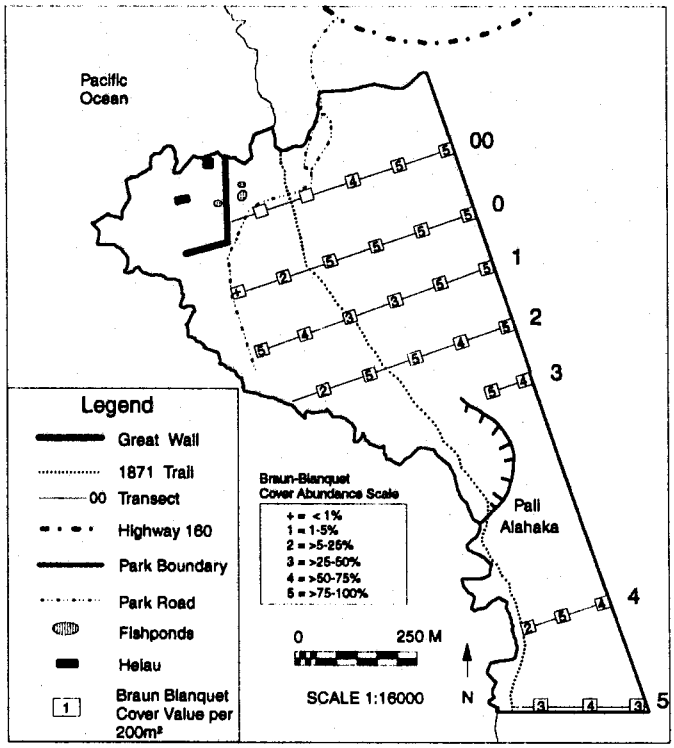

Figure 2. Estimated cover of ēkoa (Leucaena leucocephala) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

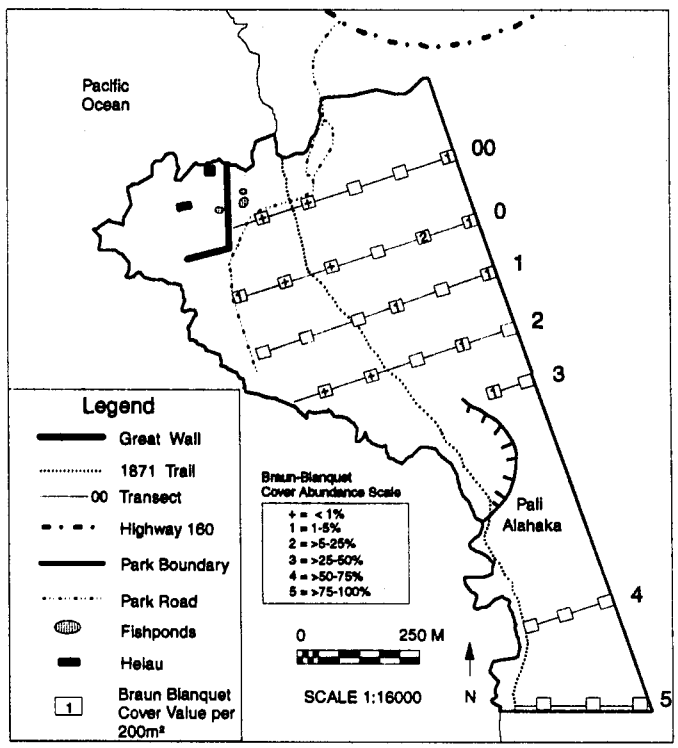

Figure 3. Estimated cover of Christmas berry (Schinus terebinthifolius) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

Kiawe (Prosopis pallida) - A thorny tree in the pea family, kiawe or mesquite is native to South America, and was introduced to Honolulu from Paris in 1828. Kiawe pods were widely used in the past as cattle and horse feed, and the seeds were spread by domestic animals. The tree is now abundant in dry low-elevation regions of all the main Hawaiian Islands (Wagner et al. 1990). While economically valuable as a source of animal forage, firewood, charcoal, and honey (Neal 1965), kiawe may have the negative effect of lowering an area's water table (Smith 1985).

Kiawe was not abundant in Pu'uhonua o Hōnaunau NHP, and occurred in only 10% of vegetation plots on only two transects. Estimated cover of the tree in plots ranged from 5-25% to >75% (Fig. 4). Kiawe was found along transects only near the coast and in dense forest/shrubland near the southern Park boundary. Stands of kiawe trees were also seen away from transects at two coastal sites in the southern half of the Park. Leishmann (1986) also mapped small stands of closed kiawe near Park buildings and at the coastal picnic area.

Klu (Acacia farnesiana) - Another member of the pea family, klu is a thorny shrub native to tropical America. The shrub was introduced to Hawai'i in the 1800s for its fragrant, yellow flowers, was used for a short-lived perfume industry, and is now naturalized on all the main islands except Ni'ihau and Lāna'i (Wagner et al. 1990).

Klu occurred in 43% of vegetation plots along transects but was much more common in the northern part of the Park, particularly on the eastern side of the 1871 trail. Estimated cover of klu in plots was typically <1% or 1-5% (Fig. 5). Although in Fig. 5 klu appears to be absent from transect 2, the shrub did occur on the transect, but did not fall within sampled vegetation plots. Klu was not an important component of vegetation in the developed part of the Park.

Lantana (Lantana camara) - Lantana is a thorny shrub in the verbena family. Native to the West Indies, lantana was introduced to Hawai'i in 1858 and soon became established on all the main Hawaiian Islands (Wagner et al. 1990). A hardy plant with showy pink and orange flowers, lantana is still planted as an ornamentalin Hawai'i, although the shrub is considered a range pest, and many insect biocontrol agents have been introduced to combat its spread (Clausen 1978).

Lantana was widespread in the undeveloped northern part of Pu'uhonua o Hōnaunau, but rarely had estimated cover >1% in sampled vegetation plots (Fig. 6). The species occurred in 53% of all systematically placed plots. Very few lantana shrubs were noted in the developed portion of the Park.

'Opiuma (Pithecellobium dulce) - Another thorny South American shrub of the pea family, 'opiuma or Manila tamarind was introduced to Hawai'i as an ornamental in the late 1800s, and now grows wild in dry lowlands of all the main Hawaiian Islands except Kaho'olawe and Lāna'i (Wagner et al. 1990).

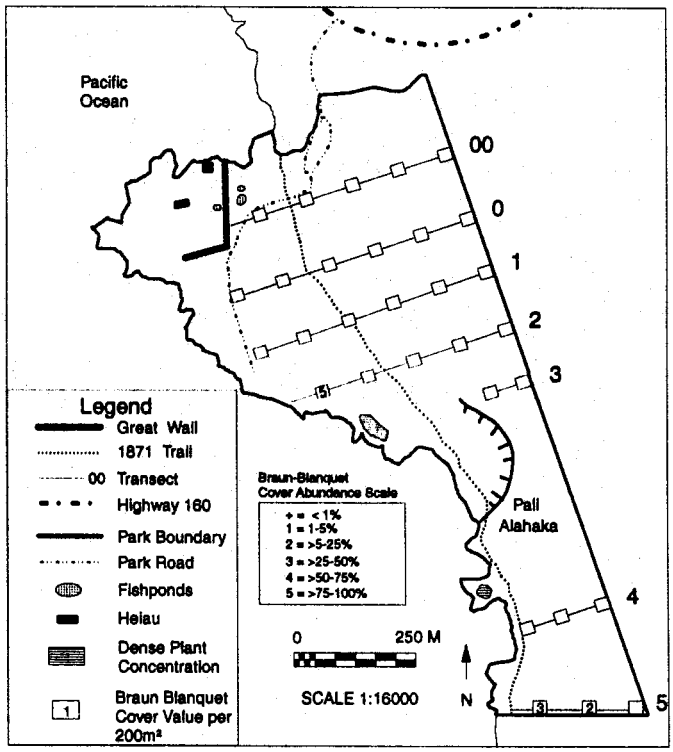

Figure 4. Estimated cover of kiawe (Prosopis pallida) in vegetation plots along transects and dense concentrations sighted off transect in Pu'uhonua o Hōnaunau National Historical Park.

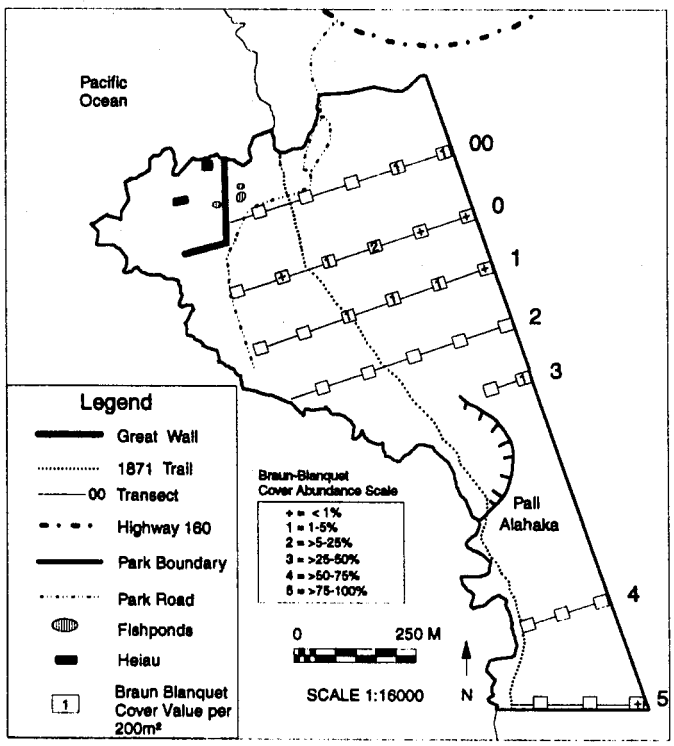

Figure 5. Estimated cover of klu (Acacia farnesiana) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

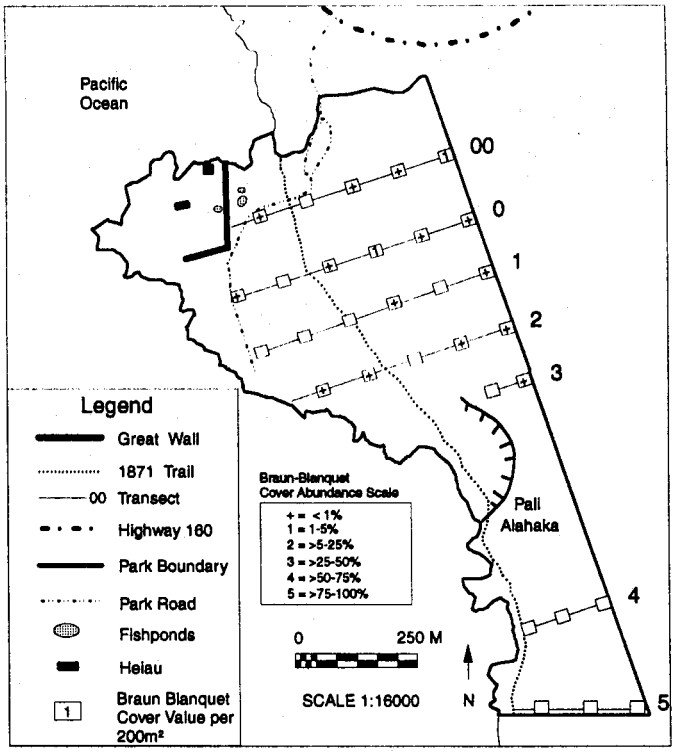

Figure 6. Estimated cover of lantana (Lantana camara) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

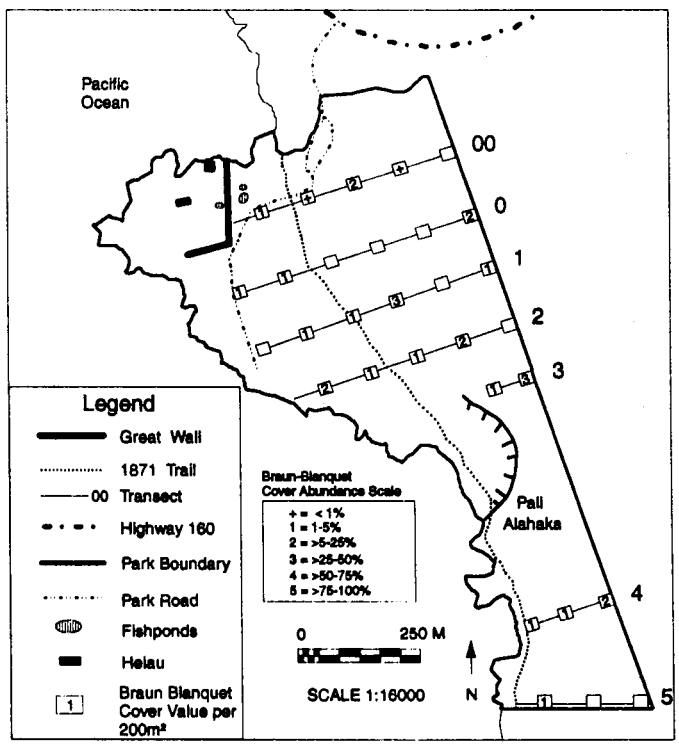

Figure 7. Estimated cover of 'opiuma (Pithecellobium dulce) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

'Opiuma was distributed throughout the Park in uncleared vegetation and was found rarely within the developed area near the Great Wall. The shrub occurred in 70% of all vegetation plots and was sighted on all transects. 'Opiuma was most abundant on transects north and east of Alahaka Pali, where estimated cover was as high as 25-50% (Fig. 7). In approximately half the sampled vegetation plots, the shrub had cover estimated at 1-5% or <1%. 'Opiuma was a co-dominant of shrublands at the base of Alahaka Pali, and the shrub was scattered along the 1871 trail and the coastline of the southern half of the Park.

Guinea grass (Panicum maximum) - A large grass native to Africa, Guinea grass was introduced to Hawai'i for cattle forage in the late 1800s and now grows on all the main islands (Wagner et al. 1990). Guinea grass forms tall dense stands that exclude other plant species, and the grass may also produce allelopathic substances (Smith 1985).

Guinea grass was found in 33% of all vegetation plots. The grass was most abundant in the southern half of Pu'uhonua o Hōnaunau NHP; on the two southernmost transects, estimated cover was as high as >75% (Fig. 8). North of Alahaka Pali, Guinea grass had high cover in only one vegetation plot near the coast, but occurred with <1% cover in several other plots. The grass was also scattered in alien shrublands of the northeastern part of the Park near the eastern boundary fence and the unpaved service road to the sewage facility. Areas of high Guinea grass cover in the southern part of the Park correspond to Leishmann's (1986) map unit of closed tall ēkoa/Guinea grass. Leishmann also mapped one patch of Guinea grass near Park service buildings that was not encountered in the current survey.

Natal redtop (Rhynchelytrum repens) - A perennial grass native to Africa, Natal redtop is smaller than Guinea grass and forms less dense stands. Natal redtop plants are spreading clumps with narrow, yellow-green foliage and are conspicuous when infloresences of pink silky flowers are present. Introduced in the 1890s as cattle forage (Whitney et al. 1964) and first collected naturalized in 1903, the grass is now widely distributed in dry areas on all the main Hawaiian Islands (Wagner et al. 1990). In earlier literature, the grass was known as Tricholaena repens or T. rosea.

Natal redtop was found in 67% of all sampled vegetation plots in Pu'uhonua o Hōnaunau; the grass was very common north of Alahaka Pali. Estimated cover in vegetation plots was most often 1-5% or 5-25%, but in several plots near the 1871 trail Natal redtop had cover of 25-50% or 50-75% (Fig. 9). The area of greatest Natal redtop cover in the current survey corresponds to one of the vegetation units mapped as redtop grassland by Leishmann in 1986. Natal redtop was common at the base of Alahaka Pali, but south and east of the cliff Natal redtop was largely replaced by the taller Guinea grass. In the extreme southern part of the Park, redtop grass was scattered in open areas between the 1871 trail and the coast. Except near the parking lot, redtop grass was not common in the developed part of the Park.

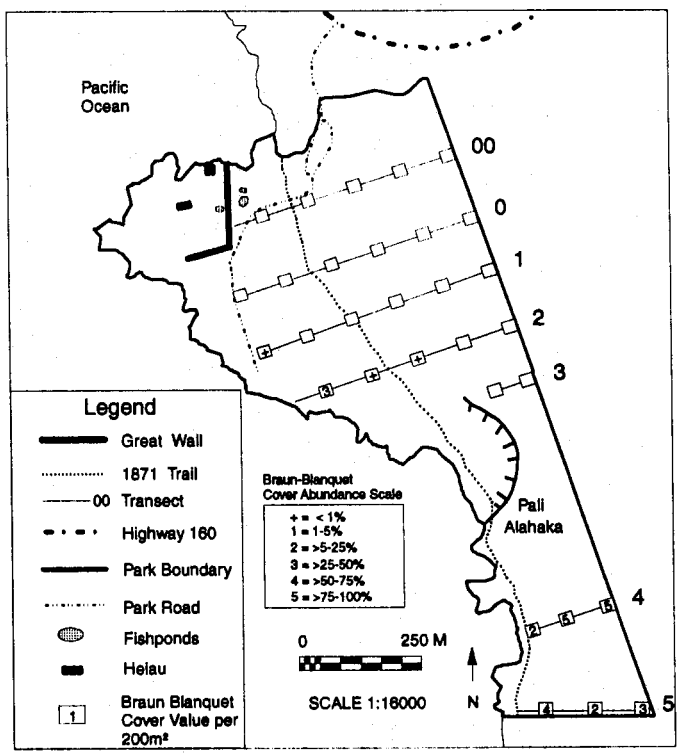

Figure 8. Estimated cover of Guinea grass (Panicum maximum) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

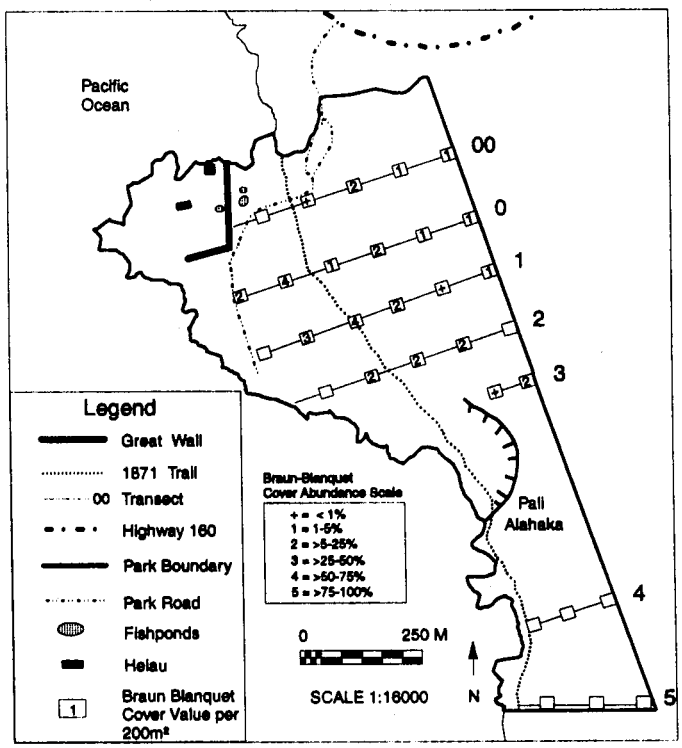

Figure 9. Estimated cover of Natal redtop (Rhynchelytrum repens) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

Potentially Invasive Alien Plants - Several alien plant species that are known to be invasive and disruptive elsewhere were seen as one or few individuals within Pu'uhonua o Hōnaunau in 1992-93. These plants may eventually spread and become more common within the Park. Sourbush (Pluchea symphytifolia), a shrub in the sunflower family, is from tropical America, but has spread widely in the lowlands since its arrival in the 1930s (Wagner et al. 1990). In some coastal areas sourbush may form dense thickets and threaten anchialine pools. In Pu'uhonua o Hōnaunau, sourbush occurred in only one vegetation plot between the 1871 trail and the coast, where its estimated cover was 1-5% (Fig. 10); the shrub was sparsely scattered in shrublands at the base of Alahaka Pali and near Park buildings. Only one individual shrub was sighted in the southern part of the Park near the rocky shore. This species was rated as uncommon by Smith et al. in 1986; they suggested it be controlled to prevent its spread to archaeological sites.

Prickly pear cactus or pānini (Opuntia ficus-indica), one of the few members of the cactus family found on the island, was an early intentional introduction into Hawai'i (Nagata 1985). Prickly pear cactus is now naturalized on five of the main Hawaiian Islands (Wagner et al. 1990). On Hawai'i Island, the cactus was a pest in rangelands before the introduction of several biocontrol agents (Davis et al. 1992). Only one small individual was found within the Park in 1992-93; this cactus was growing on the steep rocky face of Alahaka Pali just east of the 1871 trail and Alahaka ramp (Fig. 11). This species was not listed by Smith et al. from Pu'uhonua o Hōnaunau NHP in 1986, but was mentioned as a vegetation component of Hōnaunau in 1957 (Greenwell 1986).

Autograph tree (Clusia rosea) is a shrub or small tree of the mangosteen family; the species is native to the West Indies and Florida. Introduced to Hawai'i as an ornamental, autograph tree has become established at low elevations on Kaua'i, O'ahu, and Hawai'i. Spread by birds, the tree has recently invaded lowland forests in the Kona and Hilo Districts (Wagner et al. 1990). Only one young plant was seen in Pu'uhonua o Hōnaunau NHP during the 1992-93 survey; this individual was growing beside the canoe shed in the developed part of the Park not far from the visitor center. Autograph tree is undoubtedly a recent arrival in the Park, as Smith et al. (1986) did not see it during their survey.

Another tree seen only once in Pu'uhonua o Hōnaunau NHP is Chinese banyan (Ficus microcarpa), a member of the mulberry family. Native to India, China, Australia, and several island groups, Chinese banyan was introduced to Hawai'i as an ornamental and reforestation tree around 1900 and became naturalized after its pollinating wasp was introduced in 1938 (Wagner et al. 1990). While not generally considered a disruptive species on Hawai'i Island, Chinese banyan might pose a threat to archaeological sites. One young banyan tree was growing near a brackish pond just east of the Great Wall; the tree was visible from the road to Park buildings and the picnic area. This species was not present within the Park in 1986 (Smith et al. 1986).

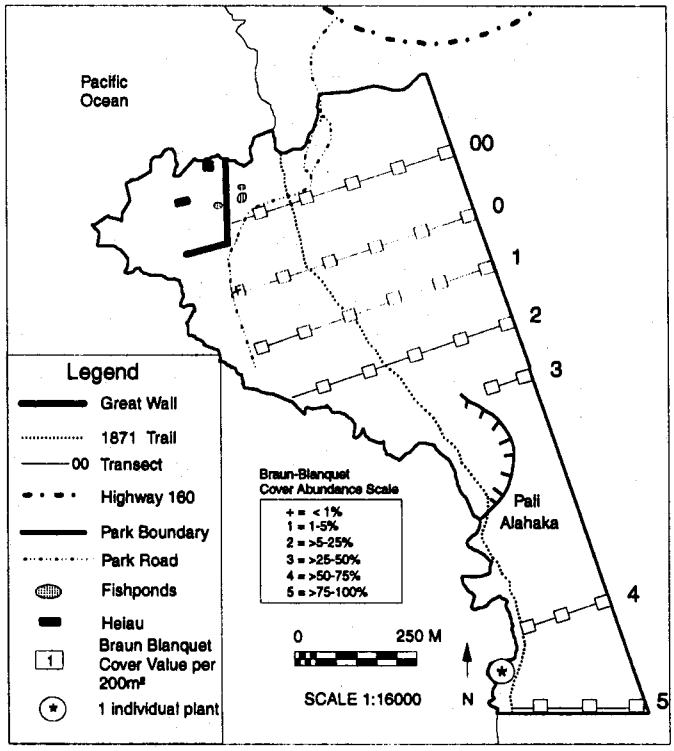

Figure 10. Estimated cover of sourbush (Pluchea symphytifolia) in vegetation plots along transects and off-transect sighting in Pu'uhonua o Hōnaunau National Historical Park.

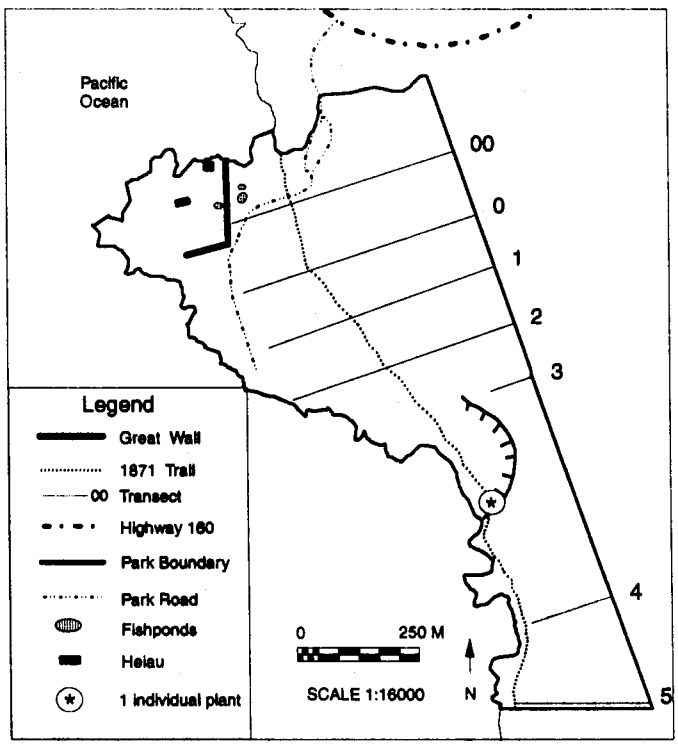

Figure 11. Off-transect sighting of prickly pear cactus (Opuntia ficus-indica) in Pu'uhonua o Hōnaunau National Historical Park.

Pickleweed or 'ākulikuli kai (Batis maritima), a member of the saltwort family, is a sprawling, salt-tolerant, succulent shrub native to tropical and subtropical America. The plant has been in Hawai'i for more than 100 years and is naturalized on coasts of all the main islands (Wagner et al. 1990). Pickleweed may be highly invasive, particularly on the margins of brackish ponds. In Pu'uhonua o Hōnaunau NHP, pickleweed was growing as one patch on the margin of the northernmost pool just east of the Great Wall. This alien plant has only recently appeared in the Park, as it was not present during the Smith et al. (1986) survey. It would be prudent to manually remove pickleweed to prevent its spread to adjacent pools that support native sedges and herbs.

Common Herbaceous Alien Species - Several vines and herbs were very widespread in the undeveloped part of Pu'uhonua o Hōnaunau NHP, but generally had low cover values and did not appear to be as disruptive as the previously discussed shrubs and grasses.

Balsam pear or bitter melon (Momordica charantia), an orange-fruited vine of the gourd family, was seen in 53% of vegetation plots throughout the Park, but its estimated cover was typically <1% or 1-5% (Fig. 12). The plant was most abundant near the 1871 trail, where the vine had estimated cover of 5-25%. In these open grassy areas, balsam pear was climbing on scattered alien shrubs, rock walls, and rock outcroppings. Another vine, love-in-a-mist or scarlet-fruited passion flower (Passiflora foetida) occurred in 33% of plots, but had cover >5% in only one plot below the 1871 trail (Fig. 13).

Talinum triangulare, a fleshy, yellow-flowered herb of the purslane family, was very common in shrublands throughout the Park and occurred in 57% of all plots. While generally estimated to have <1% cover, Talinum triangulare had >50% cover beneath dense ēkoa shrubs in two plots (Fig. 14). This formerly cultivated plant has only recently (1979) become naturalized on Hawai'i Island (Wagner et al. 1990). Three other shrubby herbs were widely distributed in the Park. West Indian beggar's tick (Bidens cynapiifolia), a weedy member of the sunflower family, was found in 43% of all plots, and was most common in the northern half of the Park between the 1871 trail and the coast (Fig. 15). In the southern part of the Park, the annual herb was seen along fencelines. Madagascar periwinkle (Catharanthus roseus), an escaped ornamental in the dogbane family, occurred in 50% of plots, almost entirely upslope of the 1871 trail. This shrubby, purple-flowered herb had estimated cover <1% in most plots where it occurred (Fig. 16). Coral berry (Rivina humilis), a member of the pokeweed family, was noted in 43% of vegetation plots, scattered throughout the Park. Estimated cover of this red-fruited herb or weak shrub was greatest in two plots near the coast and upslope of Park buildings, where it had 5-25% cover. Elsewhere, coral berry had estimated cover <1% (Fig. 17).

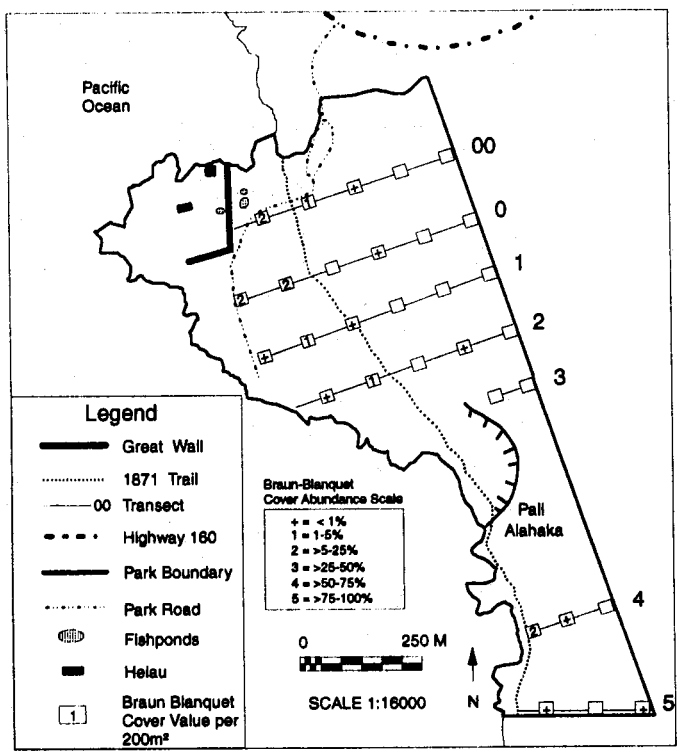

Figure 12. Estimated cover of balsam pear (Momordica charantia) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

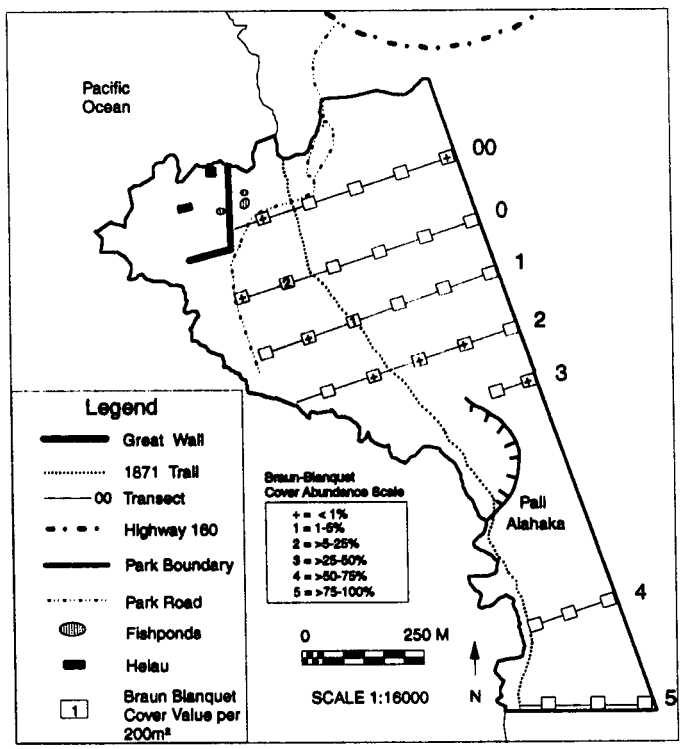

Figure 13. Estimated cover of scarlet-fruited passion flower (Passiflora foetida) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

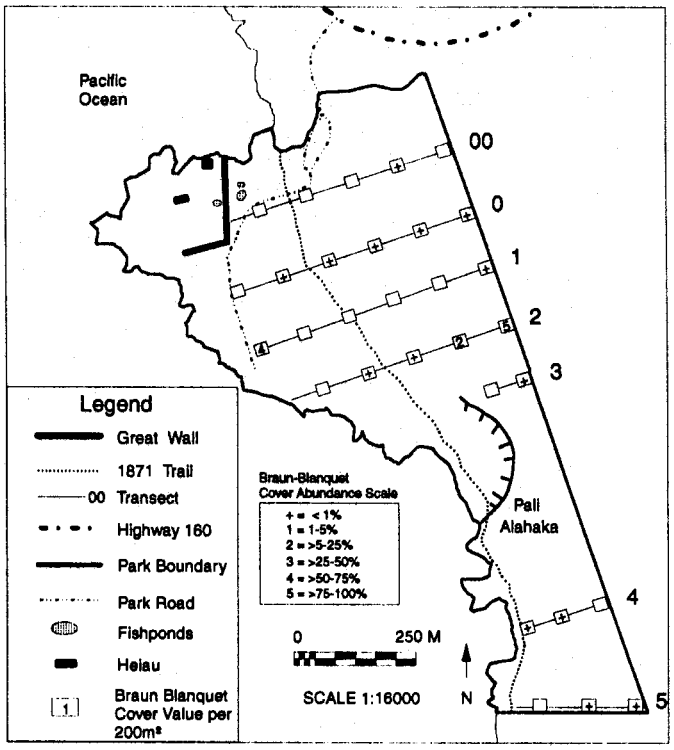

Figure 14. Estimated cover of Talinum triangulare in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

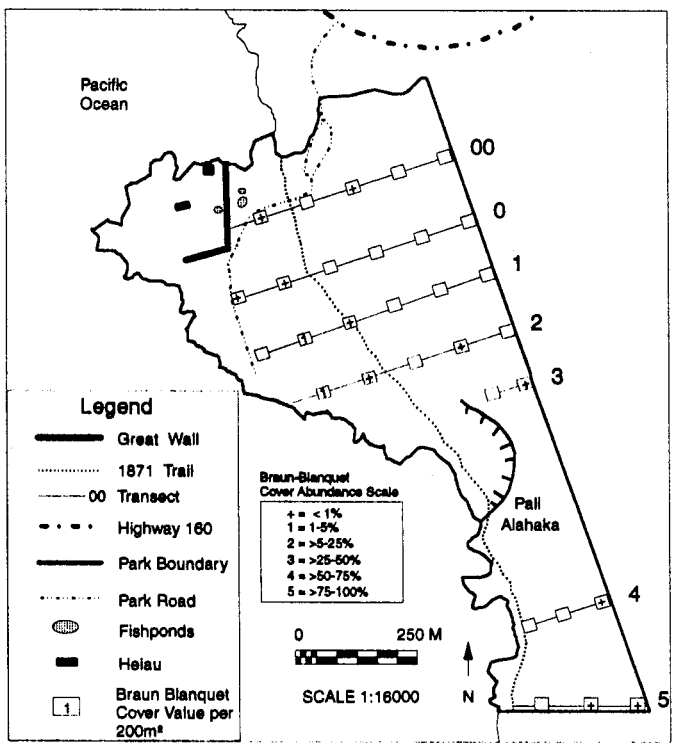

Figure 15. Estimated cover of West Indian beggar's tick (Bidens cynapiifolia) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

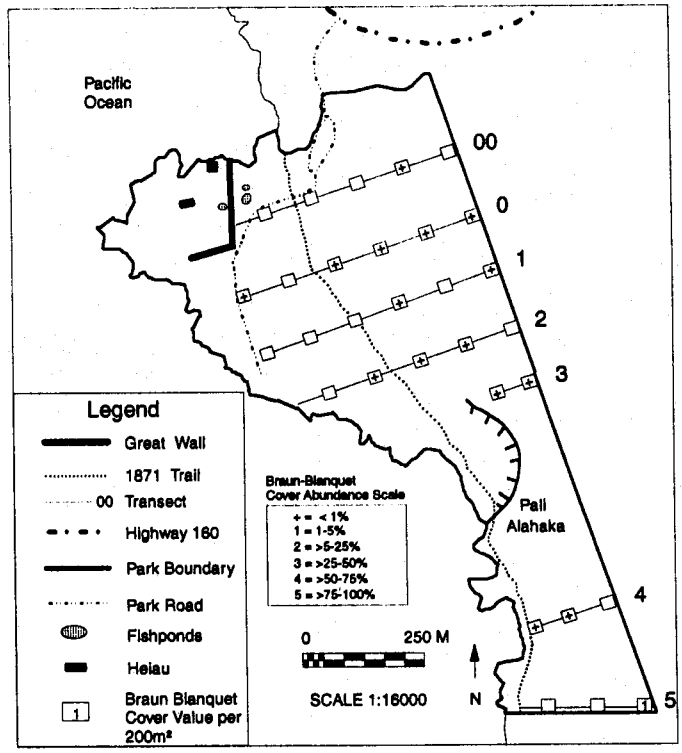

Figure 16. Estimated cover of Madagascar periwinkle (Catharanthus roseus) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

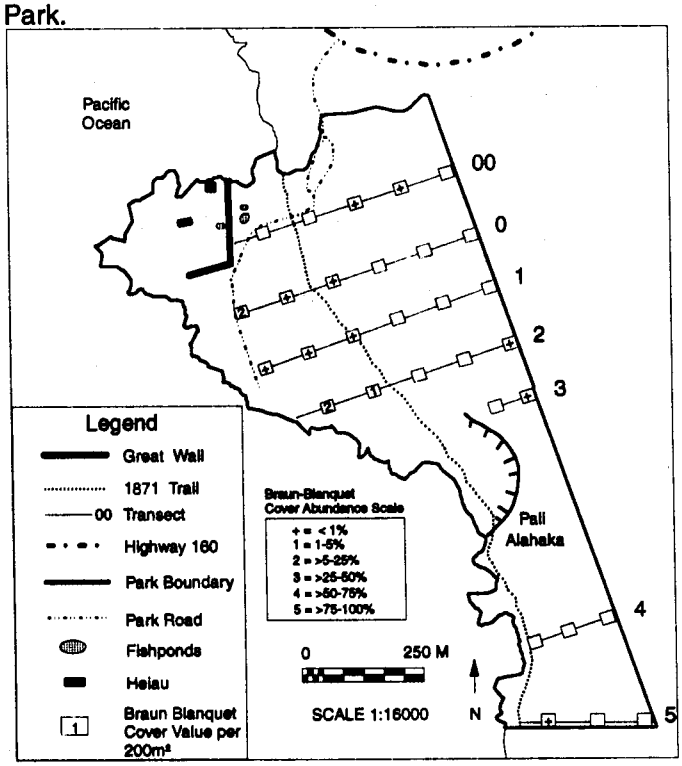

Figure 17. Estimated cover of coral berry (Rivina humulis) in vegetation plots along transects in Pu'uhonua o Hōnaunau National Historical Park.

Native Plants and Polynesian Introductions

Rare and Uncommon Endemic Plants - Six endemic Hawaiian plant species were found within Pu'uhonua o Hōnaunau during the 1992-93 survey. Three of these were represented in the Park only by planted individuals. Loulu palms (Pritchardia sp.) were planted at the visitor center parking lot and near the Superintendent's house. These palms are probably P. affinis, a listed endangered species native to dry leeward coastal regions of Hawai'i Island. Pua kala or Hawaiian prickly poppy (Argemone glauca) was seen only behind Park service buildings, where 17 plants were counted in 1992. These prickly herbs were presumably planted or progeny of a former planting. 'Ākia (Wikstroemia pulcherrima) was planted near the Park visitor center. These three planted species were also noted by Smith et al. (1986).

Three endemic plant species appeared to be naturally occurring in Pu'uhonua o Hōnaunau: maiapilo, Hawaiian moon flower, and 'iwa'iwa. Maiapilo or puapilo (Capparis sandwichiana) is currently a candidate for endangered species status (U.S. Fish and Wildlife Service 1994). A sprawling shrub with dull green leaves and large white flowers, maiapilo is found in coastal areas of all the main Hawaiian Islands (Wagner et al. 1990, St. John 1965). Only one individual maiapilo was found within the Park during the 1992-93 survey; this shrub was near Transect 1, 150 m west of the upslope boundary fence and approximately 200 m east of the 1871 trail (Fig. 18). This maiapilo was rooted in a crack on a rocky tumulus surrounded by alien shrubs. Smith et al. (1986) reported that maiapilo was rare "growing in 'a'ā along main road"; this sighting may have been outside the Park boundary. In 1992-93, maiapilo was not seen along any roads within the Park.

Hawaiian moon flower (Ipomoea tuboides) was also seen as a single individual in Pu'uhonua o Hōnaunau NHP. A vine with shallowly-lobed, heart-shaped leaves and white, funnel-shaped flowers, the Hawaiian moonflower is native to dry lowland vegetation and 'a'ā lava on all the main Hawaiian Islands (Wagner et al. 1990). During the 1992-93 survey, one moon flower vine was found in the northeastern part of the Park, on Transect 00, 100 m from the eastern fenced boundary (Fig. 19). Smith et al. (1986) reported Hawaiian moon flower from the Park in 1984-86, but did not describe a locality or give an abundance rating for the species. Presumably, Hawaiian moon flower was also rare in 1986. Greenwell (1986) did not find Hawaiian moon flower at Pu'uhonua o Hōnaunau in 1957, but the species was listed as suggested for the Hōnaunau area.

'Iwa'iwa (Doryopteris decora), is a small terrestrial fern native to the dry lowlands of the Hawaiian Islands, and is relatively common on Hawai'i Island. Specimens from Pu'uhonua o Honaunau may represent hybrids between Doryopteris decora and D. decipiens (Wagner and Wagner 1992). During the 1992-93 survey, the fern was found in only one area at the base of Alahaka Pali (Fig. 20), but it likely occurs elsewhere in

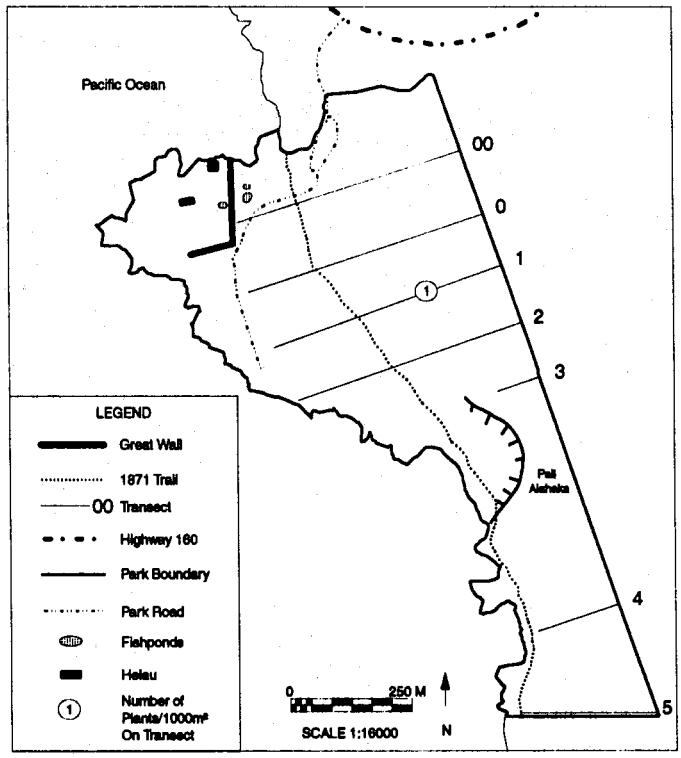

Figure 18. Number of maiapilo (Capparis sandwichiana) plants on or near transects in Pu'uhonua o Hōnaunau National Historical Park.

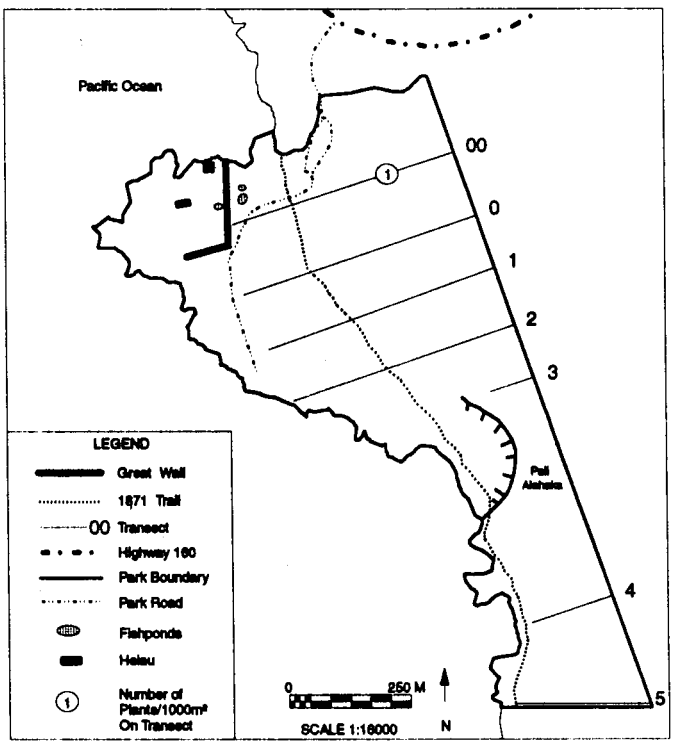

Figure 19. Number of Hawaiian moon flower (Ipomoea tuboides) plants on or near transects in Pu'uhonua o Hōnaunau National Historical Park.

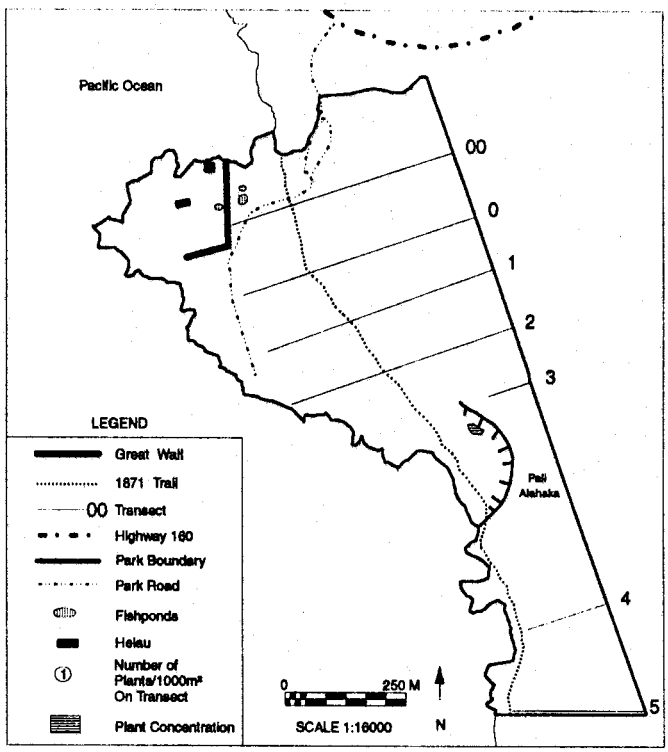

Figure 20. Sightings of 'iwa'iwa fern (Doryopteris decora) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

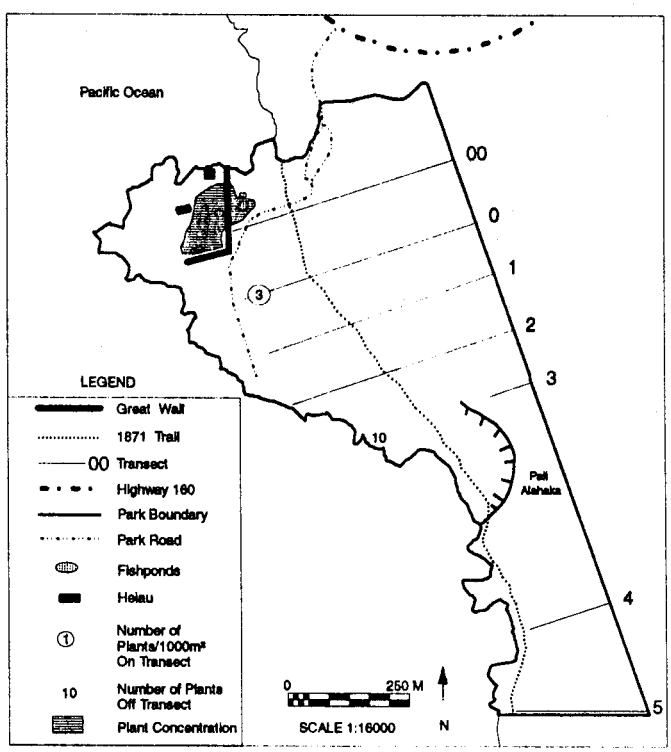

Figure 21. Number of plants or dense concentrations of 'ahu'awa (Mariscus javanicus) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

the Park. Smith et al. (1986) did not find this fern during their survey, and Greenwell (1986) did not specifically name 'iwa'iwa as present at Pu'uhonua o Hōnaunau in 1957.

Indigenous Plants of the Coast and Brackish Ponds - Eight indigenous species were found primarily along the coast and near several brackish ponds adjacent to the Great Wall; this group included three sedges, one vine, one sprawling herb, and three shrubs or trees.

'Ahu'awa or 'ehu'awa (Mariscus javanicus) was the largest of the native sedges in the Park. This stout sedge grows to 1 m in height and is relatively common in coastal and lowland regions of most of the main Hawaiian Islands (Wagner et al. 1990). In 1992-93, 'ahu'awa was scattered throughout the area enclosed by the Great Wall and also grew near the brackish pools east of the wall (Fig. 21). A few individuals were found on Transect 0 and in a crack on the rocky coastline northwest of Alahaka Pali. Smith et al. (1986) also found this sedge to be common near brackish ponds, but Greenwell (1986) did not list the sedge as present in 1957.

Makaloa (Cyperus laevigatus) is a sedge found near coasts and ponds of five of the main Hawaiian Islands; the species is also native to other warm temperate and tropical areas (Wagner et al. 1990). A sedge with fine stems, narrow leaves, and small inflorescences, this plant was important to Hawaiians as a source of materials for mats and other articles (Neal 1965). During the 1992-93 survey, makaloa was found only near the brackish pools east and west of the Great Wall (Fig. 22). Smith et al. (1986) found makaloa in the same area in 1986, but Greenwell (1986) did not note the sedge at Hōnaunau in 1957.

Mau'u 'aki'aki (Fimbristylis cymosa) is an indigenous sedge common on sandy beaches and rocky coasts throughout the Pacific basin (Wagner et al. 1990). This compact, wiry sedge was found scattered throughout the area enclosed by the Great Wall and was widespread on otherwise bare lava substrates along the coast of the Park (Fig. 23). Mau'u 'aki'aki was less abundant and more patchy in distribution in the southern part of the Park. Leishmann mapped several vegetation units dominated by Fimbristylis along the coast in 1986; these units correspond to areas that in 1992-93 had a dense sedge cover and few other plants.

Pōhuehue (Ipomoea pes-caprae subsp. brasiliensis) is a robust morning glory vine with two-lobed leaves and large pink to purple, funnel-shaped flowers. Pantropical in distribution, pōhuehue is found in coastal areas of all the main Hawaiian Islands (Wagner et al. 1990). In Pu'uhonua o Hōnaunau, pōhuehue was found in low numbers near the margins of brackish ponds, within the Great Wall, and at only one coastal site (Fig. 24). Less than 30 pōhuehue plants were counted in these areas. Smith et al. (1986) noted that pōhuehue was occasional along the strand, and the vine was also seen at Hōnaunau in 1957 (Greenwell 1986).

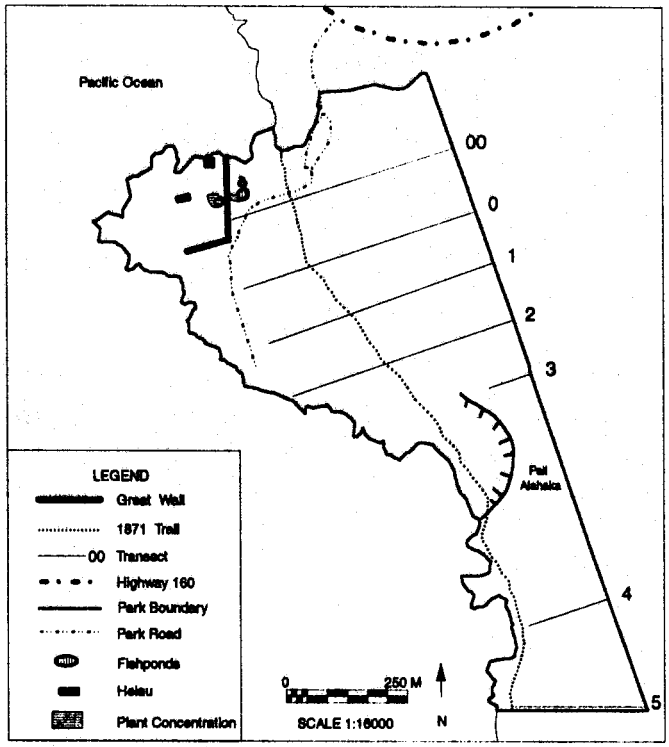

Figure 22. Number of plants or dense concentrations of makaloa (Cyperus laevigatus) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

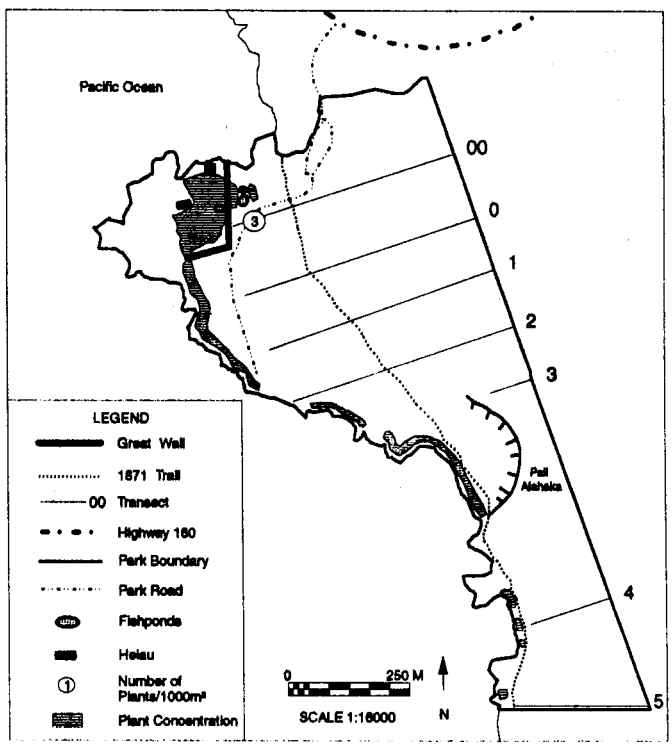

Figure 23. Number of plants or dense concentrations of mau'u'aki'aki (Fimbrystylis cymosa) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

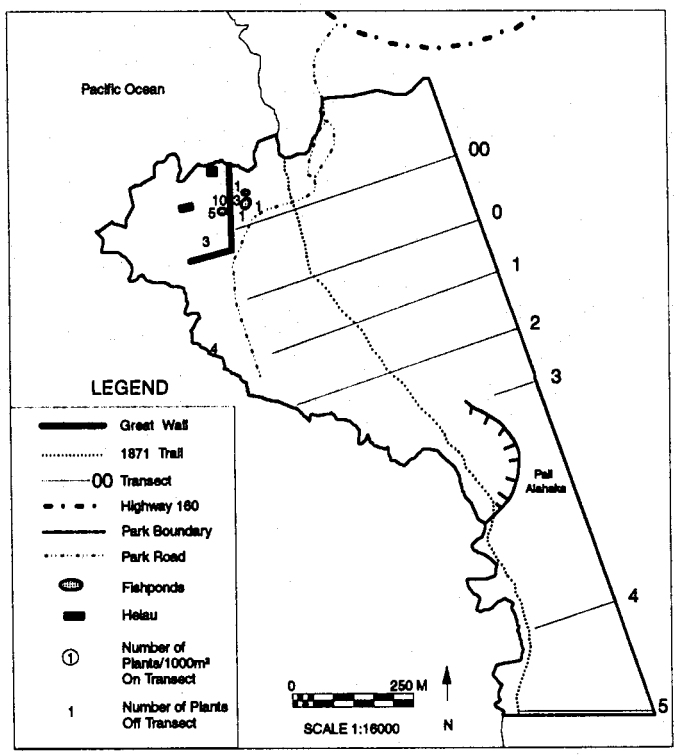

Figure 24. Number of pōhuehue (Ipomoea pes-caprae) plants on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

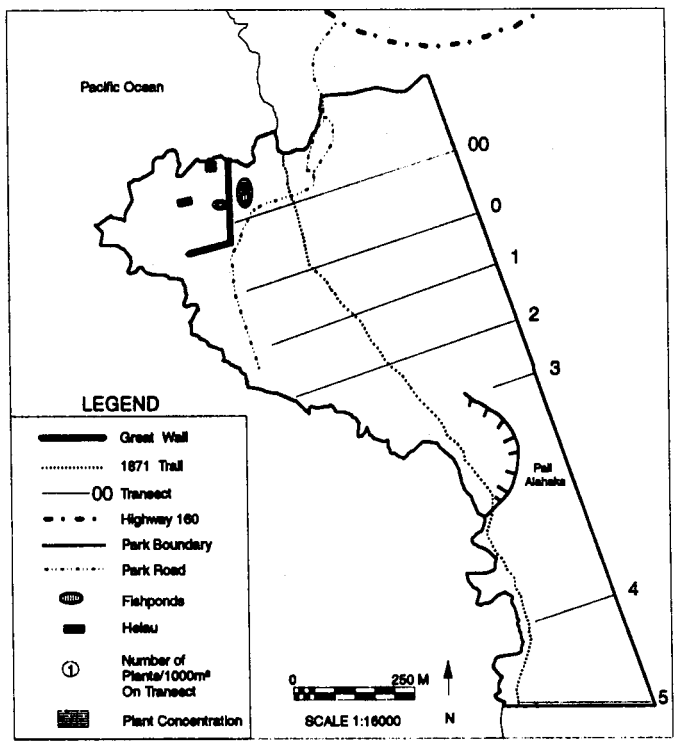

Figure 25. Number of plants or dense concentrations of 'ākulikuli (Sesuvium portulacastrum) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

'Ākulikuli or sea purslane (Sesuvium portulacastrum) is a sprawling herbaceous plant with reddish stems, succulent leaves, and small pink flowers. The species is pantropical and widely distributed throughout the Pacific. In Hawai'i, 'ākulikuli occurs on coasts of all the main Hawaiian Islands (Wagner et al 1990). During the 1992-93 survey, 'ākulikuli was found only on the edges of brackish ponds near the Great Wall (Fig. 25). Because of its matted growth form, individuals could not be distinguished. This was the same area where 'ākulikuli was seen in 1986, when it was rated as common (Smith et al. 1986). 'Ākulikuli was not listed from Hōnaunau in 1957 (Greenwell 1986).

Hala (Pandanus tectorius) is a shrubby tree with prickly stems often supported by many prop roots. Hala leaves are long and narrow with prickly margins. Widespread in Australia and the Pacific Islands, hala is indigenous to Hawai'i, but has also been considered a species possibly introduced by Hawaiians (Wagner et al. 1990). A recent fossil find on Kaua'i of a hala imprint in 1.2 million-year-old lava is evidence that hala arrived in the Hawaiian Islands long before humans (Cunningham 1994). During the 1992-93 survey, hala trees were not seen on transects, but several individuals were noted near brackish ponds, and others were seen near the visitor center and at Park buildings along the unpaved coastal road (Fig. 26). It is possible that most or all of these trees were intentionally planted. Smith et al. (1986) found hala occasionally around the visitor center and Greenwell (1986) listed the tree (as Pandanus odoratissimus) from Hōnaunau in 1957.

Milo (Thespesia populnea) is a shrub or tree of coasts and wetlands with shiny heart-shaped leaves and large yellow flowers. Distributed from tropical Africa to Hawai'i, milo grows along coasts of all the main Hawaiian Islands. The tree may be indigenous to Hawai'i or a Polynesian introduction (Whistler 1992, Wagner et al. 1990). Milo was not seen along transects during the 1992-93 survey of Pu'uhonua o Hōnaunau, but was growing in a dense stand of more than 50 trees on the edge of one of the brackish ponds near the Great Wall (Fig. 27). Other milo trees near the visitor center were possibly planted. Milo was noted near the visitor center by Smith et al. (1986) and was listed by Greenwell (1986) in 1957.

Naupaka kahakai (Scaevola sericea), a shrub with large fleshy leaves, irregular white flowers, and buoyant white fruit, is found on coasts throughout the tropical and subtropical Pacific and Indian Oceans. The shrub is common in coastal areas of all the main Hawaiian Islands (Wagner et al. 1990). The former scientific name of this plant (S. taccada) may actually be the correct name, and may be accepted and widely used in the future (C.H. Lamoureux, pers. comm. 1995). During the 1992-93 survey of Pu'uhonua o Hōnaunau, naupaka was found on only one transect and had a very low density of 0.04 plants/1,000 m^2. The shrub was more common off-transect, where it was distributed on sandy and rocky substrate in a coastal band in the northern half of the Park (Fig. 28). Individuals could not be easily distinguished in this coastal strip, but several hundred shrubs were present. Naupaka was also scattered in coconut groves near the Great Wall

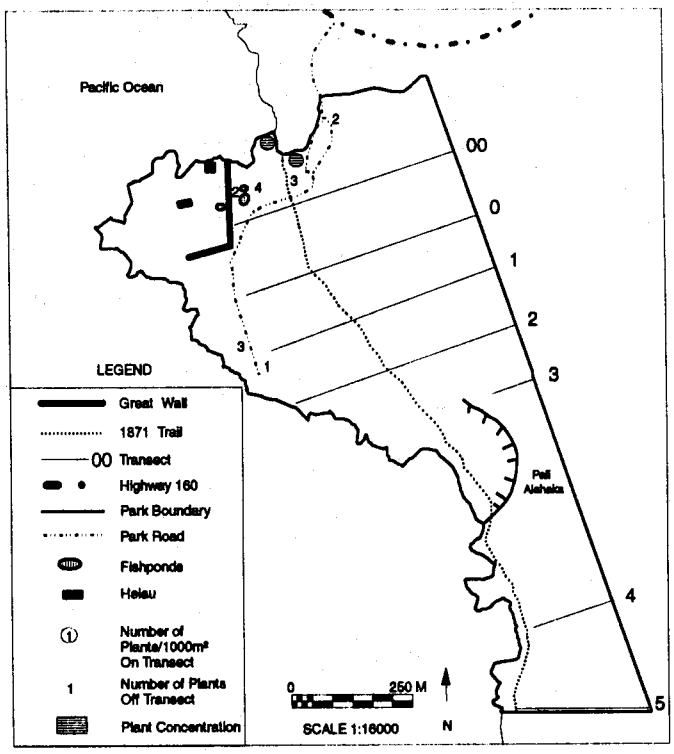

Figure 26. Number of plants or concentrations of hala (Pandanus tectorius) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

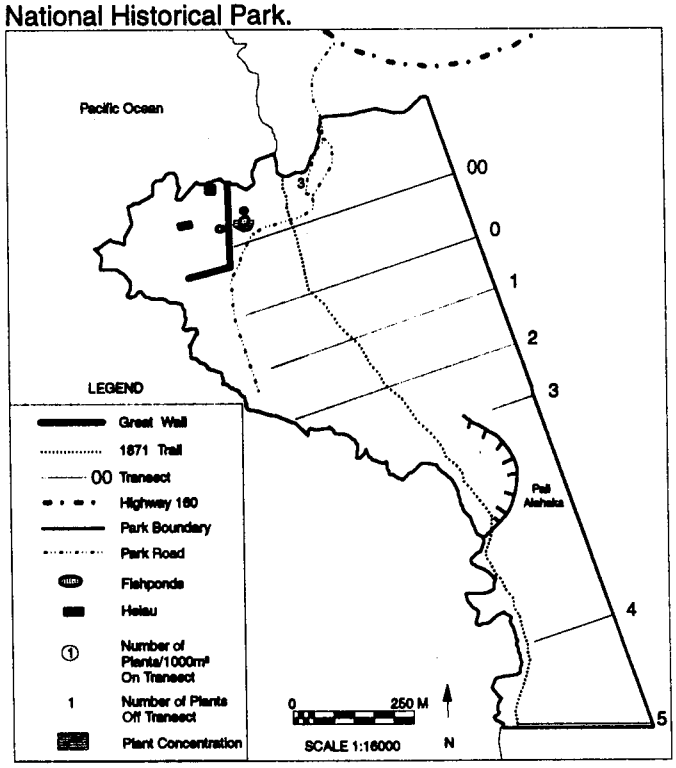

Figure 27. Number of plants or dense concentrations of milo (Thespesia populnea) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

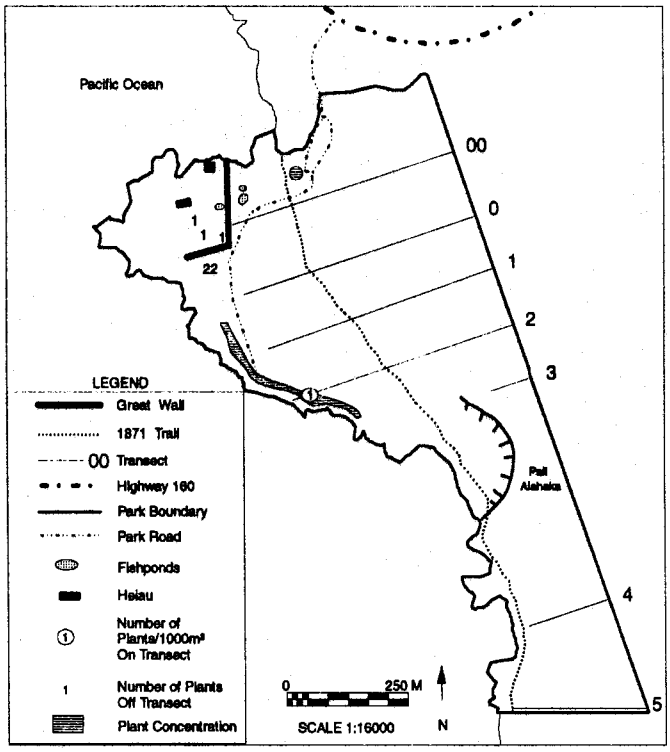

Figure 28. Number of plants or dense concentrations of naupaka kahakai (Scaevola sericea) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

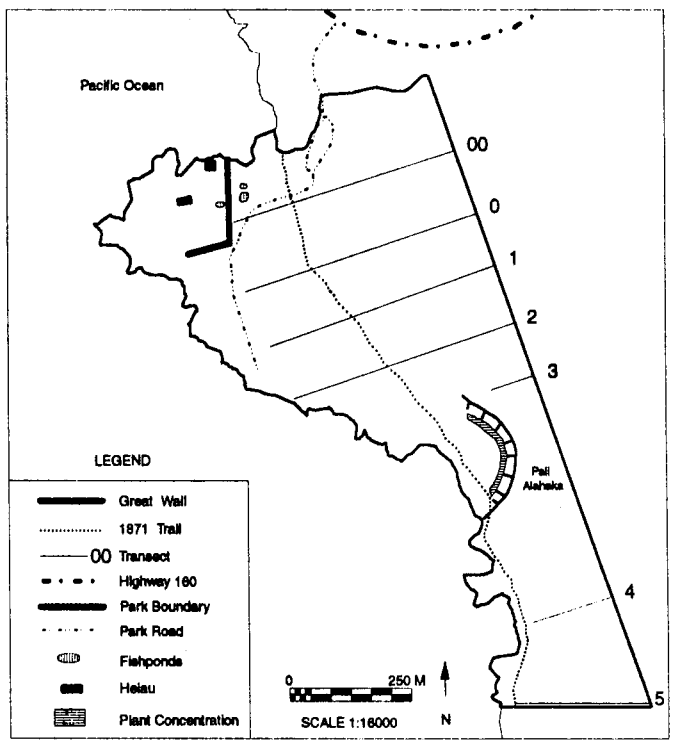

Figure 29. Dense concentration of 'ala'ala wai nui (Peperomia leptostachya) and spurflower (Plectranthus parviflorus) found off transect in Pu'uhonua o Hōnaunau National Historical Park.

and was planted near the visitor center. Naupaka may have increased in the Park since 1984-86, when the shrub was rated as occasional in coastal areas (Smith et al. 1986). Naupaka was not listed as present at Hōnaunau in 1957 (Greenwell 1986).

Indigenous Plant Species Found Upslope - Several indigenous plant species were found along transects in the eastern part of the Park, were at the base of Alahaka (Keanae'e) Pali, or were in the developed part of the Park away from the shore or ponds. These upslope native plant species included three herbs, one grass, and two shrubs.

'Ala'ala wai nui (Peperomia leptostachya) and 'ala'ala wai nui pua kī or spurflower (Plectranthus parviflorus) are succulent terrestrial herbs. 'Ala'ala wai nui is a member of the black pepper family; this small herb has reddish stems, fleshy leaves, and tiny flowers borne in small fleshy spikes. Spurflower belongs to the mint family and has toothed, hairy leaves and upright inflorescenses of pale blue flowers. Both species are native to Australia, Polynesia, and other Pacific Islands, and occur at low elevations on all the main Hawaiian Islands (Wagner et al. 1990). During the 1992-93 survey of Pu'uhonua o Hōnaunau, these two herbs were found only at the base of Alahaka Pali, where they were numerous on the sparsely vegetated rock face shaded by alien shrubs (Fig. 29). Both species were noted in 1986 on inland cliffs (Smith et al. 1986), and both were listed as present in Hōnaunau in 1957 (Greenwell 1986).

Moa or whisk fern (Psilotum nudum) is a small, herbaceous, leafless plant related to extinct primitive vascular plants. Whisk ferns are often grouped with ferns. Moa is native to Hawai'i and also widespread in the tropics (Degener 1975). In 1992-93, moa was found on only one transect, just east of the Great Wall. Although the species is often epiphytic, moa was a terrestrial plant beneath trees and shrubs in the developed part of the Park and was growing on rocks at the base of Alahaka Pali (Fig. 30). Moa was seen in the same localities in the 1984-86 survey (Smith et al. 1986).

Pili (Heteropogon contortus) is a bunchgrass most conspicuous when its flower spikes, characterized by dark, twisted awns, are present. Pili is distributed throughout the tropics and is probably indigenous to Hawai'i, where the grass occurs in dry rocky areas at low elevations on all the main islands (Wagner et al. 1990). The grass was very important to Hawaiians as thatching material, and some botanists have considered pili to be an intentional Polynesian introduction. Certainly Hawaiians encouraged the spread and intensification of pili through the use of fire (Kirch 1982). During the 1992-93 survey, pili was found at two sites on Transects 0 and 2 (Fig. 31). On Transect 0, several patches of pili totalling approximately 30 individuals were found just west of the boundary fence; on Transect 2, a small clump of five pili plants was seen on a rock outcropping. The on-transect density of pili was 1 plant/1,000 m^2. Pili was also present in the Park in 1992-93 as planted patches at the parking lot near the visitor center. In the 1984-86 survey, only planted pili near the parking area was reported (Smith et al. 1986). Pili was found at Hōnaunau in 1957 (Greenwell 1986), and was apparently more common in the

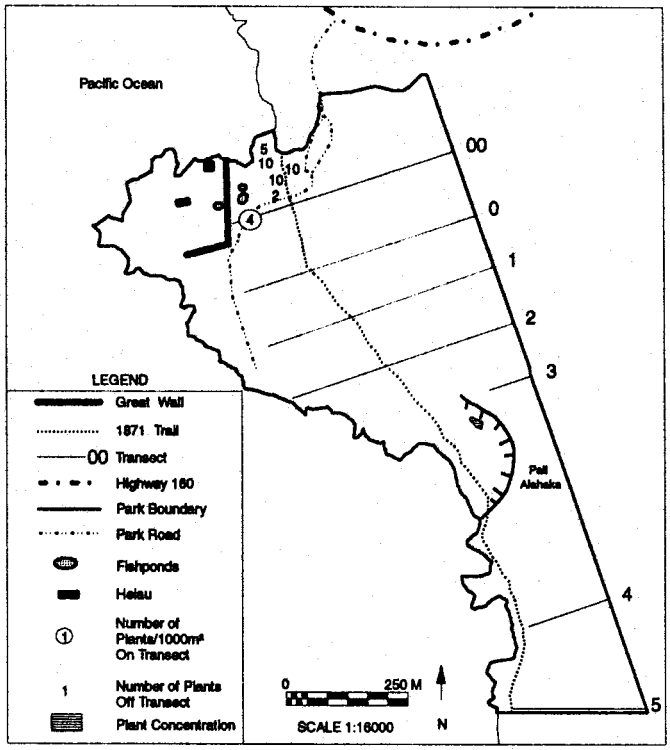

Figure 30. Number of plants or dense concentrations of moa or whisk fern (Psilotum nudum) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

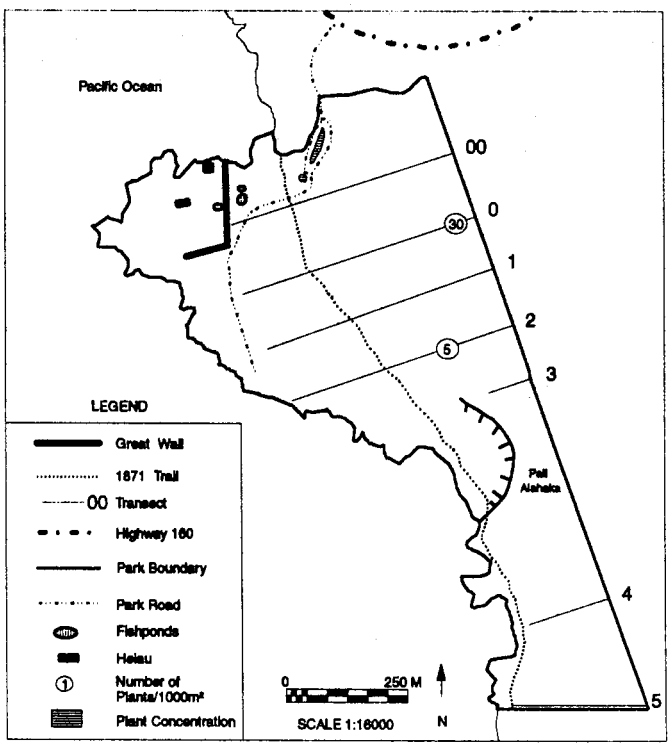

Figure 31. Number of plants or dense concentrations of pili (Heteropogon contortus) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

area in the early 1900s and during the period of Hawaiian habitation (National Park Service 1976).

'Ilima (Sida fallax) is a shrub native to China and Pacific Islands; in Hawai'i the species occurs in dry areas at low and middle elevations on all the main islands (Wagner et al. 1990). 'Ilima is variable in growth form, ranging from a prostrate, viny plant near the ocean to a large upright shrub in upslope forest vegetation. During the 1992-93 survey, 'ilima was found in low numbers at scattered localities in the Park (Fig. 32). The shrub was growing among alien shrubs at four sites along transects; the on-transect density of 'ilima was 0.4 plants/1,000 m^2. Stands of 'ilima were also noted at three sites off-transect: near archaeological features on the coast near the Park's southern boundary, near the Great Wall, and along a trail near the visitor center. 'Ilima was rated as uncommon in the 1984-86 survey of Pu'uhonua o Hōnaunau (Smith et al. 1986) and was also present in 1957 (Greenwell 1986).

'Uhaloa or hi'aloa (Waltheria indica) is a low, spreading shrub with toothed, hairy leaves and tiny yellow flowers. Pantropical in distribution, 'uhaloa is found in dry lowland regions on all the main Hawaiian Islands (Wagner et al. 1990). Although the species has sometimes been called a non-native weed (Neal 1965, St. John 1979), 'uhaloa is now considered to be indigenous to Hawai'i (Wagner et al. 1990). 'Uhaloa was the most abundant native plant in Pu'uhonua o Hōnaunau NHP, where it was distributed on all transects, fencelines, and surveyed trails. Only Transect 4, with its dense cover of Guinea grass, had few 'uhaloa shrubs. The on-transect density of 'uhaloa was 74 plants/1000 m^2; this density value is low because of the need to estimate the number of 'uhaloa where it was too abundant to accurately count or map. 'Uhaloa was also scattered throughout the developed part of the Park. Smith et al. (1986) rated 'uhaloa as occasional during their survey of the Park.

Naturalized Polynesian Introductions - Most of the 15 species of plants originally introduced by Polynesians were found only in the developed part of the Park near the visitor center, where they appeared to have been planted. Three species introduced by Polynesians were naturalized at Pu'uhonua o Hōnaunau (yellow wood sorrel, 'auhuhu, and noni), and two others may be partially naturalized but are also planted (kou and niu or coconut). Yellow wood sorrel or 'ihi 'ai (Oxalis corniculata) is a tiny herb with yellow flowers; the species is either an accidental Polynesian introduction or indigenous (Wagner et al. 1990, St. John 1978). A small weedy plant, yellow wood sorrel was found occasionally only in the developed part of the Park and was not mapped.

'Auhuhu (Tephrosia purpurea var. purpurea) is a small white-flowered shrub in the pea family. The shrub is native to Africa, southern Asia, Australia, and some Pacific Islands, and was introduced to Hawai'i for its value as a fish poison (Wagner et al. 1990, Whistler 1992). During the 1992-93 survey of Pu'uhonua o Hōnaunau, 26 'auhuhu were found along transects or on the eastern boundary fenceline (Fig. 33.). The on-transect density of 'auhuhu was 0.8 plants/1,000 m^2. Smith et al. (1986) found 'auhuhu only

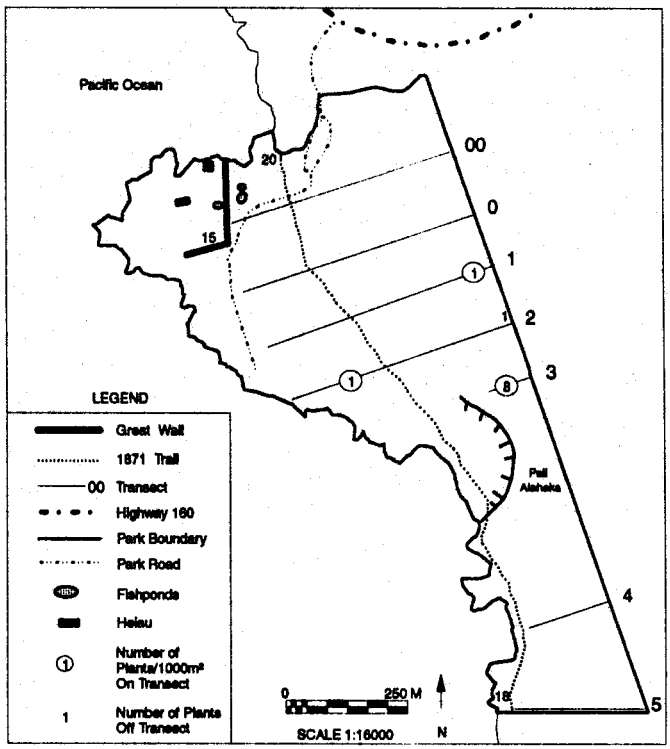

Figure 32. Number of 'ilima (Sida fallax) plants on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

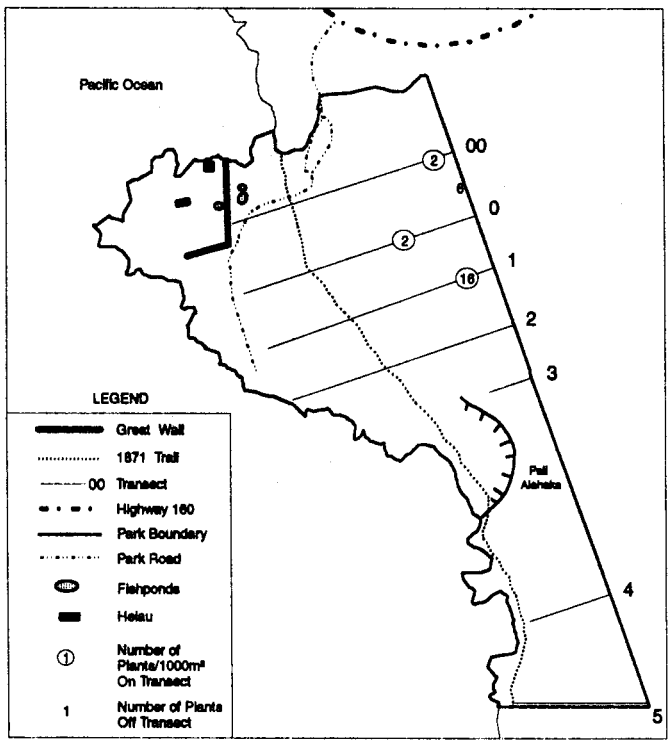

Figure 33. Number of 'auhuhu (Tephrosia purpurea) plants on or near transects in Pu'uhonua o Hōnaunau National Historical Park.

along a service road during their survey and rated the species as rare in the Park. The species was not listed as present in 1957 (Greenwell 1986), but a photograph of 'auhuhu being used for fish poison at Hōnaunau in 1919 was included in the 1957 natural history survey report (Stokes 1986).

Noni or Indian mulberry (Morinda citrifolia) is a shrub or small tree in the coffee family with large, shiny, conspicuously-veined leaves; small white flowers; and large, white, multiple fruits. Native to southeast Asia and Australia, noni was introduced to Hawai'i as a medicinal and dye plant; the plant is now naturalized on the main Hawaiian Islands (Wagner et al. 1990). Noni was the most common naturalized Polynesian plant at Pu'uhonua o Hōnaunau; nearly 200 individuals were counted along transects and the 1871 trail (Fig. 34). Noni plants were abundant in the northern part of the Park below the 1871 trail. Near the trail's intersection with the unpaved Park access road, noni were too dense and numerous to accurately count. On-transect density of noni was 5.8 plants/1,000 m^2. Noni plants were also growing in the developed area of the Park and were planted near the visitor center. Very few noni shrubs were seen off-transect in the southern third of the Park. Smith et al. (1986) found noni to be occasional throughout the Park, and the species was present at Hōnaunau in 1957 (Greenwell 1986).

Kou (Cordia subcordata), a tree in the borage family, has large ovate leaves and orange, tubular flowers. Native to tropical Asia, kou was spread throughout Micronesia and Polynesia in ancient times, where the tree was valued for its flowers and wood (Whistler 1992). During the 1992-93 survey, 37 kou trees were found along the two northernmost transects and at a cluster of coastal sites near Transect 2 (Fig. 35). The on-transect density of kou was only 0.4/1,000 m^2. These sightings may represent naturally reproducing plants, or the trees may persist from former plantings. Kou was also noted near the visitor center, where it was probably planted. Smith et al. (1986) reported several kou trees near the visitor center and along the coast.

Niu or coconut palm (Cocos nucifera) is an ancient introduction to Hawai'i; its place of origin is uncertain, but is probably southeast Asia or the southwest Pacific. The tree was immensely important to Hawaiians, was widely planted, and is now sparingly naturalized in coastal areas of all of the main Hawaiian Islands (Wagner et al. 1990). Coconut trees were too numerous to count, except along transects, where the on-transect density was 3.7 trees/1,000 m^2. The tree was distributed throughout the developed part of the Park and in the northwestern quarter of the Park, primarily below the 1871 trail (Fig. 36). A narrow coastal band of palms extended along the coast toward Alahaka Bay, and a few trees were found near the southern Park boundary. Eight different vegetation types dominated by coconut palms were mapped by Leishmann (1986); the distribution of coconut palms seen in 1992-93 was very similar to that of 1986. Palm trees have been regularly planted by Park Service personnel since the Park's establishment in 1961; the oldest known stand of coconut trees in the Park was planted in 1904 (National Park Service 1976).

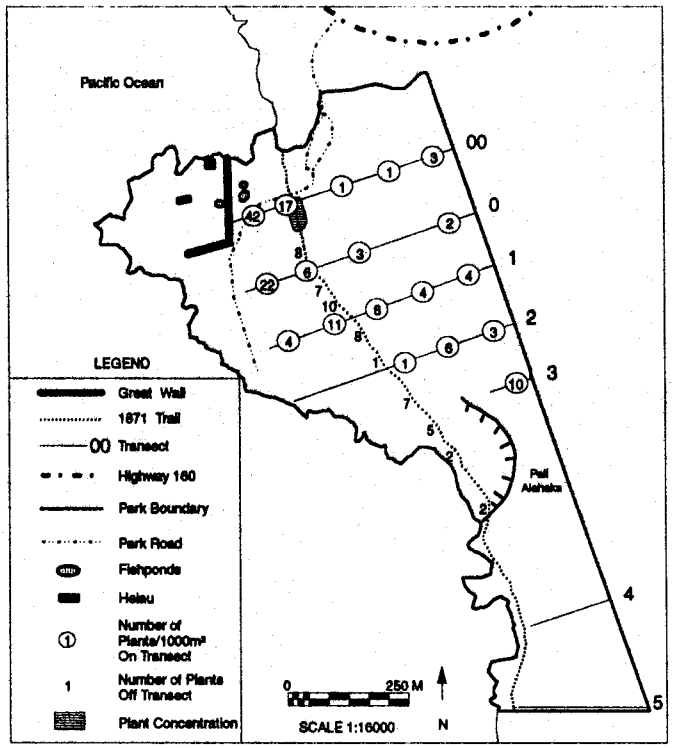

Figure 34. Number of plants or dense concentrations of noni (Morinda citrifolia) on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

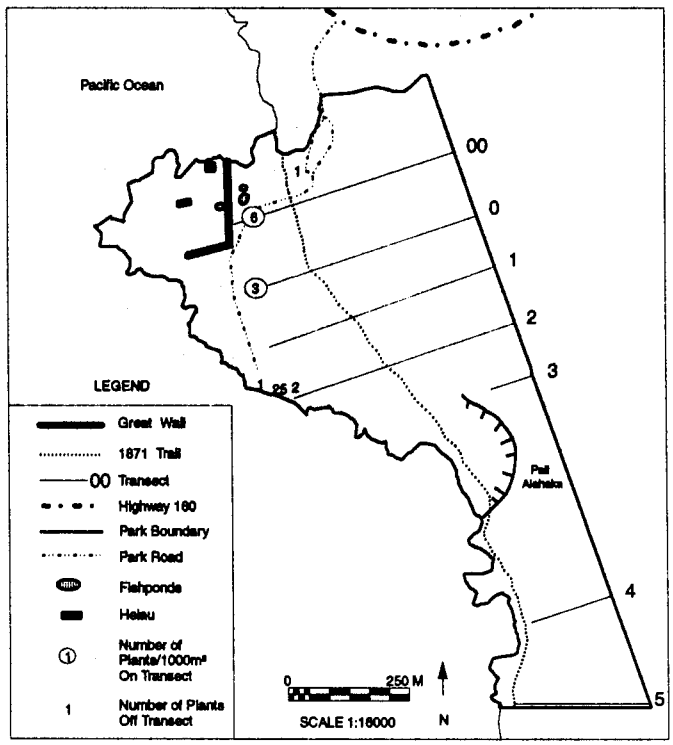

Figure 35. Number of kou (Cordia subcordata) plants on or near transects and in other surveyed areas of Pu'uhonua o Hōnaunau National Historical Park.

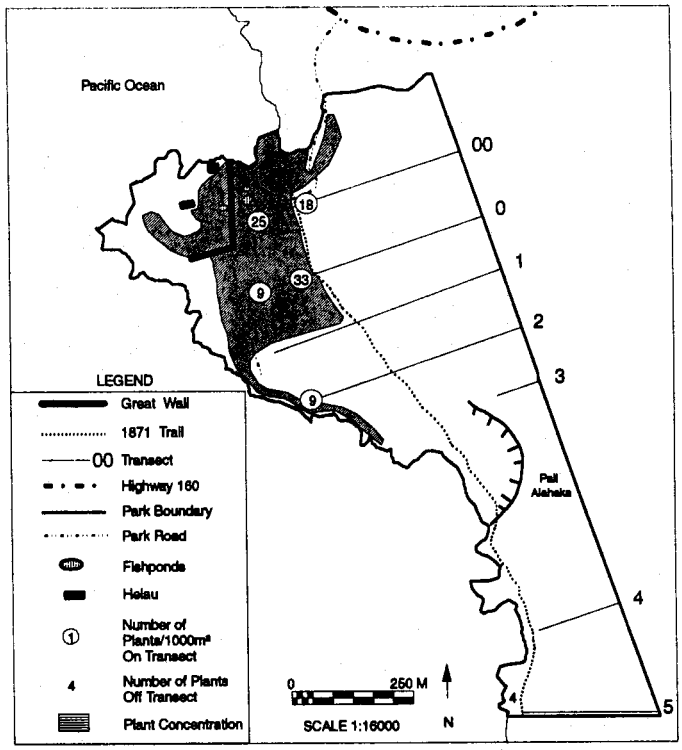

Figure 36. Number of plants or dense concentrations of niu or coconut (Cocos nucifera) on or near transects and in other surveyed areas of Pu'uhonua o Hõnaunau National Historical Park.

Vegetation Types

The dominant vegetation type along transects in Pu'uhonua o Hōnaunau was ēkoa or koa haole shrubland. Almost half (47%) of the systematically-placed vegetation plots supported a dense stand of ēkoa (>75% estimated cover) with a mixture of other alien shrubs. Ground cover in these dense ekoa shrublands consisted of small amounts of Natal redtop grass, alien vines, and alien herbs such as Talinum triangulare. In a few plots Talinum had >50% cover. Small patches of bare rocky substrate were usually present. Ten additional plots (33%) had vegetation in which ēkoa was the co-dominant plant. In two of these plots in the eastern central part of the Park 'opiuma was a co-dominant with ēkoa. One plot near the southern Park boundary had a high percentage cover of ēkoa, but tall kiawe was co-dominant with estimated cover of 5-25%; Guinea grass was the ground cover. Five plots in the southern extreme of the Park had tall ēkoa shrubs with a dense ground cover of Guinea grass. Two plots were covered by a mixture of ēkoa and Natal redtop grass.

Natal redtop grassland was sampled in only two of the systematic vegetation plots. Redtop grass had >50% cover in these two plots, which also supported ēkoa and other alien shrubs. Natal redtop grassland appeared to cover less of the Park than it did when Leishmann (1986) mapped relatively large areas of grassland in the northern extreme of the Park and in the area west of the 1871 trail. Ēkoa may have invaded some of the former redtop grasslands and converted them to shrublands with a grass component.

Miscellaneous vegetation types that occurred in several vegetation plots were coconut/noni grove and noni/Natal redtop shrubland near the Great Wall, a stand of kiawe trees with Guinea grass ground cover near the coast, and a disturbed area near the Park access road with a high percentage cover of 'uhaloa and small amounts of many alien herbs.

Composition and abundance data collected in vegetation plots along transects in 1992-93 generally supported Leishmann's 1986 vegetation map of Pu'uhonua o Hōnaunau, except for the previously discussed apparent decrease in Natal redtop grassland. The Park south of Alahaka Pali remained a closed forest of tall ēkoa with a dense ground cover of Guinea grass. A few areas in this southern third of the Park that had a high cover of kiawe in 1992-93 were not mapped as kiawe in 1986. This species may have increased since 1986. The large expanse of ēkoa shrubland mapped by Leishmann east of the 1871 trail extending north from Alahaka Pali was still present in 1992-93, but the vegetation type had become a closed shrubland rather than open ēkoa shrubland as previously mapped.

Coconut-dominated vegetation types appeared to be as mapped in 1986. Strand communities were not a significant part of the systematic vegetation plots in the current study, but the 1992-93 coastal survey for native plants indicated that both naupaka

kahakai coastal strand and areas supporting the sedge Fimbristylis cymosa have expanded since 1986.

Recommendations

Alien Plant Removal - Several species that have invaded the Park since the last botanical survey should be removed while they are still localized in distribution and few in number. Autograph tree and Chinese banyan were present as only one individual each and were both growing in visible sites in the developed part of the park. Their removal should be relatively easy and might save the Park from a later heavy infestation. Prickly pear cactus was also found as just one individual in the Park, not far from the 1871 trail. Pickleweed should be removed from the brackish pool it currently infests before it increases in cover or invades the other Park pools. Sourbush is not currently threatening the Park's pools, but it would be desirable to remove any individuals found near pools in the future.

Future Botanical Surveys - The number of vascular plant additions to the very thorough checklist of 1986 (Smith et al. 1986) indicates that it would be worthwhile to periodically update the Park's checklist. Brief, systematic botanical surveys of the Park (perhaps every 5-10 years) would assist Park managers in the evaluation of new alien plant threats and the status of native plants.

Native Plant Monitoring and Future Restoration - As maiapilo is currently being considered for endangered species status, it would be desirable to monitor the condition of the one known existing plant in the Park and to search the vicinity for more plants. Maiapilo and indigenous plants recently lost from the Park (if not re-discovered) might be considered for future restoration projects in the Park. However, any outplanting in the Park should only be undertaken after preparation of a native plant management and outplanting plan. This is particularly critical if rare plants are to be outplanted. Documentation of the Park's outplanting and restoration efforts and maintenance of permanent records are necessary to prevent future confusion over natural versus restored or manipulated vegetation. There are also many concerns about introduction of inappropriate species and inadvertant introduction of non-native insects and plant pathogens to public parklands that should be addressed before outplanting is carried out.

Guidelines for restoration and revegetation in National Parks are found in the National Park Service (Western Region) directive and publication "Revegetation and related vegetation management guidelines for disturbed areas" circulated in 1993. Other agencies, organizations, and arboreta in Hawai'i have produced guidelines (Woolliams and Llop 1993) or are currently working on rare plant outplanting guides, and these may be available in the near future through the Center for Plant Conservation or other rare plant groups.

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APPENDIX 1
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

ANNOTATIONS AND SYMBOLS

Status:

E = Endemic, native and unique to Hawaiian Islands

I = Indigenous, native to Hawaiian Islands, also found elsewhere in world

P = Introduced by Polynesians (Hawaiians)

A = Alien, introduced to Hawaii after 1778, non-indigenous, exotic

Abundance Ratings:

A = Abundant

C = Common, numerous and widespread

O = Occasional, scattered in many localities in Park

U = Uncommon, few plants scattered or localized

R = Rare, one or very few plants seen

lc = Localized

Symbols:

! = Species in Park in 1986 (Smith et al.), but not seen in 1992-93

* = Additions to Park's flora since 1986 checklist

Nomenclature:

Scientific names of flowering plants are from W.L. Wagner, D.R. Herbst, and S.H. Sohmer, 1990, Manual of the Flowering Plants of Hawai'i, University of Hawaii and Bishop Museum Press. Fern nomenclature is taken from W.H. Wagner Jr. and F.S. Wagner, 1995, Revised Tentative Checklist of Hawaiian Pteridophytes, unpublished list, February 22, 1995.

New voucher specimens are noted by collector's initials and number (L. W. Pratt # or Lyman L. Abbott #) at end of entries; these are deposited at Hawaii Volcanoes National Park Herbarium.

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
FERNS AND FERN ALLIES		
DRYOPTERIDACEAE (NEPHROLEPIDOIDEAE) - WOODFERN FAMILY (SWORDFERN SUBFAMILY)		
Nephrolepis exaltata (L.) Schott Kupukupu, swordfern Reported by Smith et al. 1986; not seen in 1992-93 survey.	I !	
Nephrolepis multiflora (Roxb.) F. M. Jarrett ex C. V. Morton Scaly swordfern Common on exposed rock throughout Park	A *	C
POLYPODIACEAE - POLYPODY FAMILY		
Phymatosorus grossus (Langsd. & Fisch.) Brownlie Laua'e Common terrestrial fern in developed area near Park visitor center and in planters near buildings; also found on Transect 00 and at base of Alahaka Pali.	A	C
PSILOTACEAE - WHISK FERN FAMILY		
Psilotum nudum (L.) P. Beauv. Moa, pipi, whisk fern Small terrestrial or epiphytic herb near Park visitor center, in stands of coconut and noni, and at base of Alahaka Pali.	I	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
PTERIDACEAE (CHEILANTHOIDEAE) - PTERIS FAMILY (LIPFERN SUBFAMILY)		
Doryopteris decora Brack. 'Iwa'iwa Small fern growing on rock face at base of Alahaka Pali (LWP 2574).	E *	R
FLOWERING PLANTS - DICOTYLEDONS (MAGNOLIOPSIDA)		
AIZOACEAE - FIG-MARIGOLD FAMILY		
Sesuvium portulacastrum (L.) L. 'Ākulikuli, sea purslane Succulent herb locally common at margins of brackish ponds in developed area of Park.	I	U
AMARANTHACEAE- AMARANTH FAMILY		
Alternanthera pungens Kunth (Syn: Alternanthera repens) Khaki weed Herb along trails in developed area of Park (LWP 2701).	A	U
Amaranthus spinosus L. Spiny amaranth Large herb seen only on Transect 00 (LLA sn).	A	U
Amaranthus viridis L. Slender amaranth Herb occasional along coast, also seen on Transect 2 (LWP 2703).	A	O
Gomphrena globosa L. Globe amaranth Ornamental herb at Superintendent's house.	A *	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
ANACARDIACEAE - MANGO FAMILY		
Schinus terebinthifolius Raddi Christmas berry Large shrub common in alien shrublands of northern half of Park, particularly near upper boundary.	A	C
APOCYNACEAE - DOGBANE FAMILY		
Catharanthus roseus (L.) G. Don Madagascar periwinkle Small shrubby herb scattered throughout Park shrublands and in open rocky areas.	A	O
Plumeria rubra L. Plumeria, frangipani Tree planted near visitor center, at Superintendent's house, and at grave site on point in southern part of Park (red-, pink-, and yellow-flowered forms are present).	A	O
ARALIACEAE - GINSENG FAMILY		
Polyscias sp. Panax Shrub planted at Superintendent's house.	A *	R
ASTERACEAE (COMPOSITAE) - SUNFLOWER FAMILY		
Ageratum conyzoides L. Ageratum Herb seen only at base of Alahaka Pali (LWP 2572).	A	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
ASTERACEAE - SUNFLOWER FAMILY (Continued)		
Bidens cynapiifolia Kunth West Indian beggar's tick Common annual herb in alien shrubland throughout Park.	A	C
Bidens pilosa L. Spanish needle, beggar's tick Annual herb seen only on Transect O, at base of Alahaka Pali, and near roads. Both forms formerly listed as varieties pilosa and minor were present.	A	U
Eclipta alba (L.) Hassk. False daisy Several small plants seen near brackish ponds.	A	R
Emilia fosbergii Nicolson Pualele Few herbaceous plants seen on Transects 0 and 1, at base of Alahaka Pali, and among cultivated plants near visitor center (LWP 2569).	A *	U
Emilia sonchifolia (L.) DC (Syn: Emilia javanica) Flora's paintbrush Scattered plants on Transects 0, 1, and 2 (LWP 2552).	A	O
Gnaphalium purpureum L. Purple cudweed Herb reported by Smith et al. (1986); not seen during 1992-93 survey.	A !	

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
ASTERACEAE - SUNFLOWER FAMILY (Continued)		
Pluchea symphytifolia (Mill.) Gillis (Syn: Pluchea odorata) Sourbush, shrubby fleabane Scattered shrubs in alien shrublands, at base of Alahaka Pali, and along coast.	A	U
Tridax procumbens L. Coat buttons Herb seen only on Transect 00 near jeep road; also growing in highway divider.	A *	U
BATACEAE - SALTWORT FAMILY		
Batis maritima L. Pickleweed, 'ākulikuli kai Sprawling shrub seen only near brackish pond.	A *	U
BIGNONIACEAE - BIGNONIA FAMILY		
Crescentia cujete L. Calabash tree Reported by Smith et al. (1986) as planted near visitor center; not seen in 1992-93.	A !	
BORAGINACEAE - BORAGE FAMILY		
Cordia subcordata Lam. Kou Tree planted near visitor center and persisting in a few sites near the coast.	P	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
BORAGINACEAE - BORAGE FAMILY (Continued)		
Heliotropium curassavicum L. Kīpūkai, nena, seaside heliotrope Reported by Smith et al. (1986) from strand; not seen in 1992-93 survey.	I !	
Myosotis azorica H. C. Wats. ex Hook. Forget-me-not Cited by Smith et al. (1986) from earlier survey; not seen in 1986 or 1992-93.	A !	
Tournefortia argentea L. fil. (Syn: Messerschmidia argentea) Tree heliotrope One tree west of the Great Wall.	A	R
BRASSICACEAE (CRUCIFERAE) - MUSTARD FAMILY		
Lepidium virginicum L. Wild peppergrass Roadside weed near visitor center.	A	O
CACTACEAE - CACTUS FAMILY		
Hylocereus undatus (Haw.) Britton & Rose (Syn: Cereus undatus) Night-blooming cereus Large succulent vine on rock walls adjacent to Park.	A	U
Opuntia ficus-indica (L.) Mill. Prickly pear cactus, pānini One plant seen on Alahaka Pali near ramp.	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
CAPPARACEAE - CAPER FAMILY		
Capparis sandwichiana DC Maiapilo, pua pilo One sprawling shrub on Transect 1, also along road outside Park. This is a candidate endangered species (category 2) (LWP 2577).	E	R
Cleome gynandra L. (Syn: Gynandropsis gynandra) Wild spider flower Common in open areas throughout Park.	A	C
Cleome spinosa L. Honohina Cited by Smith et al. (1986) from earlier survey; not seen in 1986 or 1992-93. Wagner et al. (1990) list the last collection as 1864-65 and report the plant's distribution as Ni'ihau, O'ahu, and Maui.	I !	
CARICACEAE - PAPAYA FAMILY		
Carica papaya L. Papaya A few large plants grow along the base of Alahaka Pali and on Transect 00, also planted at Superintendent's house.	A	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
CHENOPODIACEAE - GOOSEFOOT FAMILY		
Atriplex eardleyae Aellen Saltbush Reported as Atriplex semibaccata by Smith et al. (1986); common in Park in 1986; not seen in 1992-93 survey. Specimen from Park (now at BISH) was later identified as Atriplex eardleyae, an annual species (Wagner et al. 1989).	A !	
Chenopodium album L. Pigweed, lamb's quarters Reported by Smith et al. (1986), not seen in 1992-93 survey.	A !	
Chenopodium murale L. Nettle-leaved goosefoot, 'āheahea Herb in sandy soil near coast.	A *	U
CLUSIACEAE (GUTTIFERAE) - MANGOSTEEN FAMILY		
Calophyllum inophyllum L. Kamani Tree planted near visitor center and in center of parking area.	P	U
Clusia rosea Jacq. Autograph tree One individual seen near canoe shed in developed part of Park (LWP sn).	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
COMBRETACEAE - INDIAN ALMOND FAMILY		
Terminalia catappa L. Tropical almond, false kamani Few trees observed near Park visitor center and scattered along coast.	A	O
CONVOLVULACEAE - MORNING-GLORY FAMILY		
Ipomoea batatas (L.) Lam. 'Uala, sweet potato Vine planted at visitor center.	P	R
Ipomoea pes-caprae (L.) R. Br. subsp. brasiliensis (L.) Ooststr. Pōhuehue, beach morning glory Few vines near brackish ponds and along coast.	I	O
Ipomoea tuboides Degener & Ooststr. Hawaiian moon flower One plant found on Transect 00.	E	R
Merremia aegyptia (L.) Urb. Hairy merremia One plant seen on Transect O.	A *	R
CRASSULACEAE - ORPINE FAMILY		
Crassula sp. Jade tree Succulent ornamental shrub planted at Superintendent's house.	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
CRASSULACEAE - ORPINE FAMILY (Continued)		
Kalanchoe pinnata (Lam.) Pers. Air plant Common ground cover in forest and shrublands of southern half of Park; locally abundant on boundary fenceline.	A	C
CUCURBITACEAE - GOURD FAMILY		
Cucumis dipsaceus Ehrenb. ex Spach Hedgehog gourd, teasel gourd Annual vine reported as rare by Smith et al. (1986); not seen in 1992-93 survey.	A !	
Momordica charantia L. Balsam pear, bitter melon Common vine in alien shrublands and open areas throughout Park.	A	C
EUPHORBIACEAE - SPURGE FAMILY		
Aleurites moluccana (L.) Willd. Kukui, candlenut Tree planted near visitor center.	P	O
Chamaesyce hirta (L.) Millsp. (Syn: Eurphorbia hirta) Hairy spurge Small herb scattered in open areas throughout Park (LLA sn).	A	O
Chamaesyce hypericifolia (L.) Millsp. (Syn: Euphorbia glomerifera) Graceful spurge Herb scattered in open areas throughout Park (LWP 2705).	A	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
EUPHORBIACEAE - SPURGE FAMILY (Continued)		
Chamaesyce prostrata (Aiton) Small (Syn: Euphorbia prostrata) Prostrate spurge Small herb scattered along trails, roads, and open rocky sites (LWP 2704).	A	O
FABACEAE (LEGUMINOSAE) - PEA FAMILY		
Acacia farnesiana (L.) Willd. Klu Widespread shrub with low cover in alien shrublands throughout Park.	A	C
Chamaecrista nictitans (L.) Moench subsp. patellaria (DC ex Collad.) H. Irwin & Barneby var. glabrata (Vogel) H. Irwin & Barneby (Syn: Cassia leschenaultiana) Partridge pea Small shrub scattered in open vegetation throughout Park.	A	O
Crotalaria pallida Aiton Smooth rattlepod Uncommon shrub, encountered on Transect 2; probably the same species listed as Crotalaria sp. by Smith et al. (1986) (LWP 2567).	A	U
Desmodium cajanifolium (Kunth) DC No common name Shrub scattered on Transects 00 and 0 and near the junction of the jeep road and the 1871 trail.	A *	O
Desmodium tortuosum (Sw.) DC Florida beggarweed Shrub in few sites on Transects 2 and 3.	A *	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
FABACEAE - PEA FAMILY (Continued)		
Indigofera suffruticosa Mill. Indigo Scattered shrub in alien shrublands and grass patches (LLA sn).	A	O
Leucaena leucocephala (Lam.) de Wit Ēkoa, koa haole Most abundant shrub in the Park.	A	A
Pithecellobium dulce (Roxb.) Benth. 'Opiuma, Manila tamarind Very common shrub throughout undeveloped part of Park.	A	C
Prosopis pallida (Humb. & Bonpl. ex Willd.) Kunth Kiawe, mesquite Tree or large shrub seen occasionally near coast and at southern boundary of Park.	A	O
Samanea saman (Jacq.) Merr. Monkeypod Large tree scattered throughout Park, most noticeable on 1871 trail.	A	O
Senna occidentalis (L.) Link (Syn: Cassia occidentalis) Coffee senna Scattered shrub found near 1871 trail on Transects 00, 0, 1, and 4 (LWP 2707).	A	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
FABACEAE - PEA FAMILY (Continued)		
Senna pendula (Humb. & Bonpl. ex Willd.) H. Irwin & Barneby (Syn: Cassia bicapsularis) No common name Few shrubs near 1871 trail. Cassia sp. reported by Smith et al. (1986) should be included here; a Cassia sp. specimen in the HAVO Herbarium (Higashino & Stemmermann 10327) appears to be Senna pendula.	A	U
Tamarindus indica L. Tamarind One tree planted at Superintendent's house and several trees along coast in southern part of Park.	A	U
Tephrosia purpurea (L.) Pers. var. purpurea 'Auhuhu Scattered shrubs along upper fenceline and on Transects 00, 0 and 1.	P	U
GOODENIACEAE - GOODENIA FAMILY		
Scaevola sericea Vahl (Syn: Scaevola taccada) Naupaka kahakai Distributed in narrow coastal strip in northern half of Park and near the Great Wall; also planted at visitor center.	I	C
LAMIACEAE (LABIATAE) - MINT FAMILY		
Ocmium gratissimum L. Wild basil Reported by Smith et al. (1986), not seen during 1992-93 survey.	A !	

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
LAMIACEAE - MINT FAMILY (Continued)		
Plectranthus parviflorus Willd. Spurflower, 'ala'alawainui pua kī Low herb scattered at base of Alahaka Pali (LWP 2575).	I	O
Salvia sp. ? Unknown One non-flowering plant found near rock wall behind Superintendent's house (LWP 2554).	A *	R
LOGANIACEAE - STRYCHNINE FAMILY		
Fagraea berteriana Gray ex Benth. Pua kenikeni Reported by Smith et al. (1986) as planted near visitor center; not seen in 1992-93.	A !	
MALVACEAE - MALLOW FAMILY		
Abutilon grandifolium (Willd.) Sweet Hairy abutilon Shrub scattered on Transects 00, 4, and 5, and along the 1871 trail.	A	O
Gossypium barbadense L. Cotton Reported by Smith et al. (1986) as planted near canoe house; not seen during 1992-93 survey.	A !	
Hibiscus sp. Hibiscus One cultivated shrub at Superintendent's house.	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
MALVACEAE - MALLOW FAMILY (Continued)		
Malvastrum coromandelianum (L.) Garcke subsp. coromandelianum False mallow Occasional in rocky areas of Park and along 1871 trail.	A	O
Sida fallax Walp. 'Ilima Shrub observed near upper fenceline, on Transect 2, near the Great Wall, and in developed area of Park near visitor center.	I	U
Thespesia populnea (L.) Sol. ex Correa Milo Stand of trees at brackish ponds east of the Great Wall; also planted near visitor center.	I	U
MORACEAE - MULBERRY FAMILY		
Broussonetia papyrifera (L.) Venten. Wauke, paper mulberry Shrub planted at visitor center.	P	U
Ficus microcarpa L. fil. Chinese banyan One small tree along jeep road near 1871 trail.	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
NYCTAGINACEAE - FOUR-O'CLOCK FAMILY		
Boerhavia coccinea Mill. No common name Herb seen occasionally near coast, on Transects 00, 0, and 4, and along 1871 trail.	A	O
Bougainvillea spectabilis Willd. Bougainvillea Planted near Park entrance and at Superintendent's house.	A	U
OLEACEAE - OLIVE FAMILY		
Jasminum sambac (L.) Aiton Pīkake, Arabian jasmine Reported by Smith et al. (1986) as planted near canoe house; not seen during 1992-93 survey.	A !	
Noronhia emarginata (Lam.) Stadm. in Thouars Madagascar olive Tree planted behind visitor center.	A	R
OXALIDACEAE - WOOD SORREL FAMILY		
Oxalis corniculata L. Yellow wood sorrel, 'ihi 'ai Small herb in developed area of Park.	P	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
PAPAVERACEAE - POPPY FAMILY		
Argemone glauca (Nutt. ex Prain) Pope var. decipiens Ownbey Pua kala, Hawaiian prickly poppy Approximately 17 plants growing behind Park maintenance buildings near Superintendent's house, possibly reproducing from a planting.	E	R
PASSIFLORACEAE - PASSION FLOWER FAMILY		
Passiflora foetida L. Love-in-a-mist, scarlet-fruited passion flower Vine frequently seen in shrublands and grassy areas near 1871 trail.	A	C
Passiflora suberosa L. Huehue haole Vine observed on Transects 00 and 0 and on coast near southern Park boundary (LWP 2702).	A	O
PHYTOLACCACEAE - POKEWEED FAMILY		
Rivina humilis L. Coral berry Herb or weak shrub common in alien shrublands throughout Park.	A	C
PIPERACEAE - PEPPER FAMILY		
Peperomia leptostachya Hook. & Arnott 'Ala'ala wai nui Terrestrial herb growing on rocks at base of Alahaka Pali (LWP 2576).	I	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
PLUMBAGINACEAE - LEADWORT FAMILY		
Plumbago zeylanica L. 'Ilie'e Reported as uncommon, without locality, by Smith et al. (1986); not seen during 1992-93 survey.	I !	
POLYGONACEAE - BUCKWHEAT FAMILY		
Coccoloba uvifera (L.) L. Sea grape Reported by Smith et al. (1986) as planted near heiau and at Superintendent's house; not seen during 1992-93 survey.	A !	
PORTULACACEAE - PURSLANE FAMILY		
Portulaca oleracea L. Pigweed, common purslane Herb in rocky areas throughout Park, particularly along the 1871 trail.	A	O
Portulaca pilosa L. (Syn: Portulaca cyanosperma) No common name Small herb scattered throughout Park; formerly thought to be an endemic species.	A	O
Talinum paniculatum (Jacq.) Gaertn. Jewels of Opar Common herbaceous ground cover in ēkoa shrublands (LWP 2503).	A	C
Talinum triangulare (Jacq.) Willd. No common name Common herb in ēkoa shrublands and open rocky areas throughout Park (LWP 2504).	A	C

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
RUBIACEAE - COFFEE FAMILY		
Coffea arabica L. Arabian coffee Shrub planted near visitor center.	A	U
Hedyotis corymbosa (L.) Lam. No common name Small herb seen in visitor center parking area and at Superintendent's house (LWP 2553).	A *	U
Morinda citrifolia L. Noni, Indian mulberry Common understory tree or shrub in coconut groves near developed part of Park, also scattered in alien shrublands throughout Park.	P	C
Spermacoce assurgens Ruiz & Pav. (Syn: Borreria laevis) Buttonweed Herb seen once near trail in developed part of Park (LWP sn).	A	R
RUTACEAE - RUE FAMILY		
Citrus sp. Citrus, species unknown One tree planted at Superintendent's house (sterile at time of survey).	A *	R
SAPINDACEAE - SOAPBERRY FAMILY		
Dodonaea viscosa Jacq. 'A'ali'i One shrub planted near visitor center, another planted near Park offices and maintenance buildings.	I *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
SOLANACEAE - NIGHTSHADE FAMILY		
Nicotiana glauca R. C. Graham Tree tobacco Cited by Smith et al. (1986) from earlier survey; not seen in 1986 or 1992-93.	A !	
Nicotiana tabacum L. Tobacco Planted or persisting behind Park maintenance buildings.	A	R
Solanum americanum Mill. (Syn: Solanum nigrum) Pōpolo, glossy nightshade Reported as uncommon by Smith et al. (1986); not seen during the 1992-93 survey.	I !	
STERCULIACEAE - CACAO FAMILY		
Waltheria indica L. (Syn: Waltheria americana) 'Uhaloa, hi'aloa Very common small shrub found throughout Park.	I	A
THYMELAEACEAE - 'ĀKIA FAMILY		
Wikstroemia pulcherrima Skottsb. 'Ākia One shrub planted behind visitor center.	E	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
TILIACEAE - LINDEN FAMILY		
Triumfetta semitriloba Jacq. Sacramento bur Few shrubs seen in alien shrubland on Transect 2 near 1871 trail.	A	U
VERBENACEAE - VERBENA FAMILY		
Lantana camara L. Lantana Common shrub in alien shrublands throughout Park.	A	C
Vitex rotundifolia L. fil. (Syn: Vitex ovata) Pōhinahina, beach vitex Planted in median strip near Park entrance and between parking lot and visitor center.	I	U
ZYGOPHYLLACEAE - CREOSOTE BUSH FAMILY		
Tribulus terrestris L. Puncture vine Prostrate vine or herb common along trails and roads.	A	C
FLOWERING PLANTS - MONOCOTYLEDONS (LILIOPSIDA)		
AGAVACEAE (LILIACEAE IN PART) - AGAVE FAMILY		
Cordyline fruticosa (L.) A. Chev. (Syn: Cordyline terminalis) Kī, ti Planted near visitor center and at Superintendent's house.	P	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
AGAVACEAE - AGAVE FAMILY (Continued)		
Pleomele marginata (Lam.) N. E. Br. Money tree Ornamental shrub planted at Superintendent's house.	A	R
Sansevieria trifasciata Prain var. laurentii (de Wild.) N. E. Br. Bowstring hemp, snake plant Ornamental herb planted at Superintendent's house.	A *	R
ARACEAE - PHILODENDRON FAMILY		
Colocasia esculenta (L.) Schott Kalo, taro Planted in front of visitor center.	P *	U
Epipremnum pinnatum (L.) Engl. Taro vine, pothos Large vine planted at Superintendent's house.	A *	R
ARECACEAE (PALMAE) - PALM FAMILY		
Cocos nucifera L. Niu, coconut Common in developed part of Park and along coastline in northern half of Park.	P	C
Phoenix sp. Date palm One small tree on roadside near the Great Wall.	A *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
ARECACEAE - PALM FAMILY (Continued)		
Pritchardia sp. Loulu Planted at visitor center parking area and near Park buildings; probably P. affinis.	E	R
BROMELIACEAE - PINEAPPLE FAMILY		
Ananas comosus (L.) Merr. Pineapple Planted near Superintendent's house.	A *	R
CANNACEAE - CANNA FAMILY		
Canna indica L. Indian shot, ali'i poe Reported by Smith et al. (1986) from archaeological sites near Park's southern boundary; not seen in Park during 1992-93 survey.	A !	
COMMELINACEAE - SPIDERWORT FAMILY		
Commelina benghalensis L. Hairy honohono Large patch at base of Alahaka Pali (LWP 2573).	A *	U
Commelina diffusa N. L. Burm. Dayflower, honohono Low, spreading herb on Transect 1.	A	U, lc

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
COMMELINACEAE - SPIDERWORT FAMILY (Continued)		
Tradescantia spathacea Sw. (Syn: Rhoeo spathacea) Oyster plant Ornamental herb planted near Superintendent's house.	A	R
Tradescantia zebrina Bosse (Syn: Zebrina pendula) Wandering jew Ornamental herb planted near Superintendent's house.	A *	R
CYPERACEAE - SEDGE FAMILY		
Cyperus compressus L. No common name Small sedge in developed part of Park near Great Wall (LWP 2700).	A	U
Cyperus laevigatus L. Makaloa Sedge restricted to brackish ponds near Great Wall.	I	C, lc
Cyperus rotundus L. Nut grass Small sedge growing with plantings and other aliens in highway median strip.	A	C, lc
Fimbristylis cymosa R. Br. Mau'u 'aki'aki Low sedge scattered along rocky shoreline.	I *	C, lc

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
CYPERACEAE - SEDGE FAMILY (Continued)		
Kyllinga brevifolia Rottb. (Syn: Cyperus brevifolius) Kili'o'opu Small sedge seen only on Transect 00 and near Great Wall.	A *	U
Mariscus javanicus (Houtt.) Merr. & Metcalfe (Syn: Cyperus javanicus) 'Ahu'awa, 'ehu'awa Large sedge common in and near brackish ponds near the Great Wall, uncommon elsewhere in Park (Transect O and on coast).	I	C,lc
Mariscus meyenianus (Kunth) Nees (Syn: Cyperus meyenianus) No common name Cited by Smith et al. (1986) from earlier survey; not seen in 1986 or 1992-93.	A !	
Pycreus polystachyos (Rottb.) P. Beauv. (Syn: Cyperus polystachyos) No common name Sedge seen near trails in developed part of Park (LWP 2706).	I	O
DIOSCOREACEAE - YAM FAMILY		
Dioscorea alata L. Uhi, yam Vine planted near visitor center.	P *	R

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
LILIACEAE - LILY FAMILY		
Aloe vera L. Aloe Planted near visitor center and at Superintendent's house, also found among ruins near southern boundary of Park.	A	O
PANDANACEAE - SCREW PINE FAMILY		
Pandanus tectorius S. Parkinson ex Z Hala Scattered trees in developed part of Park near visitor center; also planted at Superintendent's house and near other service buildings.	I	O
POACEAE (GRAMINEAE) - GRASS FAMILY		
Brachiaria mutica (Forssk.) Stapf California grass Reported by Smith et al. (1986); not seen during 1992-93 survey.	A !	
Cenchrus ciliaris L. Buffelgrass Seen in only one locality on Transect 2 between 1871 trail and coast.	A *	R
Cenchrus echinatus L. Common sandbur Scattered in developed part of Park and near Great Wall (Transect 00).	A	O
Chloris barbata (L.) Sw. (Syn: Chloris inflata) Swollen fingergrass Annual grass reported by Smith et al. (1986) as common throughout Park; seen only in highway median strip during 1992-93 survey.	A	U

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
POACEAE - GRASS FAMILY (Continued)		
Cynodon dactylon (L.) Pers. Bermuda grass, mānienie Mat-forming grass common in developed part of Park, at Superintendent's house, and near brackish ponds; one large patch on coast.	A	C, lc
Cynodon sp. No common name Reported by Smith et al. (1986); not distinguished from C. dactylon during 1992-93 survey.	A !	
Dactyloctenium aegyptium (L.) Willd. Beach wiregrass Few individuals seen along coast.	A	U
Digitaria insularis (L.) Mez ex Ekman (Syn: Tricachne insularis) Sourgrass Large grass found only along jeep road and eastern Park boundary fence near sewage treatment site.	A	U
Digitaria sp. Crabgrass Scattered in developed part of Park near Great Wall.	A	O
Eleusine indica (L.) Gaertn. Wiregrass Scattered in developed part of Park near visitor center and Great Wall (Transect 00).	A	O
Eragrostis tenella (L.) P. Beauv. ex Roem. & Schult. Japanese lovegrass Small grass scattered in developed part of Park near visitor center, at Great Wall, and along 1871 Trail (LLA sn).	A	O

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
POACEAE - GRASS FAMILY (Continued)		
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult. Pili Planted near visitor center parking area, also found on Transects 0 and 2 near eastern Park boundary (LWP 2568).	I	U
Panicum maximum Jacq. Guinea grass Dominant ground cover in shrublands between Alahaka Pali and southern Park boundary, also near sewage treatment site.	A	A
Pennisetum setaceum (Forssk.) Chiov. Fountain grass Reported by Smith et al. (1986) as present in low numbers; not seen during 1992-93 survey.	A !	
Rhynchelytrum repens (Willd.) Hubb. (Syn: Tricholaena rosea) Natal redtop Abundant in part of Park north of Alahaka Pali.	A	A
Saccharum officinarum L. Kō, sugar cane Planted near Park visitor center.	P	R
Sporobolus diander (Retz.) P. Beauv. Indian dropseed Reported by Smith et al. (1986) as uncommon along service roads, not seen during 1992-93 survey.	A !	
Stenotaphrum secundatum (Walter) Kuntze St. Augustine grass Locally common near trails in developed part of Park near visitor center.	A	C, lc

APPENDIX 1 (Continued)
PU'UHONUA O HŌNAUNAU NATIONAL HISTORICAL PARK
VASCULAR PLANT CHECKLIST - 1992-93

	Status	Abundance
TACCACEAE - TACCA FAMILY		
Tacca leontopetaloides (L.) Kuntze Pia, Polynesian arrowroot Large herb planted at Park visitor center.	P *	R
ZINGIBERACEAE - GINGER FAMILY		
Curcuma longa L. 'Ōlena, turmeric Large herb planted at Park visitor center.	P *	R